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How Would *You* Defend the Planet From Asteroids?

When NASA collaborated with social scientists to engage the public in two-way conversations about the agency's Asteroid Initiative, the outcome surprised everyone.



Participants discuss Asteroid Redirect Mission options at the Arizona Science Center forum. (Photo by Marissa Huth.)

On September 26, 2022, NASA successfully smashed a spacecraft into a tiny asteroid named Dimorphos, altering its orbit. Although it was 6.8 million miles from Earth, the Double Asteroid Redirect Test (DART) was broadcast in real time, turning the impact into a rare pan-planetary moment accessible from smart-phones around the world.

For most people, the DART mission was the first glimmer—outside of the movies—that NASA was seriously exploring how to protect Earth from asteroids. Rightly famous for its technological prowess, NASA is less recognized for its social innovations. But nearly a decade before DART, the agency had launched the Asteroid Grand Challenge. In a pioneering approach to public engagement, the challenge brought citizens together to weigh in on how the taxpayer-funded agency might approach some technical decisions involving asteroids.

The following account of how citizens came to engage with strategies for planetary defense—and the unexpected conclusions they reached—is based on the experiences of NASA employees, members of the Expert and Citizen Assessment of Science and Technology (ECAST) network, and forum participants.

JULY 2013–JANUARY 2014 **A series of fortunate events**

Citizens have long asked to be involved in science and technology policy deliberations, and scientists and science agencies regularly express interest in working with the public on questions of national interest—but there is no designated space for this to happen. When it does occur, serendipity plays an outsized role.

Jason L. Kessler (former program executive, NASA Asteroid Grand Challenge): In 2010, after years of prioritizing the moon as a destination, NASA set the goal of sending astronauts to an asteroid as a steppingstone to Mars. In 2013, NASA released an integrated strategy to support human space exploration and to protect Earth: the Asteroid Initiative. One part of the initiative was the Asteroid Grand Challenge, which “focused on finding all asteroid threats to human populations and knowing what to do about them,” according to the program description. The grand challenge was supposed to accelerate NASA’s efforts to locate potentially hazardous asteroids through nontraditional collaborations. This was revolutionary.

One outcome of all the activity around asteroids was the release of a request for information (RFI) in late June of 2013. Given the technical challenges, NASA’s integrated Mission Directorate team sought to source ideas outside of the agency to prepare and improve the mission design. RFIs are a traditional way to engage externally, but it wasn’t clear that this RFI would reach the type of nontraditional partners the grand challenge was seeking. The RFI had six parts, primarily on technical components—as you’d expect from a science and engineering agency—but the sixth, which the grand challenge team successfully lobbied for, called for “Partnerships and Participatory Engagement.”

Mahmud Farooque (principal coordinator, ECAST):

By 2013, the academics, informal science educators, and policy people who made up ECAST had completed our first demonstration project but we were in a bind. Three years before, we had united to create ECAST with the aim of improving outcomes for science and technology through dialogue with informed citizens, building a framework for engagement in public forums called participatory technology assessment (pTA). Over the subsequent years, we brought universities, science museums, and nonpartisan think tanks together with the public to inform United Nations policy negotiations on biological diversity. But even though decisionmakers welcomed the idea of complementing expert assessment with public participation, we discovered that the combination did not fit easily with agencies’ existing decisionmaking mechanisms.

Fortuitously, two ECAST interns, Carole Mabry and Katie Reeves, undergraduate and graduate students at the University of Georgia and University of Michigan, respectively, had chosen to focus on space policy. On July 8, Carole published a blog post on NASA’s public outreach, which got the attention of some readers at NASA, who then sent us an email mentioning the Asteroid Initiative’s RFI.

Part 6 of the RFI immediately caught our attention. Although the text didn’t specifically call out pTA, it mentioned crowdsourcing and citizen science and the goal of broadening public participation. It also posed questions relevant to ECAST’s policy and programming: *What would make participating in the Asteroid Initiative highly desirable ...? How can we generate momentum with near-term goals? How do you see the Asteroid Initiative contributing to our nation’s future role in space?*

The RFI seemed to have been written with ECAST in mind, but there was one big challenge: we had just three days to put a response together. This was one place where a trait that often worked to our disadvantage—being interdisciplinary and institutionally distributed—turned out to be an asset because the task didn't fall entirely on one set of shoulders.

We reframed NASA's questions to show that a pilot pTA could provide useful answers along with other benefits: "By tasking these citizen forums to write a report for decisionmakers ... new perspectives and public and technical values are brought forward that can help NASA better plan and implement missions." We touted our "highly interdisciplinary" credentials and mentioned that a pilot study would cost under \$200,000.

Jason L. Kessler: The grand challenge team was pleasantly surprised to receive 55 submissions for Part 6—many more than we anticipated and from a refreshingly diverse set of proposers. The ECAST proposal, with its combined academic and citizen science team, hands-on experience, and a proven method for engaging a diverse set of citizens, fit extremely well with initial action plans for the grand challenge—but it could also help with other important mission planning decisions. The relatively affordable proposal helped our team envision a way to engage the public early and get a jumpstart on our mandate. ECAST presented their proposal, alongside other applicants, at a workshop in Houston, Texas.

Given the interest in policy conversations coming out of the workshop, the grand challenge team began exploring how to start working with ECAST as soon as possible. We decided on a cooperative agreement rather than a grant because it ensured the government could influence the design of the work after the award.

APRIL–AUGUST 2014 Planning and pitfalls

Even before the public could be engaged, ECAST's group of interdisciplinary academics and NASA's mission-oriented bureaucracy encountered unexpected turbulence. To navigate rising expectations and keep the project from foundering, the leaders had to work across cultures to establish trust.

Jason L. Kessler: NASA is filled with brilliant problem-solvers and people who spend their time developing requirements and working to execute those requirements. Traditionally, NASA has either had the answers or was responsible for finding them. For many at NASA, the grand challenge's mandate to look outside the agency for answers was completely foreign. We put in effort to explain to our colleagues that we sometimes needed to

step back from developing the answers and instead provide questions.

The grand challenge team believed part of the value in engaging with the ECAST team was their ability to communicate technically complicated material. So we highlighted this when we enrolled people within NASA to participate in the initial planning meetings. The result was that those who showed up at the kickoff meetings were curious, open, and willing to cocreate with the ECAST team.

Mahmud Farooque: As we started this project, ECAST had to change the way we worked while also navigating uncertainty about what NASA wanted. With a grant, we would usually get a year to design a pTA ourselves, figuring out who to engage, what questions to ask, what information to provide, and what outputs to generate for policy and decisionmakers. For this project, we needed to work much faster and more collaboratively, and that required learning to understand our partners.

In May 2014, both teams met at NASA headquarters for two days. By the end, we understood that the grand challenge team wanted to hear from those in the American public who don't engage with other space events, academic conferences, or NASA socials. And they wanted to know what this vast majority of the public thought about options to detect asteroids and prevent them from threatening the planet. Those insights could provide guidance for both the Asteroid Initiative and outreach strategies.

ECAST proposed two day-long deliberations to be held in December 2014, one at the Museum of Science in Boston and one at the Arizona Science Center in Phoenix. Each meeting would target about 100 people, recruited to represent the demographic diversity of the two locations. We chose three themes to explore: (1) Asteroid Detection, (2) Asteroid Mitigation, and (3) Asteroid Mission Governance.

Jason L. Kessler: When the grand challenge team briefed our NASA colleagues about the ECAST plan, there was so much support that leadership requested that we accelerate the timeline. In particular, a part of the Asteroid Initiative called the Asteroid Redirect Mission (ARM) had reached a decision point where the agency had to choose between two strategy options.

The ARM was a response to President Obama's vision of having astronauts visit an asteroid by 2025. It proposed bringing an asteroid into the moon's orbit where astronauts could rendezvous with it. Option A would send a robotic spacecraft to capture a small asteroid about 10 meters in diameter. Option B would send a different kind of spacecraft to an asteroid ten

times as large, where it would use a set of robotic arms to collect a boulder off the asteroid's surface. A and B had much in common, but they were also riddled with uncertainties and complex scientific, technological, and economic tradeoffs.

If ECAST could complete the workshops by November of 2014, then the insights gained from the public deliberations could actually be considered as part of the final decisionmaking process for ARM. No longer speaking in generalities and theories, we could be positioned to inform an actual technical decision. For the grand challenge team, this was a dream come true; proof that our efforts to convince colleagues of the value of nontraditional engagement had succeeded and that public insights were welcomed as potential input for an important technical decision.

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Mahmud Farooque: For ECAST, the request to move up the forum date was exciting and unsettling. Exciting because here was a rare opportunity to incorporate public values into the process of making an actual, consequential agency decision. Unsettling because we had no experience doing content development, participant recruitment, forum hosting, and the rest in such a short time! After some frantic emailing between the teams, we decided to move up the forum dates and finish analysis of responses to the ARM options by the end of November. Further results could come later.

But then we hit a new snag. ECAST's social scientists had started by framing broad, context-setting questions about the Asteroid Initiative with the aim of using them to develop actual deliberation questions, which we intended to finalize in a meeting between the teams later in the summer. However, when the grand challenge team shared our framing questions with NASA program leads, they interpreted them as provocative questions about the mission overall—causing some unanticipated and potentially deal-breaking tensions.

Jason L. Kessler: I had to quickly explain to my colleagues that the social scientists were just asking questions. Unless you have someone with a foot in both camps to translate what's happening within each organization, small misunderstandings like this can derail a collaboration. Also, during the summer of 2014, ARM was controversial: the science community was divided about its merits, and there were tensions over the budget. The grand challenge team was committed to use ECAST not to try to “sell” ARM to the public, but to engage citizens about technical considerations for the overall initiative.

However, just as we were preparing to meet in Boston in August, the space press reported on concerns raised about ARM at a scientific meeting. The broader NASA team became worried that the ECAST engagement could exacerbate negative feelings toward the mission. Our team arrived in Boston minus a few NASA experts, but we were still determined to focus on the “how” of capturing an asteroid rather than on the “why” or “what.”

Mahmud Farooque: Somewhat oblivious to the tension, but generally aware of expert skepticism around public deliberation, ECAST wanted our NASA colleagues to experience a pTA session firsthand. ECAST forum deliberations are immersive and engaging in ways that most public discussions are not. They also make great icebreakers.

So we held a simulated forum that focused on conserving Boston's historical sites from the threat of rising sea levels. After a quick overview of projected impacts from climate change, forum participants deliberated benefits and tradeoffs of three mitigation options for protecting the Old North Church in Boston.

Jason L. Kessler: This was the perfect way to begin. It was hands-on, lowered tensions, and provided a tangible example of what was possible. NASA subject-matter experts could envision how their expertise could be organized to engage the lay public.

Mahmud Farooque: By the afternoon, when we presented a mockup of a proposed deliberation session on asteroid detection, the NASA experts were eager to jump in. The discussion was refreshingly generative and useful. The NASA team, coming from different parts of the agency, began to bounce ideas off one another. This back-and-forth gave us clarity about what the agencywide initiative needed.

By the day's end, we were no longer talking about what we needed to take off the table, but what else we could add. Out of our separate anxieties, we had realized that we could work together productively toward the same objective.

NOVEMBER 2014

A surprising “electric buzz”

The forums revealed a deep and unrecognized public interest in protecting the planet from asteroids. Unexpectedly, the meeting between citizens and experts also had a powerful emotional charge.

Mahmud Farooque: The ECAST and NASA teams worked furiously to meet deadlines for the first forum in Arizona and the second in Boston. We planned to start each with a live planetarium show on asteroids, followed by four discussion sessions on detecting asteroids, mitigating planetary threats, evaluating asteroid retrieval options, and creating pathways for the journey to Mars. Each session started with specially produced ten-minute educational videos. In addition, we created interactive game boards, information briefs, and a training program for moderators. We planned the logistics of the day meticulously, from parking to lunches, as we recruited a representatively diverse mini-public.

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We usually generate a large pool of applicants, expecting that at least 20% won’t turn up. We used a flat \$100 stipend to incentivize participation, particularly for lower-income participants, and we also took care to minimize participants who were somehow affiliated with space or NASA via professional, advocacy, or social networks. We ended up with 113 confirmed participants for Phoenix and 106 for Boston, and planned for a maximum of 80 in each city.

That produced the first surprise of the day: on the first morning of the event at the Arizona Science Center, 98 people showed up. We called for more lunches and were happy to learn that the caterer was still loading the van. Attendance in Boston was similarly high, reflecting the fact that the public was genuinely interested in this topic. A second happy surprise was that this enthusiasm came from the general public we had sought to reach—not just space fans.

David Gamez (participant in the Phoenix forum): They gave us a welcome inside of the Dorrance Planetarium. They had the mood lighting and some music from the

movie *Armageddon*. Then they started talking about space, technology, and science intersecting. There was a movie that came out at the time, *Interstellar*, so it was really good timing. The buzz was electric.

After we left the science center, we moved to the downtown Phoenix campus.... We sat at tables of eight people with a facilitator and a recorder. We watched videos and discussed details, and then we had a scenario where there was an asteroid coming to Earth. We didn’t have a lot of time, and this asteroid was projected to cause trillions of dollars of damage and hundreds of thousands or millions lost in human life. And everyone at the table was saying, OK, we need to nuke this thing. We’re gonna go *Armageddon*-style. I had some hesitation with that because of the nuclear fallout since it was so close to Earth—I just wasn’t sure if that would be the best route possible. And everyone was trying to give their two cents on trying to figure out, like, “OK, is nuclear fallout really the problem?” Like, is that really going to stop you in the face of losing hundreds of millions of lives? And then later on, I came to the point of saying, “Well, OK, then maybe we should just nuke this rock in space.” And other people were saying, “Oh, you’re starting to finally come around.” And it was some playful banter, but some really thought-provoking banter as well.

Mahmud Farooque: The session devoted to asteroid mitigation required participants to discuss how to assess the threat posed by an incoming asteroid, and then consider the costs and uncertainties of different mitigation strategies. The teams pondered details ranging from the time available to the scale of the possible impact. As the back and forth in David’s group shows, the participants not only embraced the complexity of the choices and constraints given, they debated their preferred options with each other quite comfortably and provided a robust defense for their final choice. Surprisingly, the majority of the groups, like David’s, overcame some reluctance to settle on possible nuclear detonations. However, as David describes, the decision was clearly tortured, suggesting that the public could be interested in developing alternative technological responses to incoming asteroids. The conversations also suggested how such issues might be communicated with the public.

Sue Hakala (participant in the Phoenix forum): I represent the older woman demographic. I’ve been invited to a number of focus groups, but this one was particularly memorable. And I thought of it again when I heard about the DART mission. One thing that made this session special was that we had a representative from NASA there, and I chit-chatted with him during the coffee break.

There were probably six to eight tables of people deliberating. At the end of a session someone from our table stood up and gave the summary of our results, and all of

the tables said the same thing! When it came to something as critical as a meteorite zooming to Earth that can kill us all, it was really important not to put this in the hands of a private company. Why? Because they would turn to the Earth and say just, “Well, how much is it worth to you?” And it was interesting that every single group said the exact same thing—which was that we wanted NASA to do the job.

Mahmud Farooque: This agreement on NASA’s role in planetary defense was one of the biggest surprises of the forums. Back in 2014, it wasn’t clear who would lead planetary defense—within NASA, many felt that the agency’s role should be confined to supporting astronomers as they observed potential threats. We probed public opinion on this in two separate ways, giving options that included an international partnership led by NASA, private industry, the international scientific community, and other variations. The first time the question was asked, the focus was on cost, and participants overwhelmingly felt a US-led international partnership would be fairest—splitting the burden. However, when the question was asked again, indirectly, after participants had been discussing impact scenarios, support shifted toward the NASA-led international consortium and away from private industry or any of the other options. What was surprising was that participants had a sophisticated grasp of the complexity of planetary defense: they mentioned twice as many plausible governance challenges as had been provided in the background material.

Lindley Johnson (planetary defense officer, NASA): I think it was one of the first times that we directly saw the opinion of the public about planetary defense—and how important they thought it was for NASA to be doing it. It was one of the first times we had seen that public reaction. Asteroids had certainly always been talked about in Hollywood movies and that kind of thing. But to actually interface with the public and talk about this subject and see their support and how important they thought it was [was illuminating]. And they were disappointed that NASA wasn’t already doing a lot in this area. I think that’s the only time in my 40 years of government service that I’ve ever talked directly with the public.

Jason L. Kessler: When the Asteroid Grand Challenge first made the argument for nontraditional engagements to help accelerate the hunt for hazardous asteroids, we didn’t really know what would come out of it. It sounded nice, but how it would actually manifest was wildly unknown. After the first forum in Arizona, and even more so after the second in Boston, it was clear the results could exceed even our most optimistic expectations. In my closing remarks that day I described what happened in the room as “magic,” and I still think that captured the mood. My only regret is that more of my NASA colleagues weren’t there to see it.

We were no longer talking about what we needed to take off the table, but what else we could add. Out of our separate anxieties, we had realized that we could work together productively.

The NASA subject-matter experts who attended found it to be an exciting and valuable day because they got to hear taxpayers’ thoughts on how NASA should spend its budget. I felt we’d accomplished a lot. Not only had we captured priorities and insight from a representative lay public, but we had also proven to the extended NASA team the value and benefit of this type of engagement.

DECEMBER 2014

Data-digging for decisionmaking

To make the results of the forums useful for decisionmaking, the researchers had to go beyond providing simple statistics by delving into participants’ motivations for a qualitative picture of how the public perceives tradeoffs.

Mahmud Farooque: As soon as the forums were done, we had to find out what NASA really needed to know to help with decisionmaking on ARM. The data were clear: the public in both forums showed a strong preference for option B, which involved retrieving a boulder from the surface of a big asteroid, over option A, which was to capture a very small asteroid. Overall, they favored option B by 3 to 1 over A.

But we needed to provide more than that—we needed to give the public’s rationale. So we went back to the notes from individual tables to reconstruct participants’ thought processes, the knowledge they used, and how they arrived at their decisions. This led us toward a more qualitative presentation of the results, which NASA subject-matter experts found more persuasive and useful. Essentially, forum participants saw option B as having more benefits, particularly because it could be used to improve our understanding of technologies that could be later used for planetary defense.

Jason L. Kessler: Having accelerated the project’s timeline, the grand challenge team was glad to have raw results available in December 2014 to present to NASA leadership before they made the critical decision about ARM. It was understood by the grand challenge team that the data from the public forums were not a part of the final decision criteria. However, NASA leadership did seek a summary of the initial findings as additional information for consideration.

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Lindley Johnson: Maybe it's a little biased on my part, but I felt that we were already pretty well in tune with what the public would think. I mean, who wouldn't want to be for saving Earth from an asteroid, right? We were asking them to choose between two approaches—A involved using a robotic spacecraft to capture a small asteroid, but B had more benefits from the standpoint of planetary defense. I was pretty much expecting them to take what we felt was the most logical approach and action, which was B.

Prior to the meeting, NASA was struggling with which approach to take. And although I won't say it was the deciding factor, it was definitely maybe what pushed it over the threshold that there was more public support for that option B approach.

And, in general, I think the public is pretty logical about how they go about things. There are certainly exceptions when you talk to individuals. But as a whole, the majority follows pretty much what makes sense.

DECEMBER 2022

The long arc

The Asteroid Initiative was cancelled in 2017. As we went back through our notes from 2013 and 2014 to write this article, we reflected on how the pTA project became possible, why it hasn't been replicated since, and what it would take to regularly involve citizens in science and technology decisionmaking.

Jason L. Kessler: Eight years after the forums, technology and subject-matter experts at NASA still have an appreciation for the value of engaging citizens. I've heard about the forums from people within the agency as well as others who've moved on. So there's recognition about the value it brings to us; what's missing is the interstitial tissue that enables it to happen.

Normally, communication with the public would fall to a communications team, which is mostly involved in transmitting information. To have two-way communication on technical matters requires someone to own that engagement process. In our case, that was the ECAST team. Then, on the science and technology side, the experts need to have a willingness to engage with nonexperts and believe that there will be value added from that engagement. Crucially, there needs to be a champion or broker who creates a vision of the possibilities from this type of exchange and who can absorb some of the risk for an organization that is stepping outside its comfort zones.

Mahmud Farooque: For ECAST, finding this sweet spot between championing, brokering, and codesigning a participatory engagement process and informing decisions about science and technology has proven elusive. Other federal agencies that do science have followed NASA's example and supported pTA activities at much larger scale, but they have not used it to inform programmatic or administrative decisions.

For members of ECAST, this has raised an existential question about the possible value of institutionalization. Should we stay loosely affiliated and keep pushing disciplinary and organizational boundaries from the outside while searching for open policy windows to become involved in decisionmaking? Or should we try to organize formally or work to become part of a mandated or sanctioned participatory decisionmaking capacity inside of agencies?

Jason L. Kessler: As exciting as the experience of two-way decisionmaking was, and as meaningful as the results were, there were no more pTAs. What made this possible was that the Asteroid Grand Challenge had a budget, support from the highest levels within NASA, and a mandate to support nontraditional collaboration. I had a role to pursue this type of thing and a willingness to take the risks associated with this nascent type of engagement on behalf of my technical counterparts within my agency and the lay public outside. To discover and develop the utility of shared decisionmaking, I believe leaders of technical organizations should support an office or team with the capacity and resources to champion more such engagements over the long term.

Mahmud Farooque has been shepherding the ECAST network since its inception and serves as the associate director of Arizona State University's Consortium for Science, Policy & Outcomes. Jason L. Kessler is an author, executive coach, entrepreneur, and currently serves as NASA's program executive for the Small Business Innovation Research and Small Business Technology Transfer programs. As a consultant, he combined strategy, design, and facilitation to create learning experiences to enable better outcomes in environmental and climate change programming for clients in the developing world.