# The 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

Overview

This white paper provides an overview of the use of Grand Challenges, including how determine if a goal warrants a Grand Challenge and considerations for designing and implementing grand challenges within federal departments and agencies. This paper also draws on ways Grand Challenges have been used by non-government entities. The information in this paper is largely based on relevant literature, including articles from journals, news, and other outlets, as well as interviews with federal employees who have collaborated on grand challenges.

## Introduction

A Grand Challenge is an articulation of a desired objective that is wide in scope and does not have an obvious solution space. The value of the Grand Challenge framework 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 in topics such as high performance computing, global public health, and engineering.

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

* Grand vision: Explicitly setting grand, ambitious targets – like making solar energy as cheap as coal, understanding the human brain, or destroying cancerous tumors while leaving healthy cells untouched – galvanizes public excitement and draws in new communities of 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-sect collaborations. Agencies can augment their impact by involving contributions from other agencies, foundations, research universities, companies, and citizens.
* Ambitious yet achievable: The key lies in a willingness to set bold, audacious goals: Historical examples include landing a man on the moon, the Human Genome Project, and Wikipedia. These examples have a definite, unambiguous outcome.
* Flexible framework: The Grand Challenge framework includes a variety of implementation mechanisms to engage new solvers – including, but not limited to, prize competitions[[1]](#footnote-1), crowdsourced innovations[[2]](#footnote-2), contracts[[3]](#footnote-3), and partnerships.

### Why

By construction, Grand Challenges help achieve a large, seemingly unattainable goal for any one agency or department. The development and execution of Grand Challenges enable the federal government to:

* Marshal resources with an “all hands on deck” approach;
* Align with the modern collaborative research environment, while offering a “new language” and framework for research and problem-solving;
* Inspire the next generation of scientists, engineer, and entrepreneurs to work on hard and important problems.

#### Help marshal multi-sector resources with an “all hands on deck” approach

Numerous companies have undertaken their own Grand Challenge goals in recent years. Google’s self-driving car [is a direct outgrowth of a 2005 DARPA Grand Challenge for unmanned vehicles](http://spectrum.ieee.org/robotics/artificial-intelligence/the-unknown-startup-that-built-googles-first-selfdriving-car). IBM’s advances in artificial intelligence (AI) have been driven by [Grand Challenge frameworks –](http://www-03.ibm.com/marketing/br/watson/what-is-watson/the-next-grand-challenge.html) including Deep Blue which, in 1997, beat Gary Kasparov, world chess champion at the time; and Watson which, in 2011, defeated two Jeopardy champions. Universities can also create and launch learning opportunities, research initiatives, and capital campaigns that support Grand Challenges.

#### Offer a "new language" for research and problem-solving frameworks

The Grand Challenge framing syncs 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."[[4]](#footnote-5)

#### Inspire the next generation of scientists, engineers, and entrepreneurs to work on hard and important problems

In the landmark 2008 [Grand Challenges for Engineering](http://www.engineeringchallenges.org/File.aspx?id=11574&v=ba24e2ed) report, a committee of world-class scientists and engineers issued a clarion call to the engineering field. The vision? For the engineering field – particularly 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. In embracing the Grand Challenge framework, the goal is to inspire the next generation to devote their life’s 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](http://www.engineeringchallenges.org/File.aspx?id=15680&v=c29105cb) to integrate Grand Challenge programs into their undergraduate curriculums, pledging that in a decade, 20,000 engineers will be trained to tackle these complex challenges.

### How – exec summary of implementation guidelines – come back to this after I write Implementation guidelines

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’s 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 context, but three themes for their design and implementation are:

## Background

### History of Grand Challenges

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. Grand Challenges were first introduced into public organizations as part of the advocacy for high-performance computing. [The High Performance Computing Act of 1991](https://www.gpo.gov/fdsys/pkg/USCODE-2011-title15/html/USCODE-2011-title15-chap81-sec5503.htm) defined Grand Challenges narrowly 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.”

The Bill & Melinda Gates Foundation recognized the power and potential of the Grand Challenge framework, setting the stage for their [Grand Challenges in Global Health](http://gcgh.grandchallenges.org/announcement/grand-challenges-global-health-announced) in 2003. The elevation of the term by the Gates Foundation was a milestone in the broader application of the concept. The Gates Foundation used the Grand Challenge framework to set an agenda and articulate specific scientific or technological innovations to solve important global health challenges.

A third, concurrent milestone was the first instance of a Grand Challenge undertaken by a federal agency—the Defense Advanced Research Projects Agency (DARPA) [Grand Challenge](http://archive.darpa.mil/grandchallenge04/index.htm) from 2002-2004. The first DARPA Grand Challenge required contestants to build driverless vehicles that could withstand long distance trials. Since its first Grand Challenge, DARPA has sponsored the [Spectrum Collaboration Challenge](https://spectrumcollaborationchallenge.com/), the [Robotics Challenge](http://www.darpa.mil/program/darpa-robotics-challenge), and the [Cyber Grand Challenge](http://www.darpa.mil/program/cyber-grand-challenge) underneath the Grand Challenge framework.

The National Academy of Engineering’s [Grand Challenges in Engineering](http://www.engineeringchallenges.org/) followed in 2008.

## 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. “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).[[5]](#footnote-6)

Grand Challenges can be implemented in a variety of ways. For example, USAID implemented Grand Challenges with a variety of tools for sourcing and funding (Resource Box 1. How is a Grand Challenge different from a Prize Competition?”). Seema Patel, Division Chief, Innovation Design and Advisory, at the U.S. Global Development Lab at USAID, reflected on how Grand Challenges have been used in their 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.”[[6]](#footnote-7)

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| **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 available resources,” explains Cristin Dorgelo, former Chief of Staff at the Office of Science and Technology Policy (OSTP) 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 their Grand Challenge program, but not necessarily.  Successful challenges demonstrate the array of possible approaches, from 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, or even simply high-level commitments that create the space for other stakeholders to develop and fund implementation. |

Agency practitioners report that the 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 articulation of a grand vision also justifies why *now* is the moment for action. Other common ingredients—like 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. “Not all Federal agencies use all of those ingredients in pursuing their Grand Challenge goals”, notes Cristin Dorgelo, former Chief of Staff at the Office of Science and Technology Policy (OSTP) and former Vice President of Prize Operations at the XPRIZE Foundation -- either because the goal being pursued didn’t call for it, they haven’t thought of it, or they don’t have enough resources for those activities.[[7]](#footnote-8)

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](http://h) National Nanotechnology [Initiative’s Nanotechnology-inspired Grand Challenge for Future Computing](http://www.nano.gov/grandchallenges), in which the goal for nanotechnology grand challenges was announced via [blog posts](https://obamawhitehouse.archives.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing). A public request for information and follow-on engagement work at industry-specific convenings spurred active discussion on what it would take to pursue such a goal, leading to the development of a [white paper](https://www.nano.gov/sites/default/files/pub_resource/federal-vision-for-nanotech-inspired-future-computing-grand-challenge.pdf) and statements of support from various agencies and organizations.) At the mid-point of the spectrum, Dorgelo points to efforts like the [DARPA Grand Challenges](http://archive.darpa.mil/grandchallenge/)—including its most recent [Cyber Grand Challenge](https://www.cybergrandchallenge.com/)—which have a grand challenge goal but primarily rely on an incentive prize model, with additional funding opportunities and community convening.[[8]](#footnote-9) 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 [SunShot](https://energy.gov/eere/sunshot/sunshot-initiative) and [EV Everywhere Grand Challenges](http://energy.gov/eere/vehicles/downloads/ev-everywhere-grand-challenge-blueprint), 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.

## Implementation Guidelines – detailed explanation of “how”

Grand Challenges can be implemented through three broad phases:

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### Problem Definition

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.[[9]](#footnote-10)

Cristin Dorgelo emphasizes that problem definition is such a key component of instituting a Grand Challenge that agencies need to consider 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. Then what? “What happens next is essentially a program development effort where, based on that goal, the program managers need to work backwards to figure out ‘What resources do we already have or could we develop that would help us pursue the goal? What partners and stakeholders do we need to bring around our planning table?’”[[10]](#footnote-11)

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| **Insights on the Problem Definition Process by Cristen Dorgelo** |
| 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.  There are probably some very talented, very bright scientists and engineers who could and have defined that goal by themselves alone in a room. But most program managers who are wrestling with a thorny problem such as how to get solar adoption across the United States or how to make electric vehicles as cost-effective as gas powered vehicles, struggle—like all of us do—with problem definition. 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 the Department of Energy 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. So even though they had a theory of the case about how you would get an electric vehicle that was as affordable and cost-effective and convenient to own as gas powered vehicle, they didn’t publish that immediately. 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. You could be looking at effectiveness 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: Interview with Cristin Dorgelo, August 3, 2016. |

### Design

Some design elements for Grand Challenges include:

* Defining measurable targets for success and timing of completion: A Grand Challenge that is too narrowly defined or that presumes some particular technical approach may reduce the opportunity for new and truly effective solutions; to combat this, invest significant planning time in problem definition.
* Setting a timeframe: Typically a 5 to 10 year timeframe, but at most 20 years. The timeframe often falls outside the customary administrative time frame (four-year term). Multi-year engagement is fundamental since time is necessary to build momentum and catalyze self-sustaining “marketplaces” where stakeholders have truly invested.
* Assessing incentive levels if designing prize competitions or grants: Setting a prize level large enough to get people interested and engaged and their balancing with the workforce necessary to manage them.
* Launching a comprehensive engagement strategy to draw in stakeholders, particularly ways to reach stakeholders with which Federal agencies may not have previously engaged.

### Implementation

Dorgelo advises: “Figure out what funding and other resources you have. Figure out your plan for getting the word out and attracting people to help you and to work towards your identified goal. Figure out what relevant authorities your agency has at its disposal for partnering or for funding projects flexibly, and what you can and can’t do based on those authorities. And figure out what the schedule and timeline is going to be for getting people around the table to execute the Grand Challenge Program. Who is going to be around that planning table, what are you going to ask them to do, and what are you allowed to ask them to do?”[[11]](#footnote-12)

Three key steps to implementation:

1. Determining the amount of control a federal agency will have over the Grand Challenge implementation
   * Total commitment from government
   * Engaging matching funds from private sector’
   * Agency announces commitment framework, creating space for others to support it’
   * Agency makes a commitment and sources a prize with external partnerships, but the agency does not fund resulting solutions.
2. Figuring out how appropriated funds can be designated for particular purposes
3. Developing an engagement strategy and timeline, and assessing communications resources (event planning, communications roll-out strategy) with the goal of convening the community
   * Set clear benchmarks for progress.
4. Reviewing who partners are or could be, and evaluating authorities, requirements, and responsibilities for partnerships.
   * Leverage the stakeholder community.
   * Encourage partners and networks to plan follow-on activities around the Challenge, in order to fully capture benefit from the activity generated.

## Lessons Learned

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

* Thoughtful program design to appropriately adapt the framework
* Open-minded approach to goal definition and redefinition
* High-level support and receptivity for new problem-solving approaches
* Right team in place to break down silos
* Advanced planning and alignment within budget cycles

### Thoughtful program design to adapt the framework appropriately for sectoral contexts

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 Cristin 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.”[[12]](#footnote-13)

### Open-minded approach to goal definition and redefinition

Appropriately defining the scope and boundaries of the challenge goal is foundational for success. It’s 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’s 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 is isn’t achievable, or it’s too hard, or the facts on the ground may mean you need to change it.”[[13]](#footnote-14) 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.

### Breaking down silos requires having the right team

Grand Challenges inherently require multi-sectoral collaboration, which also brings organizational challenges. But overcoming 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.

### Advance planning and alignment within budget cycles

A necessary ingredient is a Grand Challenge with budget authority. But 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 a 1-2 year timeframe. 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 needs to 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 Cristin Dorgelo.[[14]](#footnote-15)

## Future Considerations

Still conducting research for this section. Intend to frame this section as a way to frame Grand Challenges in a context relevant to federal employees that are not necessarily department leadership.

Researching the potential for Grand Challenges to be applied in the social policy realm.

Researching the potential to combine Grand Challenges with other innovative strategies like PPPs.

###### Case Studies

Case studies

* DOE: SunShot
* NASA: Asteroid Grand Challenge
* USAID: Grand Challenges for Development
* Grand Challenges Scholars Program

STPI is still conducting a thorough review of the citations and verifying the accuracy of the included case studies.

###### Examples of Supporting Policies

1. [www.challenge.gov/toolkit](https://www.challenge.gov/toolkit/) [↑](#footnote-ref-1)
2. [crowdsourcing-toolkit.sites.usa.gov](https://crowdsourcing-toolkit.sites.usa.gov/) [↑](#footnote-ref-2)
3. [www.gsa.gov/portal/content/103364](https://www.gsa.gov/portal/content/103364) [↑](#footnote-ref-3)
4. D. (2016). Grand Challenges in US science policy attempt policy innovation. International Journal of Foresight and Innovation Policy, 11(1-3), 22-42. [↑](#footnote-ref-5)
5. A. Bonnell, in-person interview, November 14, 2016. [↑](#footnote-ref-6)
6. S. Patel, in-person interview, July 29, 2016. [↑](#footnote-ref-7)
7. C. Dorgelo, in-person interview, August 3, 2016. [↑](#footnote-ref-8)
8. C. Dorgelo, in-person interview, August 3, 2016. [↑](#footnote-ref-9)
9. C. Gerdes, in-person interview, July, 1, 2016. [↑](#footnote-ref-10)
10. C. Dorgelo, in-person interview, August 3, 2016. [↑](#footnote-ref-11)
11. C. Dorgelo, in-person interview, August 3, 2016. [↑](#footnote-ref-12)
12. C. Dorgelo, in-person interview, August 3, 2016. [↑](#footnote-ref-13)
13. C. Dorgelo, in-person interview, August 3, 2016. [↑](#footnote-ref-14)
14. C. Dorgelo, in-person interview, August 3, 2016. [↑](#footnote-ref-15)