Citizen Deliberations about Planetary Defense:

# A PARTICIPATORY TECHNOLOGY ASSESSMENT of NASA's Asteroid Initiative

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## ECAST partnership with NASA

We present a case study of a participatory engagement effort being used to support decision making about planetary defense. Through the Asteroid Grand Challenge, the National Aeronautics and Space Administration (NASA) partnered with the Expert and Citizen Assessment of Science and Technology (ECAST) network, to examine NASA's Asteroid Initiative. This partnership implemented a participatory technology assessment (PTA) that utilized structured deliberations on NASA's challenges for the Initiative. The goal was to provide NASA with structured public input prior to making decisions. Having this background information may better enable NASA to implement a solution in keeping with what society wants. Formally titled "Informing NASA's Asteroid Initiative: A Citizens' Forum," two PTA forums were held in November 2014, one in Phoenix and one in Boston. Deliberation themes included asteroid detection, planetary defense, the planned Asteroid Redirect Mission (ARM), and the broader Journey to Mars for human exploration.

**What is Participatory Technology Assessment (PTA)?** The basis for PTA is to provide an opportunity for people to learn about a given topic and then to debate on it. PTA in its different variants seeks to empower the public to consider decisions that some might otherwise think are too technical for a lay public. The broad focus of PTA is about assessing values and helping to inform decisions. *Sclove 2010 overviews the literature justifying participatory methods as well as past PTA exercises which have been done commonly in Europe.

## Planetary Defense Deliberation

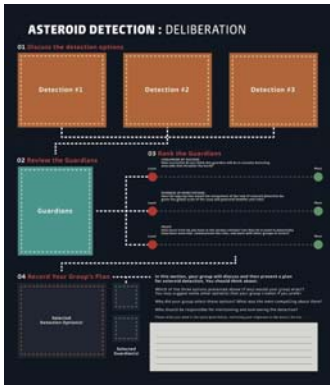
**NASA's Asteroid Initiative focus on planetary defense as a key goal. In collaboration with NASA, ECAST developed focused questions about planetary defense. Questions focused on:**

**1) Public's desire for new asteroid detection capabilities**
**2) Perceptions of trust about different actors who may be involved in planetary defense**
**3) Perceptions of the what planetary defense techniques should be used under different scenarios of potential impact.**

**Ability to see public's responses to different scenarios, perceptions of cost and value of different options were key goals for NASA.**

## ECAST led discussions in nonbiased way

ECAST's museum and academic partners facilitated and led content development. Limited text-based Q&A with NASA experts was allowed, however NASA was not allowed to speak to citizens or influence discussion. Participants were broken into table groups of 6-8 people, and had to provide group answers to questions as well as record individual responses.




**Background material and access to experts**
Citizens were given background text and videos describing the technical elements at hand. ECAST, with input from NASA, developed the background material. ECAST provided facilitators at each table that had some understanding of the technical issues and also presented an overview planetarium presentation.

## Participants

ECAST requested nominations for participants, and led the selection process to yield a diverse group of citizens. From the applicants, ECAST selected participants to attain significant diversity in the economic and cultural backgrounds of the attendees. In Phoenix, 286 people applied, 113 being selected, and 96 participating; there were over 30% Hispanic participants, and about 40% of attendees had a college degree. In Boston, 180 people applied, 106 were selected, and 87 participated; over 75% had a college degree. There was roughly equal balance between men and women and there was economic diversity as well. Less than 8% of participants had experience with NASA Socials or were connected to NASA through their work.

## Mitigation Tools Presented

**Participants were asked to consider 4 primary asteroid mitigation options and tradeoffs:**

- **Civil defense**
- **Slow-push orbit change (i.e., gravity tractor)**
- **Kinetic impactors**
- **Nuclear detonation or other blast deflection**

**Participants then discussed two potential impact scenarios (1 and 2), with hypothetical changes, to select their preferred mitigation method, and preferred planetary defense guardian, based on that scenario.**
**The participants were asked whether their technology selections, and guardian preferences, changed based on the different scenarios.**

## Tracing Attitudes Across Likelihoods

This is an example of an individual's response to different probability…
Scenario 1: 4-year scenario: A midrange NEO is detected and is estimated to be about 4 years from impacting earth. The estimated size means that the range of impacts could vary between potentially destructive airbursts to regional scale disasters, but would probably not produce globally devastating effects.
Object diameter: 25-100 meters Probability of impact: 75% Scale of impact: Regional
*Response: If the target is known, where asteroid will impact, civil defense is ideal since it eliminates the use of nuclear weapons. Additionally, kinetic impactors might be unsuccessful. Civil defense is the most important choice to try kinetic impactors to protect natural resources, structures, animals, and developed cities.*

Hypothetical 1: Imagine the probability of the asteroid impacting the Earth were estimated to be 25%, rather than 75% as described previously. Would this change your recommended mitigation strategy?
*Response: No, you still have the uncertainty factor. If 4 years is known to be the impact time civil defense and kinetic impactors still appear as the most reasonable choice.*

Hypothetical 2: Imagine that two years after the original detection, scientists make an announcement that they predict that the asteroid will hit the Western hemisphere and there is a high probability of it impacting near North America. Would this change your recommended mitigation strategy?
*Response: This changes my strategy. A high probability to hit North America means that high populations will be exposed to potential danger and civil defense is out of the question. Kinetic impactors would be the most reasonable approach. It would require too many resources to move populations.*

Hypothetical 3: Imagine that the asteroid were somewhere between 500 meters and 1 kilometer in diameter, rather than 25 to 100 meters as described previously. An impact from an asteroid this size could range between disastrous continental-scale effects to a potential global catastrophe. Would this change your recommended mitigation strategy?
*Response: Although the size of the asteroid has changed, my suggestion is bigger and multiple kinetic impactors. If multiple impactors don't work, what justifies that nuclear impactors will causan an effect? Perhaps we need more explanation on nuclear weapons use in this scenario as I am still very confused about the use of nuclear weapons and their effectiveness.*

| SCENARIO | NO ACTION | CIVIL DEFENSE | GRAVITY TRACTOR (DERIVED FROM "OTHER") | KINETIC IMPACTOR | NUCLEAR WEAPONS | OTHER (NOT GRAVITY TRACTOR) |
|---|---|---|---|---|---|---|
| **SCENARIO 1** • 4 year 25-100 meter diameter 75% impact | 3.8 | 75.5 | NA | 66.8 | 56.8 | 10.4 |
| • 4 year 25-100 meter diameter 25% impact | 6.0 | 72.3 | NA | 62.0 | 41.0 | 10.9 |
| • 4 year 25-100 meter diameter 75% north american impact | 1.1 | 77.0 | NA | 62.5 | 65.0 | 5.5 |
| • 4 year 500-1000 meter diameter asteroid 75% impact | 4.9 | 60.6 | NA | 41.8 | 85.8 | 9.3 |
| **SCENARIO 2A** • 20 year 50% impact – continental scale | 2.2 | 43.3 | 47.8 | 60.0 | 73.3 | 18.8 |
| **SCENARIO 2A-1** • 20 year 10 % impact – continental scale | 21.1 | 44.4 | 43.3 | 48.9 | 41.1 | 13.3 |
| **SCENARIO 2A-2** • 20 year 50% north American impact – continental scale | 1.1 | 46.7 | 35.6 | 58.9 | 75.6 | 12.2 |
| **SCENARIO 2B** • 20 year 10% impact – planet killer | 6.4 | 40.4 | 25.5 | 47.8 | 70.2 | 18.1 |
| **SCENARIO 2B-1** • 20 year 50% impact – planet killer | 6.4 | 42.6 | 18.1 | 43.6 | 74.5 | 19.1 |
| **SCENARIO 2B-2** •50-100 year 10% impact – planet killer | 14.9 | 24.5 | 40.4 | 42.6 | 39.4 | 25.2 |

Percentages are not cumulative: participants could choose multiple options (unless they chose no option)

## Mitigation Option Results

- **Timescale of the scenario was an important factor for participants.**
- **There was awareness of the global effect of any large-scale impact, no matter the location.**
- **Kinetic impactor preference did not vary significantly and was perceived as a desirable mitigation approach.**
- **Preference for the use of nuclear weapons was based on the severity of the threat and was reluctantly offered.**

## Perceptions of Trust

**Assessing Trust through "Guardians"**

- The below list of "guardians" were provided to the citizens to serve as proxies for different actors that can play a role in planetary defense.
- Participants were asked to state which of these actors they would want to play a role in planetary defense under a variety of hypothetical scenarios.
- In general, a preference for international partnerships was shown. Preferential variations emerged with different scenarios.
- Once the threat became greater, a willingness to trust private industry or academia was reduced in favor of government coalitions.


## Qualitative Analysis

**NASA's Findings**

- Preference for a space-based detection option was very strong.
- Participatory Technology Assessment, in addition to other citizen engagement techniques, successfully provided perspectives to inform decisionmaking.

**Relevance to PD Conference:**

- Strong participant support for international cooperation implies that integrative solutions may be the strongest approach.
- Language and discussion approaches used by participants may give insight into how public perceives threats

## Forward Work

ECAST is developing a report that will be released in the May timeframe. NASA hopes to do additional analysis of the deliberations and to share insights from the data.

Acknowledgements and References: We thank the citizens at the 2014 ECAST forums who spent a Saturday to give NASA structured input on how to protect the planet and the rest of the Asteroid Initiative.
*Sclove, Richard. (2010). Reinventing Technology Assessment: a 21st Century Model. Published by the Science Technology Innovation Program of the Woodrow Wilson Center for International Scholars. Available at: [http://www.loka.org/documents/reinventingtechnologyassessment1.pdf]