frontiers | Frontiers in Astronomy and Space Sciences

TYPE Perspective
PUBLISHED 06 April 2023
DOI 10.3389/fspas.2023.1162107

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to
Space Physics,
a section of the journal
Frontiers in Astronomy and Space
Sciences

RECEIVED 09 February 2023
ACCEPTED 23 March 2023
PUBLISHED 06 April 2023

CITATION
Curry SM (2023), MAVEN mission
perspectives and approaches
to inclusion.
Front. Astron. Space Sci. 10:1162107.
doi: 10.3389/fspas.2023.1162107

MAVEN mission perspectives and approaches to inclusion

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The Mars Atmosphere and Volatile Evolution mission (MAVEN) is a NASA spacecraft that has been orbiting Mars since 2014. The Mars Atmosphere and Volatile Evolution mission team has established a current set of best practices to strengthen Diversity, Equity, Inclusion, and Accessibility (DEIA) initiatives; there are numerous axes of diversity, and this paper does not focus on one specific aspect of diversity but rather focuses on mission-specific approaches to inclusion. We present the past and present approaches as well as future initiatives and areas of improvement to continuing our efforts towards maximizing inclusion and engagement on the Mars Atmosphere and Volatile Evolution mission team and its working environment. The approaches presented in this paper are applicable to the space physics and planetary science communities, as well as any large-scale science or mission teams.

KEYWORDS

diversity, early career, Mars, mission, inclusion

Introduction and timeline

The Mars Atmosphere and Volatile Evolution mission (MAVEN) is a NASA satellite that was launched on 18 November 2013, and entered orbit around Mars on 21 September 2014. The mission's primary goal is to explore the planet's upper atmosphere, ionosphere, and interactions with the Sun and solar wind to provide insight into the history of Mars' atmosphere and climate, liquid water, and planetary habitability.

The MAVEN proposal was submitted to the Mars Scout Program in 2006 by the original mission Principal Investigator (PI), Dr. Bruce Jakosky (University of Colorado, Boulder), and was down-selected for flight development in 2008. PI Jakosky led the MAVEN mission until 2021 when he recommended Dr. Shannon Curry (University of California, Berkeley) to succeed him as MAVEN PI.

The following perspectives will focus on 1) our practices to maximize inclusion on the MAVEN team and 2) recommendations and areas of growth. The perspectives will focus on recent actions under PI Curry, who assumed leadership during Phase E (primarily the science phase), as well as past actions under PI Jakosky. It should be noted NASA prohibits soliciting demographic information from the MAVEN team regardless of whether it is volunteered, so team demographic data is not available at any point during the mission. However, peer reviewed literature on more general demographics within the fields of planetary science and space physics is available and included in the discussion below.

TABLE 1 MAVEN approaches for inclusion.

Approaches	Actions
MAVEN Early Career (EC) Visibility and Opportunities	Appoint ECs as session leads at science meetings
	Appoint ECs as Deputy Leads for all Instruments
	Provide Research Experiences for Undergraduates (REUs)
	Promote Dedicated Early Career Group
MAVEN Management and Leadership	Represent diversity in Senior Leadership
	Represent diversity in Science Advisory Board
MAVEN Mission Tone and Culture	State culture expectations in Rules of the Road
	Provide presentations on mental health and diversity at science team meetings
	State culture expectations in verbal Code of Conduct
Communication and Accessibility	Use uniform gradient of brightness in colorbars
	Use accessible fonts and HTML
	Include alt text to accompany publicly available images

MAVEN best practices: Approaches and initiatives for inclusion

Early career visibility and opportunities

One of the largest efforts towards increasing and maximizing MAVEN team inclusion and engagement has been in the area of early career visibility. Early exposure and visibility for scientists in the beginning of their careers can have a profound effect on the collaborations, networks, and resources they can seek out to achieve success later on. Walach et al. (2022) and Bol et al. (2018) discuss this topic, specifically referencing the Matthew effect: "early successes increase future success chances." Bol et al. (2018) found that mid-career scientists who had already won a grant accumulated over twice as much funding as their peers who had not won a grant in their early career, even with nearly identical proposal ratings. Effectively, the study found that early career scientists who experienced early success were much more likely to be successful later on, even with similar abilities and qualifications. In this spirit, the MAVEN team has made a concerted effort throughout the mission to improve early career visibility and success (as summarized in Table 1).

One approach is through leadership of our science meetings. When MAVEN's primary mission began in 2014, the science team held ~4 "all person" science meetings, or Project Science Groups (PSGs), per year to discuss the latest results. Initially, the results were organized into science sessions, and the senior scientists on the team would chair and curate those sessions. However, within the first 18 months from MAVEN's launch, a number of postdoctoral fellows and graduate students joined the mission to analyze the huge volume of new Martian data. By early 2016, PI Jakosky made a concerted effort to have graduate students and postdoctoral fellows leading science sessions, all of whom were also encouraged to apply for their own grants and funding sources. The current MAVEN PI, Dr. Curry, was one of these postdocs.

Another concerted effort that the MAVEN team is making towards increasing early career visibility is having each of the nine MAVEN instrument leads select deputy leads. This provides an avenue for succession planning as well as allowing the deputy instrument leads to gain experience working on an active instrument. The deputy leads present many of the weekly and monthly instrument status updates and thereby gain experience presenting to different audiences. Three of these deputy leads later moved to roles as the current instrument leads.

MAVEN also continuously provides opportunities for undergraduate and graduate students, who are a critical demographic to introduce to Science, Technology, Engineering and Math (STEM) research. We have had Research Experiences for Undergraduates (REU) students every summer at many institutions performing research with the MAVEN datasets. Additionally, MAVEN's primary institution—the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics (CU LASP)—trains and certifies undergraduates to work in its Mission Operations Center.

Finally, a dedicated MAVEN early career group is composed of self-identified MAVEN team members and meets at PSGs and conferences throughout the year. Platforms such as Gathertown and other virtual co-hort building tools temporarily helped until in person meetings resumed, and currently the mission supports the MAVEN early career group to meet at PSGs as well as conferences throughout the year.

Management and leadership

An important aspect of inclusion and progress for the MAVEN mission is representation within the management team. In this journal issue, Hamden et al. (2022) wrote extensively about expanding the base of potential principal investigators across space sciences. They noted that "obstacles are borne out by the demographics of both PIs and Science team members for selected and proposed space missions, which tend to be both very male and very white." This observation was in part based on Centrella et al. (2019), who did a study using gender as a marker of diversity during the period 2008–2016 in NASA's Astrophysics Explorer-class missions. Over 8 years, 9 solicitations were issued, and during that time 102 Principal Investigators (PIs) submitted Explorer-class proposals, but only four of these PIs were women. The National Academies also recently released a report, "Advancing Diversity, Equity, Inclusion, and Accessibility in the Leadership of Competed Space Missions" (National Academies of Sciences, 2022a) with a number of relevant findings including opportunities for mentorship (Guiding Principle 4) and work-life balance including parental leave (Guiding Principle 5).

The current MAVEN senior leadership includes:

- Principal Investigator (PI): Dr. Shannon Curry
- Project Manager: Rich Burns
- Co-Deputy PI: Dr. David Mitchell

- Co-Deputy PI/Project Scientist: Dr. Gina DiBraccio
- Science Advisory Board lead: Dr. David Brain

Before Dr. Curry became the MAVEN PI, Dr. Janet Luhmann served as Deputy PI from 2008–2020. While gender is only one axis of diversity, female leadership on the MAVEN team has been a step forward on a Discovery class mission (note that MAVEN is part of the Mars Scout program but had a budget similar to that of a Discovery mission). Additionally, both Dr. Curry (PI) and Deputy PI (Dr. DiBraccio) have taken parental leave (multiple times) while in these roles and have been fully supported by the mission team.

The MAVEN Science Advisory Board (SAB) is another area where diversity is critical for providing a robust set of recommendations. Board membership is designed to capture the broad array of scientific expertise within the team, while keeping other axes of diversity (e.g., career level, institution, gender, race, etc.) in mind. Additionally, the board has a permanent seat for an early career representative. With this diverse set of perspectives, the SAB advises the PI on journal special issues, science working groups, science team meeting organization, relevant collaborations, communications/science products for both NASA HQ and the public, and other relevant science initiatives.

MAVEN mission climate and culture

Many of the examples to improve DEIA within the space physics and planetary science community are concrete; however, it is important to discuss the general tone, culture and working climate within a mission team (a formal recommendation by the National Academies of Sciences, 2022b, and finding from Fernando et al., 2022).

One example of setting expectations for MAVEN's mission culture is our Rules of the Road, codifying how data is shared amongst the team and across instruments. Since the primary science mission began, all MAVEN datasets are available as soon as possible to the entire science team, defined by MAVEN Co-Is and their direct research groups and students, along with NASA-selected Participating Scientists. This has been effective in creating a collaborative and inclusive atmosphere and removing territorial tendencies that have often plagued larger missions.

Another approach to creating an inclusive climate is the simple act of discussing DEIA within the team. Within MAVEN's mission wide science team, there are meetings every other week for 60–90 min to review mission status, relevant team and instrument updates followed by a 30–45 min science talk. Recently, we have expanded our science talks to include invited talks on explicit DEIA efforts, mental health and inclusion and accessibility practices within the STEM field.

We also clarify in the beginning of science meetings and PSGs that everyone in the room has the right to voice a question or comment and that we have a zero tolerance for bigotry in any form. Mission environments that are more collaborative, positive and respectful are the most successful in attracting and retaining under-represented and marginalized people (Advancing Diversity, Equity, Inclusion, and Accessibility in the Leadership of Competed Space Missions).

Communication and accessibility

Communication and presentation of scientific and mission/operational content is an important aspect of accessibility. Everything from figures in presentations to the text in written documents can affect how other members of the community can absorb the material. Below are specific initiatives that the MAVEN team has taken to.

Colorbars

Many plots in presentations and journals default to a rainbow colorbar. However, MAVEN has made a concerted effort to encourage team members to switch to more accessible alternatives. This switch is not only based in the science of human vision but address significant accessibility issues: 1) colormaps without a uniform gradient in perceived brightness are unintelligible in grayscale reproduction (potentially limiting the audience), 2) about 1 in 12 men are red/green colorblind, making rainbow colormaps less legible or illegible for a significant fraction of scientists. Use of perceptual colormaps with a uniform gradient of brightness makes graphics accessible to sighted people regardless of their color vision. The following link is commonly used on the MAVEN team to adopt this: https://github.com/planetarymike/IDL-Colorbars.

Readability

The MAVEN team has taken steps to improve media accessibility by applying best practices for font size and face, use of HTML tags used by screen readers, and exclusion of potentially disruptive or triggering website content. These adjustments are more inclusive of seniors, vision-impaired and screen reader users and include more accurate <title> tags in the HTML, using the font Lato (or Helvetica if the browser can't load Lato), increasing body font size from 13px to 15px and text line height, as well as removing flash content.

Alt text

Images play a large part in social media engagement, especially when sharing science results, but are not accessible to someone with a vision disability. Alternative text, a physical summary of an image, is a way to make images accessible by accurately describing it to a user. Alternative text, or "alt text," serves two major purposes:

- For anyone using assistive technology such as a screen reader or text-to-speech program, alt text is crucial to access digital content because it's meant to accurately describe images to the user. Oftentimes these users are blind or have a severe vision disability.
- Second, if an image on a webpage fails to load, the alt text will also indicate what the missing image was.

Since October 2021, MAVEN's social media posts have had alt text when appropriate. This is to help make MAVEN science more accessible and inclusive to users. Our communications team is always looking for materials to learn more about how to make content accessible, including better writing practices for alt text.

MAVEN areas of improvement and recommendations

Diversifying mission teams and promoting scientists and engineers from underrepresented backgrounds can be difficult due to challenges in both the recruitment and retention of diverse community members in the field (Walach et al., 2022; Davies et al., 2021). In the following recommendations we shift focus toward retention and improving the professional experience of our community members. These recommendations and areas of growth are for MAVEN, other space missions as well as the planetary, space physics and scientific community at large.

Areas of improvement: Underrepresentation and the burden of service

The most recent Planetary Decadal Survey, Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023–2032, found that Latinx/Hispanics represented 8% percent of all physical science jobs, while representing 17% of the United States workforce. Even more pronounced was the finding that Black/African Americans represented 6% of physical science jobs while representing 11% of the United States workforce and there was insufficient data on Indigenous researchers. This disparity needs to be addressed at every level—K-12, undergraduate, graduate, postdoctoral, etc.,— but the onus to implement change should not fall upon those communities who are least represented. The Planetary Decadal Survey, National Academies of Sciences, 2022b, released a finding highlighting this issue: "Community service and administrative duties are important contributions, but ones that tend to be distributed inequitably. This places a disproportionate burden on URC members and women by virtue of their smaller numbers and other responsibilities (e.g., number, culture/family, etc.)."

A recommendation to help bridge this gap at the mission level would for be for missions to participate in programs such as NASA's Here to Observe Program (H2O), Louis Stokes Alliances for Minority Participation (LSAMP) and the NSF's Organizational change for Gender Equity in STEM Academic Professions (ADVANCE). These are programs that cultivate partnerships with non-traditional institutions to pair students with NASA missions and research by:

(1) Providing access for undergraduate student observers.
(2) Supporting meaningful mentorship activities.
(3) Encouraging peer cohort-building at the institution level.

Areas of improvement: International collaboration

In addition to addressing DEIA in outreach programs, mission teams can improve on inclusion with international collaborators. A subtle and often overlooked issue is the marginalization of international scientists who work on missions with fewer resources or who have no direct mission involvement at all. Research from foreign scientists must be given objective consideration. Politics and cultural differences can contribute to inadvertently alienating or excluding team members without connections to more established institutions that have direct mission involvement. This can and does happen inadvertently, so we note that this is an area of improvement for all of us to consider as it often goes unaddressed.

Recommendation: Mission proposals

Another recommendation at the mission level to ensure that leaders of planetary and space physics missions are actively thinking about inclusion is through NASA Announcements of Opportunity (AOs). AOs could include a DEIA or mission culture plan that clearly defines the principles by which mission team members can operate in an inclusive and equitable environment. Examples include language describing a "code of conduct" and Rules of the Road for missions, inclusive succession plans and practices, leadership expectations, etc.

Conclusion

The MAVEN mission has made significant effort towards maximizing inclusion and engagement on the team and fostering a positive working environment. These efforts are applicable to the space physics and planetary science communities, as well as any large-scale science or mission teams. Specifically, we have found that providing as many opportunities for early career visibility and experience as possible has been a powerful tool for retaining and improving the professional experience of our whole team. We have also found that defining and maintaining the MAVEN mission culture has also served the mission well, including efforts such as implementing Rules of the Road that make data available to the whole team, diversifying our science advisory board and addressing DEIA and mental health issues during team meetings. The MAVEN mission has also made efforts to improve upon communication and accessibility practices through things like uniform gradient brightness colorbars, accessible fonts and alt text.

However, as a mission we need to keep listening and keep trying to improve in our efforts to engage more diverse sectors of our community. We plan to participate in the NASA H2O program to expose and include underrepresented students to working on a planetary mission by shadowing our science team meeting for a week each year. We also plan to produce a written code of conduct, with input from the whole team, to continue and codify our expectations for a positive and inclusive mission culture. As a mission, we can also take these lessons forward to future missions in development, encouraging them to develop a DEIA or mission culture plan. Finally, now and moving forward, we can continue to work with our international colleagues regardless of their mission experience to broaden the planetary community.

MAVEN launched almost 10 years ago and has provided exceptional science from an exceptional team, and much of this success can be attributed to an inclusive and positive mission team environment. We do not have all of the answers to solving DEIA issues within our community but hope some of the approaches and initiatives here can motivate others to take concrete approaches towards inclusion.

Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

Author contributions

The main author, SC is the PI of the MAVEN mission and primarily wrote the article with the inclusion of feedback from the mission team.

Funding

This work was supported by the National Aeronautics and Space Administration (NASA) Grant NNH10CC04C to the University of Colorado and by subcontract to Space Sciences Laboratory, University of California, Berkeley. The MAVEN project is supported by NASA through the Mars Exploration Program.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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