



Hypatia I: a multi-generational and multi-disciplinary crew of female analog astronauts dedicated to space research, scientific outreach, and promotion of female role models in space careers

*Arias Helena, Badenas-Agustí Mariona, Conejo-González Carla, Ribas Laia,
Farrés-Basiana Ariadna, Jar Núria, Sabaté Neus, Cufí-Prat Cesca, Bach Anna.*

Abstract

The low representation of women (~33%) in Science, Technology, Engineering and Mathematics (STEM) careers is extremely concerning and cultivates male-dominant cultures across a variety of academic and professional disciplines. In Spain, only 39% of national projects are led by women, thus evidencing the so-called “leaking pipeline”, that is, the tendency of women and other underrepresented groups to eventually abandon STEM-related fields. This social disequilibrium is particularly strong in the international space sector, where women represent less than ~20% of the workforce. The Hypatia I mission—a multi-generational and multi-disciplinary crew of 9 female scientists— seeks to help address this problem. In April 2023, the Hypatia I crew will participate in a two-week Martian analog mission at the Mars Desert Research Station (Utah, United States) with the goal of (i) performing high-quality space-related research in a simulation environment, (ii) conducting outreach and science communication activities, and most importantly, (iii) promoting female role models in STEM-related fields and inspiring future generations of scientists, particularly young girls interested in space careers.

Keywords

Female, Space exploration, Space outreach, Mars, Analog mission

1. Introduction

1.1. *The role of women in science*

Women's under-representation in Science, Technology, Engineering and Mathematics (STEM) careers is a longstanding issue, which slowly improves but remains an ongoing challenge.

Despite progress towards achieving close to gender parity in the overall pool of Ph.D. graduate in Europe since 2010, women graduates are still under-represented in the STEM fields of Physical Sciences (38.4%), Mathematics & Statistics (32.5%), ICT (20.8%), Engineering (27%), among others. Moreover, a greater proportion of men are employed as scientists and engineers compared to women within the total labor force (4.4% and 3.1% respectively). These statistics have barely changed since 2017, and while the average growth rate of women researchers has been 3.9% since 2010 –thus showing some positive changes over time– women still represent around one-third (32.8%) of the research workforce in Europe [1].

In Spain, 42.7% of the research community who published at the Web of Science (WOS) between 2014 and 2018 were women. This represents 47.7% of the Spanish scientific production during this period [2]. However, only 20% of the Spanish scientific production had a woman as a principal investigator, and only 39% of national projects are led by women [3], thus evidencing the so-called “leaking pipeline”, that is, the tendency of women and other underrepresented groups to eventually abandon STEM-related careers.

Statistics show that these numbers decrease particularly when it comes to the space field and the aerospace industry, where the percentages are roughly the same proportion as 30 years ago [4]. In this sector, less than ~20% of the workforce are women, and if we look at the privileged group of people who have been in space since 1961, when Yuri Gagarin became the first astronaut, only 11% have been women—mostly white— and only 7% of women have been able to take space walks [5].

1.2. *Mars Exploration*

The proximity of Mars to Earth, coupled with its prospects for future human settlements, make this planet extremely interesting for the field of space exploration. As of today, more than 49 international missions have conducted research on this planet, 13 of which are still operational. There are also 7 missions in development and

16 proposals to be fulfilled before 2030 [6]. Despite this interest, the complexity of sending astronauts to Mars, together with the risks they involve, make it challenging to set a date for the first human mission to the Red Planet [7]. As a result, Martian analog missions have become important to develop technologies, test safety and emergency protocols, and evaluate personal needs for a future crewed mission to Mars.

1.3. *The Mars Desert Research Station*

Located in the Utah desert (USA), the Mars Desert Research Station (MDRS) is a space analog facility designed to simulate a research facility on the surface of the Red Planet. Since it started to host analog operations in 2001, it has welcomed more than a thousand participants, all of them supervised by a Mission Support center composed of international volunteers with a shared passion for Mars [8].

The MDRS typically invites crews for two-week rotations—a time of confinement and isolation during which the selected crew members attempt to design and create useful technologies and scientific experiments for future crewed missions to Mars. The desert landscape reminds us of the Martian environment, thus making the station one of the most suitable places for Martian analog missions.

The MDRS station contains six separated modules and each of them covers different mission requirements. These include a habitat (Hab), two observatories (the Robotic Observatory and the Musk Observatory), a GreenHab, a Science Dome and a Repair and Maintenance Module (RAMM). All these buildings are communicated with tunnels to let the scientists remain in the simulation as they move between the various MDRS infrastructures.



Figure 1. The Mars Desert Research Station is a facility set in the Utah desert and contains six modules. From left to right: the Science Dome, the Musk Observatory and the Hab. Source: The Mars Society.

2. Hypatia I Crew

Hypatia I is a multi-disciplinary, intergenerational, and all-female crew from Catalonia, Spain, selected to participate in an analog mission at the MDRS in April 2023 [9]. Our crew is named after an extraordinary woman from the Mediterranean who lived during the Byzantine Empire and devoted her life to the study of mathematics, astronomy, philosophy, and the arts despite the religious bigotry of her time [10]. In the spirit of Hypatia, a role model for many women today and a symbol of the connection between the sciences and the arts, our crew embodies the belief that future human settlements on Mars will need people with a variety of interests across all ages and disciplines.

The crew, composed of seven primary and two back-up members, will conduct high-quality space-related research into astronomy, space biology, and engineering during its two-week Mars analog simulation at the MDRS. The members of Hypatia I are presented below:

2.1. Primary crew members

- The Crew Commander and Astronomer is Mariona Badenas Agustí, a Ph.D. candidate in Planetary Sciences at the Massachusetts Institute of Technology (MIT). She graduated in Astrophysics from Yale University and earned a master's degree in Astrophysics, Cosmology, and High Energy Physics from the Autonomous University of Barcelona and the Institute for Space Studies of Catalonia.
- The Crew Executive Officer and Biologist is Carla Conejo González, Head of Science Programs at the Fundació Catalunya La Pedrera. She earned a degree in Human Biology by the Pompeu Fabra University, a master's degree in Pharmaceutical and Biotechnological Industry by the same university, and a postgraduate's degree in Science Communication by the University of Vic.
- The Crew Scientist and Health and Safety Officer is Dr. Arianda Farrés, Ph.D. in Applied Mathematics from Universitat of Barcelona and a member of the Flight Dynamics team at NASA Goddard Space Flight Center, where she specializes on the impact solar radiation pressure has on Liberation point orbits and on optimization of station-keeping maneuvers.
- The GreenHab Officer is Dr. Laia Ribas, senior researcher at the Institute of Marine Sciences of the Spanish National Research Council (CSIC). Before earning her Ph.D. in Biological sciences from the Universitat Autònoma de Barcelona, she worked as a postdoc at the Imperial College of London, United Kingdom. Dr. Ribas is also a member of SONET and participated in the Nüwa project to design a city for 1 million people on Mars.
- The Crew Journalist is Nuria Jar, a freelance journalist specialized in science and health. She earned a master's degree in Scientific, Medical and Environmental Communication and has extensive experience working for some of the most important Spanish media outlets and the international community of science journalists.
- The Crew Engineer 1 is Neus Sabaté, an ICREA Professor at the Institute of Microelectronics of Barcelona and the co-founder of Fuelium, a spin-off company that works on paper-based batteries for single use portable devices. She leads the Self-Powered Engineered Devices Group (SPEED), developing sustainable diagnostic devices that optimize the amount of electronic components and extract the energy required to perform the test from the sample under analysis.
- The Crew Engineer 2 is Cesca Cufí-Prat, an aerospace engineer at Airbus Defence and Space. specialized in attitude and orbital control systems. She graduated in Aerospace Engineering at Universitat Politècnica de Catalunya and earned a master's degree in Aerospace Engineering

with a specialization in Space Systems at Institute Supérieur de l'Aeronautique et de l'Espace.

2.2. Back-up members

- The Back-up Crew Scientist and Artist in Residence Anna Bach, who graduated in Mathematics and Computer Science from Universitat de Barcelona. She currently works as a Product Analyst at the American multinational Scopely, a video game company with its European headquarters in Barcelona. Anna also draws comics trips on a regular basis that she posts on her Annet Planet Instagram page (@annetplanetcomics).
- The Back-up Crew Engineer Helena Arias, a double-degree student of Mechanical/Electronics Engineering and Physics at the Universitat Politècnica de Catalunya and the Universidad Nacional de Estudios a Distancia. She has participated in student research programs at the Instituto de Astrofísica de Canarias and the Weizmann Institute of Science, and she currently works at the Department of Physics of the UPC while developing her own start-up Light Pills.

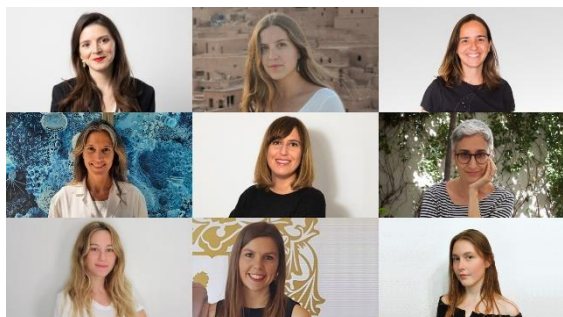


Figure 2. Hypatia I Crew. From left to right: Mariona Badenas Agustí, Carla Conejo González, Ariadna Farrés Basina (first row); Laia Ribas, Nuria Jar, Neus Sabaté (second row); Cesca Cufí-Prat, Anna Bach, Helena Arias Casals (third row).

3. Hypatia I Projects

The main goals of Hypatia I are to (i) perform space-related research at the MDRS, (ii) communicate science through outreach activities in order to promote STEM vocations, and (iii) share new, contemporary female role models, especially among young girls.

3.1. Current projects

To promote scientific and technical vocations among young students, the Hypatia I crew

members have already given numerous outreach talks in a variety of primary and secondary schools. As an example of its educational impact, Hypatia I was featured at Info K, a newscast broadcasted in the channel for children of the Catalan TV (Super3, TV3) in November 2021:

<https://www.ccma.cat/video/embed/super3/6132389/>

They have also participated in a variety of public events, including the SONET Meeting organized by the SONET Project; the DonaTIC Awards, and the NewSpace Community Presentation organized by the Catalan Government; the WIA-E Barcelona #Women4Space organized by the Women in Aerospace Europe; and the #100tífiques Meeting organized by the Barcelona Institute of Science and Technology and the Catalan Foundation for Research and Innovation.

In addition, the Hypatia I crew is leading and developing an educational course for Primary students (6 to 12 years-old) on how to become astronauts. The course will guide children to discover the basics of space-related research and covers all the science fields that Hypatia I crew will tackle during the mission at the MDRS (see section below): astronomy, engineering, space medicine, biology, and science outreach and communication. The course has been designed with the collaboration of Marina Domènech López and Mireia Kun Masvidal, referent professionals specialized in science education in Primary and Secondary level respectively. Both of them are part of Hypatia I Orbitals —women professionals that “orbit” the crew to offer specialized aid in different aspects of the initiative. The “Astronauts Course” is being deployed in collaboration with SOM-Abacus, a Catalan company.

3.2. Future projects: MDRS Projects

3.2.1. Astronomy

The astronomy projects will be mainly conducted by the Crew Astronomer. On the one hand, she will create color-magnitude diagrams of stellar clusters, groups of stars with similar compositions [11]. On the other hand, she will search for new asteroids and minor objects in space to contribute to the diverse international Space Situational Awareness projects [12]. She will also perform astrophotography of deep-sky-objects in order to share them in outreach activities.



3.2.2. *Space Biology*

Research into circadian rhythms in space will be carried out by the Crew Biologist. She will study the effects of the changes that astronauts have to make on their daily routines such as the change of workload and the longer schedules (a sol has 24 minutes more than an Earth day) [13]. The GreenHab Officer, will study the aquaculture on Mars with the aim of finding out the effects of environmental factors on the food productivity. To carry out her research, she will work with zebrafish. Cellular intelligence will also be studied at the MDRS by one of the Crew Engineers, who will study the influence of ultraviolet, visible and infrared radiation on the behavior and sporulation of the *Physarum Polycephalum*.

3.2.3. *Engineering*

Three projects will be carried out in the field of engineering during the MDRS mission. The Crew Scientist will study the different possibilities of Martian navigation: firstly, she will find reference stars to create a simple sky-map; secondly, she will research the creation of a small GPS network constellation made of CubeSats. The Crew Engineers will both design and build a suitable housing for the *Physarum Polycephalum* and study the possibility of creating sustainable organic batteries from the rough and abundant materials present in the Martian desert surface.

3.2.4. *Outreach and communication*

Daily reports and photos will be delivered by the Crew Journalist. She will also work on a narrative podcast called The sounds of Mars, where she will explain the daily challenges of the crew during the mission and the state of the research done at the MDRS. Articles and reports will also be sent to the media outlets. In addition, the Crew Journalist will write a journal in order to compile material to write a long-form story that could be published as a book.

The Crew Executive Officer will also work on a Mars on Earth alternative tourism project. The public have lately shown interest in visiting the MDRS as it is an attractive project for people that are interested in space-related research. That is why she will provide information to create awareness of the wonders of this remote place, the purpose of the simulations, the projects of the crew and the experience during the exploration.

Finally, the Crew Astronomer and Crew Scientist will share their passion for Mars and create outreach activities to learn about observational astronomy as well as navigation in remote places.

4. **Hypatia Association: Hypatia I and beyond**

One of the objectives of Hypatia I is to inspire girls to pursue space-related research and become role models for future generations. On February 11th 2022, the International Day of Women and Girls in Science, the Hypatia Association was founded. The goals of the newly created organization are to keep the Hypatia's project values alive and to support future crews of women to travel to the MDRS to conduct Mars-related research. We expect Hypatia I to be just the first of many crews.

5. **Conclusions**

To date, the low percentage of women in STEM—especially in the aerospace sector—is a concerning problem for society as a whole. To help overcome it, the Hypatia Association and its first crew will attempt to reduce gender inequalities and visibilize the contributions of female scientists by offering a chance to underrepresented communities to travel to the MDRS, pursue space-related research, and share their work with the general public. Hypatia I will be the first crew to achieve this goal in April 2023.

References

[1] European Commission, Directorate-General for Research and Innovation. She figures 2021: gender in research and innovation: statistics and indicators. Publications Office; 2021.

[2] Fundación Española para la Ciencia y la Tecnología (FECYT). Análisis de la presencia de mujeres en la producción científica española 2014-2018. Publicaciones; 2022.

[3] Comisión de Mujeres y Ciencia del Consejo Superior de Investigaciones Científicas (CSIC). Informe Mujeres Investigadoras 2022. Publicacions; 2022.

[4] United Nations, UN Affairs and NASA. Only around 1 in 5 space industry workers are women. Consulted on 21/03/2022: <https://news.un.org/en/story/2021/10/1102082>

[5] United Nations Office for Outer Space Affairs (UNOOSA). Space4Women Project. Consulted

on 21/03/2022:
[http://unoosa.org/oosa/en/ourwork/topics/spac
eforwomen/index.html](http://unoosa.org/oosa/en/ourwork/topics/spac
eforwomen/index.html)

[6] Wikipedia, the Free Encyclopedia. List of Missions to Mars. Consulted on 19/03/2022:
[https://en.wikipedia.org/wiki/List_of_missions_t
o_Mars](https://en.wikipedia.org/wiki/List_of_missions_t
o_Mars)

[7] Salotti, J. M; Heidmann, R. Roadmap to a Human Mars Mission. Acta Astronautica. Elsevier: 2014, vol. 104, issue 2, p. 558-564, ISSN 0094-5765.

[8] Mars Society. Mars Desert Research Station. Consulted on 19/03/2022:
<http://mdrs.marssociety.org/>

[9] Hypatia, Hypatia I. Consulted on 21/03/2022:
<https://hypatiamars.com/>

[10] World History Encyclopedia. Hypatia of Alexandria. Consulted on 21/03/2022:
[https://www.worldhistory.org/Hypatia_of_Alexa
ndria/](https://www.worldhistory.org/Hypatia_of_Alexa
ndria/)

[11] National Schools' Observatory, The Colour Magnitude Diagram (CMD). Consulted on 20/03/2022:
[https://www.schoolsobservatory.org/discover/p
rojects/clusters/cmd](https://www.schoolsobservatory.org/discover/p
rojects/clusters/cmd)

[12] European Space Agency, European Space Astronomy Centre, Space Situational Awareness - SSA. Consulted on 20/03/2022:
[https://www.esa.int/About_Us/ESAC/Space_Sit
uational_Awareness_-_SSA](https://www.esa.int/About_Us/ESAC/Space_Sit
uational_Awareness_-_SSA)

[13] Mallis MM, DeRoshia CW. Circadian rhythms, sleep, and performance in space. Aviation, Space and Environmental Medicine. Aerospace Medical Association: 2005, vol. 76 (6, Suppl.): B94–107.