



Contents lists available at ScienceDirect

Space Policy

journal homepage: www.elsevier.com/locate/spacepol

Participatory technology assessment for Mars mission planning: Public values and rationales[☆]

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A B S T R A C T

Public support and interest are needed to design an ambitious human spaceflight program. However, it is difficult to understand what the public values and would support. And it is even more challenging and rare to consider public views prior to actually developing a mission. Participatory technology assessment (pTA) is a method that aims to understand public preferences and values in order to inform upstream government decision-making. We assess a recently completed experiment in pTA, the “Informing NASA’s Asteroid Initiative” project. Through a cooperative agreement with NASA, the Expert and Citizen Assessment of Science and Technology (ECAST) network conducted a pTA-based forum on NASA’s Asteroid Initiative and the Journey to Mars. ECAST organized two citizen forums in Phoenix, Arizona and Boston, Massachusetts in November 2014, with a total of 183 citizens selected so as to minimize self-selection biases. This paper focuses on the “Journey to Mars” session, which had the primary goal of soliciting citizen perceptions about different Mars exploration scenarios and mission planning approaches. Citizens were given background information about three potential Mars exploration scenarios that NASA could carry out: 1) Crewed orbital mission to direct robots on the surface of Mars; 2) Short exploratory crewed mission to the surface of Mars; and 3) establishing a permanent settlement. Citizens then engaged in structured facilitated discussions about their preferences among the scenarios and NASA’s mission planning approach. Using a grounded theory coding approach, we analyzed participants’ written rationales and dialogue about Mars exploration. In general, participants did not show a strong preference for any particular mission profile, but there was a slight preference for the crewed orbital robotics scenario. Participants who supported this approach saw it as the quickest, safest, and least costly road to a successful mission. However, many participants were interested in seeing “boots on the ground,” as they believed this would propel scientific advancement, increase excitement about space exploration, and make humans a “two-planet species.”

1. Introduction

We focus here on an experiment with participatory technology assessment (pTA), “Informing NASA’s Asteroid Initiative,” to solicit public input about mission planning for Mars. NASA has focused on The Journey to Mars as its horizon goal for human exploration efforts, which recently the U.S. Congress gave a political push by authorizing a \$19.5 billion bill that emphasizes putting humans on Mars by the 2030s [1]. Mars is an attractive destination because it’s one of the most probable bodies of our solar system to host life and the closest candidate for human extraterrestrial settlement. Mars is also a destination that has historically catalysed public inspiration around space exploration. Understanding Mars also helps provide scientific knowledge

on the origin of the solar system, of possible life on other planets, as well as about the future evolution of Earth itself [2,3]. Despite the potential upsides, there are many technical and social challenges associated with exploring Mars. Issues centered on risk, cost and schedule are multifaceted, involving considerations about long transit timeframes, astronaut radiation exposure, surviving harsh surface conditions, supply and fuel problems, among other issues [4]. On the social side, the reasons for going to Mars are open-ended and layered with numerous political and ethical implications [5–7]. All of these issues are of public concern.

Historically, NASA has considered the public a significant stakeholder in space exploration [8], but generally there is very little detailed information on public values and concerns about space

[☆] All opinions are those of the authors and do not necessarily reflect the views of NASA or the United States Government.

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<http://dx.doi.org/10.1016/j.spacepol.2017.08.004>

Received 6 July 2017; Accepted 16 August 2017

0265-9646/ Published by Elsevier Ltd.

exploration beyond general surveys gauging public support (see Ref. [9] for an exception). According to several polls over the past several decades, support for going to Mars has varied from 40% to 75% of the U.S. population [10–12]. One of the most recent polls, the 2103 *Mars Generation National Opinion Poll*, showed 75% of Americans agreeing that NASA should pursue a human mission to Mars [12]. Beyond knowing that the public is interested in going to Mars, there is very little nuanced information on what the public actually desires out of human missions to Mars. Several academic studies provide thoughtful theoretical projections on how various stakeholders might envision the exploration and settlement of Mars [i.e., [13–17]], but these studies are from the perspective of scientists and bureaucratic elites. Most public opinion thus far has been gathered through polls, which do not help us understand what an informed public might think [18,19]. Another problem with opinion polls is that they generally only investigate meta-level policy issues (e.g., should NASA get more funding?), but don't allow for people to weigh in on programmatic level initiatives such as mission planning for Mars, precisely because it takes an informed citizenry to make relevant input on such topics [20]. Calls for increased public engagement abound [21–23], but very few call for the type of engagement that invokes meaningful public dialogue that could lead to effective policy input. Given that the public is an important stakeholder in Mars exploration and generally have not had much opportunity to weigh in on programmatic level decisions, there is a need for informed public deliberation around complex socio-technical issues such as Mars exploration [11,21,24].

Participatory technology assessment (pTA) is one possible method for soliciting informed public input on programmatic level initiatives. In this article, we analyze and contextualize results of a public deliberation (pTA) designed to gather people's perceptions of and preferences for the technical (technological approaches and risks) and social (value, cost, and schedule) tradeoffs of potential NASA mission planning approaches and three different Mars exploration scenarios. The Expert and Citizen Assessment of Science and Technology (ECAST) network implemented the pTA based on a cooperative agreement with NASA [25,26]. Participatory technology assessments (pTA) are specifically designed to engage a group of laypeople in the process of science and technology decision-making [27–30]. pTA deepens the social and ethical analysis of technology, complementing expert-analytic and stakeholder-advised approaches to TA [31]. Quite different from a poll or survey, forums like the one developed for this project explore the informed views and values that citizens use in assessing socio-technical issues through a structured, deliberative process [32]. In general, pTA exercises embody several public engagement benefits not found in traditional polls and surveys:

- 1) anticipate ethical concerns and social values that drive societal needs [28];
- 2) solicit broader technical and social knowledge overlooked by experts [31];
- 3) generate public excitement about emerging technologies [2,33–35];
- 4) build public trust and a sense of ownership in the governance of new technologies [29,36];
- 5) create a citizenry with the capacity to engage complex technical subjects [28]; and
- 6) perform technology assessments at a reduced cost and schedule, allowing assessments to more quickly keep up with the pace of technological advancements [25].

Overall, pTA presents an informed and empowering environment for a previously unengaged public to offer new views and consider the potential benefits, tradeoffs, and long-term consequences of proposed policies or research directions. Many pTA initiatives have been successfully implemented all over the world across several topic areas, including nanotechnologies [23,37], genetically modified organisms [38–40], climate change and energy [33], nuclear waste management

[41], among other topics. In some cases, pTA has had a real impact on political choices: the GMO consensus conferences in the EU may explain why green technologies in Europe moved more cautiously than in the U.S [31]. Until the implementation of the “Informing NASA's Asteroid Initiative” project in November 2014, no pTAs have focused on space technologies. Therefore it is important to understand the views of lay citizens that emerged from this deliberation. The implementation of pTA within the space policy realm can provide new types of insight that differ from past space agencies' engagement efforts or public surveys. As such, three basic research questions drive our analysis of the Mars deliberation. 1) How does the public view the challenges associated with going to Mars? 2) What social and technical aspects of Mars exploration do citizens gravitate to? 3) What core rationales for Mars exploration do they consider when presented with cost, schedule, and risk trade-offs between different Mars mission scenarios and planning approaches?

2. Methods

2.1. pTA forum design

In 2013, NASA released a request for information (RFI) about how to engage the public in the agency's Asteroid Initiative. NASA wanted to know about public perceptions of its Asteroid Initiative and learn more about what citizen's value with regard to space exploration. The ECAST network, which is composed of a consortium of universities, science museums and nonpartisan policy and science groups, submitted an RFI response that was very highly rated inside NASA. In May 2014, NASA awarded ECAST a cooperative agreement to conduct a pTA deliberation to solicit citizen perspectives about the Asteroid Initiative and space exploration. ECAST implemented the pTA through a pair of 1-day citizen forums. NASA and ECAST worked together to develop forum content (e.g., topics and questions) and participant background information. The one-day, in-person forums were held in Phoenix and Boston on November 8 and 15, 2014 respectively. The pTA forums sought to collect quantitative data that could be aggregated and statistically analyzed along with qualitative data to identify the diversity of priorities and social values underlying citizens' technical and policy preferences [25,26]. During the forum, participants explored several themes: asteroid detection, asteroid mitigation, the Asteroid Redirect Mission (ARM), and the Journey to Mars. This paper focuses on the results from the Journey to Mars discussion.

2.2. Participants

ECAST organized the forums, including the participant selection process. Ninety-seven citizens attended the forum in Phoenix and eighty-six attended in Boston. Attendees represented broad demographic diversity, covering a range of ages, economic backgrounds, ethnicities, and educational backgrounds (Table 1). Forum participants were selected to make the participant pool as ‘neutral’ as possible, minimizing the participation of traditional NASA stakeholders. The sample used for the qualitative analysis of group discussions (wherein groups were randomly sampled) is a good representation of the general participant population and the broader demographics of Arizona and Massachusetts with only a few exceptions (Table 1). Nonetheless, the participant pool was sufficiently diverse to fulfill the goal of soliciting input from a variety of public perspectives.

2.3. Mars deliberation background and research questions

Prior to the forum, attendees received written background information, which was also reiterated through video presentations during the forum. NASA and ECAST worked together to develop background briefing materials for participants, with ECAST assuming responsibility for the final content. ECAST had expertise in informal science communication and endeavored to make the NASA content and

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