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WOMEN IN EXPLORATION: LESSONS FROM THE PAST AS HUMANITY REACHES DEEP SPACE

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Abstract

Since the 19th century, women have been making strides in advancing technology by performing essential work in areas like coding, computing, programming and space travel, despite the challenges they have faced. In 1963, Valentina Tereshkova became the first woman to travel into space. Sally Ride joined NASA in 1978 and five years later she became the first female American astronaut to fly in space. Tereshkova and Ride's accomplishments profoundly impacted space exploration and paved the way for the dozens of other women who became astronauts, and the hundreds of thousands more who pursued careers in science and technology. These advancements have greatly affected science, technology and space travel, but women in exploration still have a long way to go. Social constructs and gender expectations have often discouraged women from pursuing careers in science, technology, engineering and mathematics (STEM), and women who do pursue one of these paths are often faced with discrimination throughout their career. Research shows a huge disparity in the ratio of men to women pursuing careers in STEM, and this difference in gender participation is a global phenomenon.

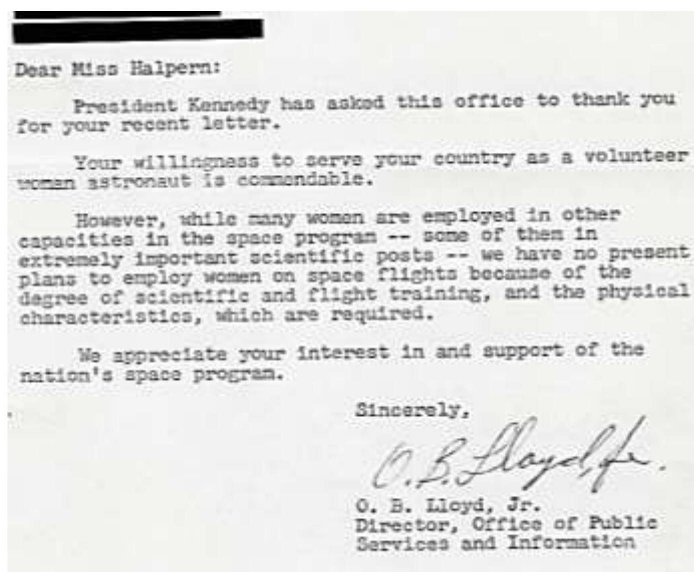
As we contemplate the next phase of human exploration--returning to the Moon and eventually traveling to Mars--our nation and the world must consider the possibilities, impacts and need for more women in aerospace and space exploration. While the challenges women must confront in the workforce have been studied and documented extensively, this paper will present a comprehensive snapshot of women in exploration, and discuss creative perspectives on empowering women and girls in STEM while increasing their involvement at every level of humanity's most ambitious endeavor yet - future missions to explore deep space.

Keywords: (TBD)

1. Introduction

The story of the status of women in society is one of familiar, ancient themes that continue to this day. Originally not given full privilege as citizens in the United States, women finally gained the fundamental right to vote with the passage of the 19th Amendment to the Constitution in 1920, 144 years after the nation declared independence. Twelve years later, Amelia Earhart became the first woman to fly across the Atlantic Ocean [16]. On one hand, the playing field was leveled in theory for every woman, and on the other, a single truly exceptional woman showed the world and young girls what is possible.

When humanity reached for the Moon three decades after Amelia's feat, women were not an assumed part of the journey (with the exception of being "astronaut wives"). Questions were posed about whether females are physically, intellectually, and/or emotionally capable for various aspects of the space program. The decision to exclude women from spaceflight was a natural extension of society at the time, with significant long-term ramifications. Space exploration provides the narrative for innovation, but it also bears on social progress as we look forward. What steps can the nation take to fully address past policies, ensuring adequate representation and inclusion for both mission success and the benefit of all humankind?



[redacted]

Dear Miss Halpern:

President Kennedy has asked this office to thank you for your recent letter.

Your willingness to serve your country as a volunteer woman astronaut is commendable.

However, while many women are employed in other capacities in the space program -- some of them in extremely important scientific posts -- we have no present plans to employ women on space flights because of the degree of scientific and flight training, and the physical characteristics, which are required.

We appreciate your interest in and support of the nation's space program.

Sincerely,

O. B. Lloyd, Jr.
Director, Office of Public
Services and Information

Official NASA response to student Linda Halpern's 1962 letter to President John F. Kennedy asking what she would need to do to become an astronaut. It states, ""We have no present plans to include women on space flights because of the degree of scientific and flight training, and the physical characteristics, which are required."[19]

2. A Tale of Two Forces

The United States' space program recently celebrated its 60th anniversary. It was brought to this point by an incredible century-long series of technological breakthroughs beginning with the first heavier-than-air flight of the Wright Brothers in 1903 and the first liquid-fueled rockets launched by Robert H. Goddard in 1926. At the same time, the nation has also been transformed by a similarly rapid and intense set of political, economic, and social changes marked by extensive military conflicts abroad and the Labor, Women's Rights, and Civil Rights Movements at home, as well as other reforms. These external factors had both positive and negative results in terms of determining the policies that fueled the growth of the space program and provided/denied work opportunities for women.

National Policies and International Wars

The National Advisory Committee for Aeronautics (NACA), the predecessor organization to the National Aeronautics and Space Administration (NASA), came into being in response to World War I in Europe illustrating the United States' comparative lack of prowess in airplane technology. Congress founded NACA on March 3, 1915, as an independent government agency reporting directly to the President.

While women were initially excluded from the war effort in a traditional sense, World War II led to a shortage of men across all levels of society due to deployments and other engagements. Women were tasked, temporarily to fill this void. In June 1941, President Franklin Roosevelt looked to expand the federal workforce and issued Executive Order 8802, which banned "discrimination in the employment of workers in defense industries or government because of race, creed, color, or national origin" (though it does not include gender) [20].

Legislation was enacted to require diversity and inclusion on a national scale from a public policy standpoint as a result of the organized and widespread protest movements and efforts by various White House administrations-- although these initiatives did not require or leverage the buy-in from those organizations that would implement the new policies. These efforts included the President's Commission on the Status of Women signed by John F Kennedy in 19962 to encourage gender equality in the workforce; the Equal Pay Act of 1963 which was the first national civil rights legislation focusing on employment discrimination; the Civil Rights Act of 1964 (enacted July 2, 1964) which was the landmark law covering civil rights and labor that outlaws discrimination based on race, color, religion, sex, or national origin in the United States; and the Equal Opportunity Act of 1972. These laws play a key role in where we are today [20].

A Very Public Space Program

NASA's founding legislation, the National Aeronautics and Space Act of 1958, directs the agency to "seek and encourage, to the maximum extent possible, the fullest commercial use of space" and to "provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof. [41]" Moreover, the exploits of aviators and rocket pioneers were inherently compelling to the American and global public.

3. Conquering Air and the Sound Barrier

Pioneers of Aeronautics

After human beings achieved the extraordinary dream of powered flight, the sky was the limit. Aeronautics--the first "A" in NASA--quickly provided a broad foundation for the agency's legacy and work, evidenced by its core roots in NACA and other precursor activities over the past 100 years. Amelia Earhart was mentioned above, and the "Wild West" atmosphere of the burgeoning field of civil aviation across the world provided ample opportunities for individual women to make their mark. These exploits were so many that in 1929 the Federation Aeronautique Internationale created a new category for records set by women pilots [29]. In just the ten-year period after the Wright Brothers made history, women made history all their own.

Selected Women in Flight Milestones [22]

1908	Mlle P. Van Pottelsberghe de la Poterie of Belgium flies with Henri Farman on several short flights at an airshow in Ghent, Belgium becoming the first woman passenger on an airplane.
1908	Therese Peltier, became the first woman to fly as a passenger in a heavier-than-air craft.
1908	Thérèse Peltier of France makes first solo flight by a woman in an airplane in Turin, Italy, flying around 200 meters in a straight line about two and a half meters off the ground.
1909	Raymonde de Laroche of France is the first woman to pilot a solo flight in an airplane.
1910	Raymonde de Laroche of France becomes the world's first woman to earn a pilot's license.
1911	Hélène Dutrieu is the first woman to win an air race.
1911	Harriet Quimby becomes the first United States and the world seventh woman to earn a pilot's license.
1912	Amelie Beese of Germany is the first woman to patent an aircraft design.
1912	Harriet Quimby is first woman to fly across English Channel.
1913	Lyubov Golanchikova became the first test pilot.
1913	Ruth Law is the first woman to fly at night.
1913	Käthe Paulus (de) develops the first modern parachute which fit inside of a "pocket" or bag.
1914	Lydia Zvereva is the first woman to perform an aerobatic maneuver (a loop).

Female civilian pilots also backfilled for their male counterparts who were pulled away for combat roles during World War II, through the Women Airforce Service Pilots (WASP) program. Over a thousand well-trained women were leading domestic flying, ferrying aircraft, towing targets, training, and transporting aircraft [29].

But where organization began in aviation, so did the upward mobility and participation of women end. The WASP program concluded after the war, women were barred from flying by the military [29], and their underrepresentation on the flight decks of commercial aircraft remains even in 2014: of the 130,000 airline pilots worldwide only 4000 (3%) are women and of 3000 Captains, only 450 are women [30].

NACA and the Conquest of the Sound Barrier

Pearl Young was hired in 1922 by NACA to work at its Langley site in support of instrumentation, as one of the first women hired by the new agency. Women were also involved with NACA at the Muroc site in California which later became NASA's Dryden Flight Research Center (now Armstrong Flight Research Center), to support flight research on advanced, high-speed aircraft. These women worked on the X-1 project, which became the first airplane to fly faster than the speed of sound. The first two women arrived at the end of 1946 to form a team of 13 or 14 engineers, technicians, and people who "computed" or conducted manual calculations. "In the Federal government's scientific community, almost without exception, the computers were women." This involved remote, secretive and labor-intensive data gathering and analysis procedures before the age of digital computers, typical instrumentation used on the X-series aircraft from the X-1 through the X-15. The war had caused a shortage of men with science and engineering degrees, and NACA had a need for "computers" who essentially served as junior engineers who worked closely with full engineers and co-authored technical reports. This working environment existed until the early 1950s. The staff at Dryden grew from 13 or 14 at the end of 1946 to 450 employees in December 1995.

These women contributed directly to solving one of humanity's grand challenges, ushering in the age of aviation which continues to enhance life on Earth.

The Human Computers of Langley

NACA hired five women in 1935 to form its first "computer pool", because they were hardworking, "meticulous and accurate" and inexpensive. After the Pearl Harbor attack yanked the nation into the largest war the world had ever known, NACA began actively recruiting similar types to meet the workload.

4. The Rocket Scientist

Early female rocket scientists like Mary Sherman Morgan (1921-2004) also found themselves on the cusp of opportunity due to extreme and unforeseen circumstances.
A local employment recruiter in Ohio was short on job candidates with chemistry backgrounds due to the Second World War, and reached out to Mary who was a college student at the time. She was hired to do a top-secret job she knew nothing about beforehand. At the Plum Brook Ordnance Works munitions factory, she was responsible for manufacturing more than one billion pounds of explosives that fueled the World War II effort. Later she began working for an aerospace contractor calculating expected performance of new rocket propellants. She was one woman in a sea of 900 engineers, and one of only a few workers without a college degree. Mary is credited with the invention of the liquid fuel Hydyne in 1957, which powered the Jupiter-C rocket that lifted the United States' first satellite, Explorer 1, to orbit—the first of a sea of satellites [42].

5. Satellite Pioneers

Marjorie Townsend was blazing trails from a very young age. She started college at age 15 and became the first woman to earn an engineering degree from George Washington University when she graduated in 1951. At NASA she became the first female spacecraft project manager, of the UHURU satellite which was the first dedicated to x-ray astronomy. She oversaw the development and launch of this satellite in 1970 which contained pace instrument used to detect, survey and map celestial X-ray sources and gamma-ray emissions. According to the American Association for the Advancement of Science, this mission "quadrupled the number of X-ray sources known at the time." She also co-invented a digital telemetry system, patented in 1968, that was part of the Nimbus program weather satellite which paved the way for future Earth-observing systems [43].

6. Exploration: Apollo Era

The Soviet Union during the Space Race

Any history of women's achievements in spaceflight or overall will include or begin with detailed discussion of the Union of Soviet Socialist Republics (USSR) space program. After World War II, the Soviet Union and the United States engaged in the Cold War, an extended period of open hostility short of warfare. This situation which involved threats, posturing and propaganda, planted the seeds for the ultimate show of superiority: the space race. Each country aimed to be the first in all aspects of spaceflight, and by 1963 the Soviets were ahead--having launched the first satellite to space in 1957 (Sputnik) and the first man into orbit in 1961 (Yuri Gagarin).

As noted by Sophie Pinkman, "The Cold War was fought as much on an ideological front as a military one, and the Soviet Union often emphasized the sexism and racism of its capitalist opponents – particularly the segregated United States. [34]" Female cosmonaut Valentina Tereshkova became the first and youngest (aged 26) woman in space as well the only woman to make a solo spaceflight.

During the historic flight in June 1963, Tereshkova orbited Earth 48 times, breaking the mission duration records of

American male astronauts thus far. Her feat inspired women inside her country and beyond [33].

Nikolai Kaminim, the lead for cosmonaut training had declared in his personal journal that "We cannot allow the first women in space to be an American." The Soviets intended to use Tereshkova's flight as propaganda to tout the "equality of Soviet women under socialism." In the decades that followed, some would content that while the competing nation had lost the space race overall, they had indeed won a different kind of race – that of equality. While others, as noted by Maria Koren as the U.S. celebrated the 50th anniversary of the Apollo Moon landing in 2019, would eventually counter that "sending the first women into space isn't the same as developing an astronaut program that values equality. [33]"

The purely nationalist intentions behind these feats could be an explanation for what happened next. While a role model and celebrity of sorts in her home country and abroad, Tereshkova never flew again. Behind the scenes, although a woman had already flown to space within their program, men debated whether women should be astronauts and ultimately deemed that the missions were too dangerous. The excuse was used that one of the trainees had a family.

In the 1970s The Soviet Union would partner with its allies to send people of color into space as well – Pham Tuan of Vietnam and Arnaldo Tamoyo Mendez of Cuba became the first Asian and person of African descent to travel to space.

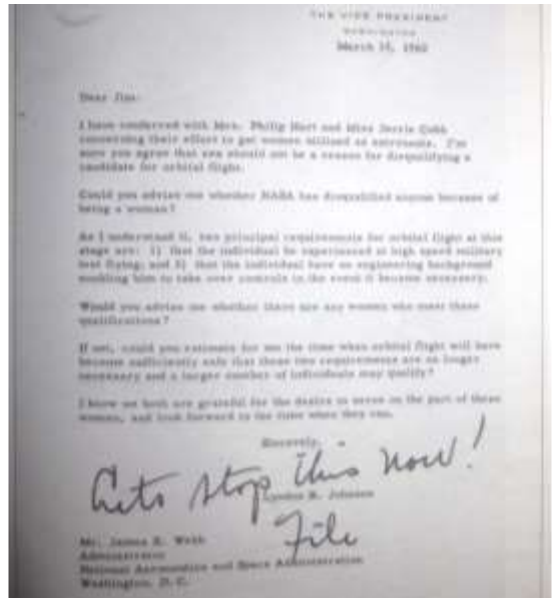
In 1983, the Soviet Union sent another woman to space nineteen years after the first: Svetlana Savitskaya. It has been speculated that this is due to NASA's preparations to send the first American woman to space. As o 2019, of the 65 women who have flown to space, only four have been Russian.

NASA's Cadence of Human Missions

After the Soviet Union successfully launched Sputnik and then Yuri Gagarin, President John F. Kennedy announced the entry of the United States into the space race in 1961 with a rousing speech that declared a bold mission to send a man to the Moon and safely return him to Earth. He had previously commanded Americans to "ask not what your country can do for you, but what can you do for your country." during a time of national turmoil over the fundamental right to political and social freedom and equality of its citizens.

The Congress delivered funding and the nation responded to the call. NASA's Mercury program was devised to create rocket technologies that could propel humans above the Earth's atmosphere. Then, the Gemini and Apollo programs progressed the technical capabilities for human space exploration, including walking in space, maneuvering spacecraft to connect in space, and landing on the Moon with a human crew. .

NASA's early decision to select military-trained jet test pilots as its first astronaut candidates, which guaranteed the exclusion of women as they had been banned from military flying after the WASPs were disbanded. Coincidentally, after the end of the Second World War and into the 1950s, jet technology came into prevalence in the military which also meant that women would have little access [35].



Lets stop this now!

File

A 1962 draft letter to NASA discovered in the Lyndon B Johnson Presidential Library asks, "Could you advise me whether NASA has disqualified anyone because of being a woman?" Vice President Johnson did not send the letter, instead writing "Lets [sic] stop this now! File. [31]"

The professional requirement for the first three classes of astronauts (1959, 1962, and 1963) was qualification as a test pilot for jet aircraft. The fourth class of astronauts in 1965 included candidates with achievements in scientific fields, hence their group nickname "The Scientists". But very few women had completed degrees at any level in science or engineering during the 1960s, so their chances remained quite slim [35].

The Women of Apollo

Despite effectively being barred from direct participation, there were other ways to contribute to the mission, including a number high level examples of women enabling Project Apollo during this time period.

- Margaret Hamilton led a NASA team of software engineers and helped develop the flight software for NASA's Apollo missions. She also coined the term "software engineering." Her groundbreaking work was also perfect – there were no software glitches or bugs during the crewed Apollo missions [39].

- A famous photograph of the Apollo 11 Mission Control room shows only one woman in a room full of men. Her name is Poppy Northcutt. She was a math major with a college degree who was hired as a "computress. [44]"
- Another woman, JoAnn Morgan is famously known as the only woman working in Mission Control during the Apollo 11 mission. She later accomplished many NASA "firsts" for women: NASA winner of a Sloan Fellowship, division chief, senior executive at Kennedy Space Center and director of Safety and Mission Assurance at the agency [39].
- Judy Sullivan, was the first female engineer in the agency's Spacecraft Operations organization, was the lead engineer for the biomedical system (health and safety) for the Apollo 11 mission, and the only woman to help Neil Armstrong suit up for flight [39].

The Hidden Figures
In the recently released film, "Hidden Figures", about NASA's human computer pool at Langley, one of the supervisors stated that "There's no protocol for women attending", to which the fictionalized version of female engineer Katherine Johnson replied, "There's no protocol for a man circling Earth either, sir. [50]" This exchange exemplifies the attitude of the agency and the nation at the time: landing a man on the Moon and returning him safely required working together and doing whatever it took --which often meant doing things differently than before. And for many women, it represented a once-in-a-lifetime opportunity.

- An alumna of the Langley computing pool, Mary Jackson was hired as the agency's first African-American female engineer in 1958. She specialized in boundary layer effects on aerospace vehicles at supersonic speeds. "Mary Jackson began her engineering career in an era in which female engineers of any background were a rarity; in the 1950s, she very well may have been the only black female aeronautical engineer in the field [39].
- An extraordinarily gifted student, Katherine Johnson, skipped several grades and attended high school at age 13 on the campus of a historically black college. Johnson calculated trajectories, launch windows and emergency backup return paths for many flights, including Apollo 11 [39].
- Christine Darden, was another woman who served as a "computress" for five years and later asked for a promotion to NASA engineer in 1972.[44]

Lovelace's Woman in Space Program
Geraldyn "Jerrie" Cobb was the among dozens women recruited in 1960 by Dr. William Randolph "Randy" Lovelace II to undergo the same physical testing regimen used to help select NASA's first astronauts as part of his privately funded Woman in Space Program [29].

Ultimately, 13 women passed the same physical examinations that the Lovelace Foundation had developed for NASA's astronaut selection process. They were: Jerrie Cobb, Myrtle "K" Cagle, Jan Dietrich, Marion Dietrich, Wally Funk, Jean Hixson, Irene Leverton, Sarah Gorelick, Jane B. Hart, Rhea Hurrle, Jerri Sloan, Gene Nora Stumbough, and Bernice Trimble Steadman. Subject to media attention, these women were given the unofficial nicknames "Fellow Lady Astronaut Trainees" and the "Mercury 13" [29].

7. Exploration: Modern Era

New Era, New Spacecraft
After Apollo, human explorers moved to orbiting laboratories in space, including the Soviet Space Station Salyut 7, the U.S. Skylab and the Russian Mir, showing our ability to conduct long-term operations in low-Earth orbit, establish extended scientific experimentation, and manage complex payloads like satellites.

The Space Shuttle Program was announced in 1972 by President Richard Nixon as a lower cost, reusable system for a new era of routine space exploration, "making it possible to send scientists, doctors, artists, photographers, both men and women, into space." This was this first public commitment from NASA on plans to send women to space [35].

The Space Shuttle became the workhorse of human spaceflight, demonstrating a long-term, complex and integrated program of ongoing human flights that involved industry and the science community. The program produced innovations and expertise related to manned experiments, in-space construction of the station, satellite servicing, and delivery of many vital payloads.

NASA Addresses Equal Opportunity
NASA center leadership met with the agency's top officials, Administrator James Fletcher and Deputy Administrator George Low, in September 1972 to discuss the inclusion of women and minorities in the Shuttle program. A Memorandum for the Record resulted, directing all centers to take "positive, deliberate steps to develop sound, affirmative action plans and to see to it that these plans are carried out" and that the astronaut program needed a plan for adequate numbers of trained astronauts ready to meet program needs but that also took "into account present equal employment opportunity policies and practices. [35]"

The call for applications to the eighth group of astronauts was made in July 1976 with a recruiting statement which publicly announced, "NASA is committed to an affirmative action program with a goal of having qualified minorities and women among the newly selected astronaut candidates. Therefore, minority and women candidates are encouraged to apply. [35]"

In January 1978, forty years ago, six women and four racial minorities were selected to join NASA's astronaut corps as its first non-white and non-male members. These individuals were: the women Sally Ride, Anna Fisher, Shannon Lucid, Judith Resnik, M. Rhea Seddon, Kathleen Sullivan; the African-American men, Guion "Guy" Bluford, Frederick Gregory, Ronald McNair; and an Asian-American man, Ellison Onizuka. This group of trailblazers changed, for NASA and the public, what it means to be an astronaut. NASA's Group 8 of astronauts selected in 1978 would change the trajectory of both space history and society.

Sustained Exploration for Diverse Crews

These developments, milestones, and lessons in human spaceflight culminated with the creation of a permanent outpost in space – the International Space Station which has served as a consistent human presence in orbit since 1991, and demonstrated a myriad of technologies, approaches, and skills necessary to achieve the next phase of human exploration of space. In contrast with the first era of human spaceflight, the participation of women has been relatively commonplace.

In a common theme, the Russian space program continued to lay the groundwork for women in human spaceflight. In the early 1980s, Roscosmos cosmonaut Svetlana Savitskaya became the first woman to fly on a space station, perform an extravehicular activity (EVA) or spacewalk (July 25, 1984) and make two spaceflights. On the U.S. side, the second flight of Space Shuttle Challenger, STS-7, was also the first flight of Dr. Sally Ride, the first American woman to fly in space.

In the modern era of the Space Shuttle and the International Space Station, women played an increasingly large role, with dozens of milestones achieved in about 4 decades [32].

- NASA astronauts Kathryn Sullivan and Sally Ride were part of the Space Shuttle crew with more than one woman, STS 41-G in 1984, where Kathryn also became the first American woman to conduct a spacewalk.
- The STS-40 mission in 1991 had three women: NASA astronauts Tamara Jernigan, M. Rhea Seddon, Millie Hughes-Fulford.
- Mae Jemison, the first African-American female astronaut, was selected by NASA in 1987 and launched to space on the STS-47 mission in 1992. Two other black women would follow in her footsteps and fly in space: Stephanie Wilson and Joan Higginbotham.
- In 1993, NASA astronaut Ellen Ochoa becomes first Hispanic woman in space as part of STS-56.
- Eileen Collins is the first woman pilot of a Space Shuttle mission, STS-63, in 1995. She returned as pilot for STS-84 in 1997.
- Shannon Lucid becomes first American woman to fly on a space station (Mir) in 1996.
- Colonel Eileen Collins becomes first woman to command a spacecraft, STS-93, in 1999. She also commanded STS-114 in 2005.
- NASA astronaut Susan Helms became the first female on the space station as part of Expedition 2 in 2001
- NASA astronauts Susan Helms and Jim Voss conducted the longest single spacewalk in 2001, of 8 hours 56 minutes which means that a woman shares the record.
- NASA astronaut Peggy Whitson became the first female Commander of an ISS crew during Expedition 16 inn 2008.
- In 2010, crew members of the STS-131 mission (Dorothy Metcalf-Lindenburger, Stephanie Wilson, and Japan's Naoko Yamazaki) connected with Expedition 23 Flight Engineer Tracy Caldwell Dyson who was part of a six person crew on the station– marking the first time ever that four women were in space simultaneously.
- ISS Expedition 24 in 2010 was the first with two women, NASA astronauts Shannon Walker and Tracy Caldwell Dyson.
- The most recent astronaut class, selected in 2013, NASA's first to have an equal number of women and men.
- In 2019, NASA astronaut Anne McClain became the first woman to have been part of multiple space station crews that had other women - first with Serena Auñón-Chancellor in 2018 and then with Christina Koch this year.

8. Overall Timeline of Women in Space

As of October 2019, 65 women have flown in space, including cosmonauts, astronauts, payload specialists, and space station participants [31].

Summary of Women in Space by Date of First Mission [18] [45]

#	Name	First Mission (Year)
1	Valentina Tereshkova	Vostok 6 (1963)
2	Svetlana Savitskaya	Soyuz T-5 (1982)
3	Sally Ride	STS-7 (1983)
4	Judith Resnik	STS-41-D (1984)
5	Kathryn D. Sullivan	STS-41-G (1984)
6	Anna Lee Fisher	STS-51-A (1984)
7	Margaret Rhea Seddon	STS-51-D (1985)
8	Shannon Lucid	STS-51-G (1985)
9	Bonnie J. Dunbar	STS-61-A (1985)
10	Mary L. Cleave	STS-61-B (1985)
11	Ellen S. Baker	STS-34 (1989)
12	Kathryn C. Thornton	STS-33 (1989)
13	Marsha Ivins	STS-32 (1990)
14	Linda M. Godwin	STS-37 (1991)
15	Helen Sharman	Soyuz TM-12/
16	Tamara E. Jernigan	STS-40 (1991)
17	Millie Hughes-Fulford	STS-40 (1991)
18	Roberta Bondar	STS-42 (1992)
19	Jan Davis	STS-47 (1992)
20	Mae Jemison	STS-47 (1992)
21	Susan J. Helms	STS-54 (1993)
22	Ellen Ochoa	STS-56 (1993)
23	Janice E. Voss	STS-57 (1993)
24	Nancy J. Currie	STS-57 (1993)
25	Chiaki Mukai	STS-65 (1994)
26	Yelena V. Kondakova	Soyuz TM-20 (1994)
27	Eileen Collins	STS-63 (1995)
28	Wendy B. Lawrence	STS-67 (1995)
29	Mary E. Weber	STS-70 (1995)
30	Catherine Coleman	STS-73 (1995)

#	Name	First Mission (Year)
31	Claudie Haigneré	Soyuz TM-24/23 (1996)
32	Susan Still Kilrain	STS-83 (1997)
33	Kalpana Chawla	STS-87 (1997)
34	Kathryn P. Hire	STS-90 (1998)
35	Janet L. Kavandi	STS-91 (1998)
36	Julie Payette	STS-96 (1999)
37	Pamela Melroy	STS-92 (2000)
38	Peggy Whitson	STS-111/113 (2002)
39	Sandra Magnus	STS-112 (2002)
40	Laurel B. Clark	STS-107 (2003)
41	Stephanie Wilson	STS-121 (2006)
42	Lisa Nowak	STS-121 (2006)
43	Heidemarie M. Stefanyshyn-Piper	STS-115 (2006)
44	Anousheh Ansari	Soyuz TMA-9/8 (2006)
45	Sunita Williams	STS-116/117 (2006)
46	Joan Higginbotham	STS-116 (2006)
47	Tracy Caldwell Dyson	STS-118 (2007)
48	Barbara Morgan	STS-118 (2007)
49	Yi So-yeon	Soyuz TMA-12 (2008)
50	Karen L. Nyberg	STS-124 (2008)
51	K. Megan McArthur	STS-125 (2009)
52	Nicole P. Stott	STS-128 (2009)
53	Dorothy Metcalf-Lindenburger	STS-131 (2010)
54	Naoko Yamazaki	STS-131 (2010)
55	Shannon Walker	Soyuz TMA-19 (2010)
56	Liu Yang	Shenzhou 9 (2012)
57	Wang Yaping	Shenzhou 10 (2013)
58	Yelena Serova	Soyuz TMA-14M (2014)
59	Samantha Cristoforetti	Soyuz TMA-15M (2014)
60	Kathleen Rubins	Soyuz MS-01 (2016)
61	Serena M. Auñón-Chancellor	Soyuz MS-09 (2018)
62	Anne McClain	Soyuz MS-11 (2018)
63	Beth Moses	VSS Unity VF-01 (2019)
64	Christina Koch	Soyuz MS-12 (2019)
65	Jessica Meir	Soyuz MS-15 (2019)

9. Science Trailblazers

In the words of President Eisenhower, expanding knowledge is one of the three primary goals of the space program – and some might argue that the science mission is the agency's most powerful and compelling, with the broadest and longest-term impact to humanity and our way of life. While "engineering culture" has been a pervading theme in the workplace environments and decisions that have adversely impacted women historically, the robust culture of scientific investigation is both substantial at NASA and a key factor in the experience of its female workforce.

Generally speaking, the participation of women in scientific fields has increased dramatically since 1970. As noted by Ceci and Williams [12], in 2011 at least half of all medical degrees and more than half of doctorate degrees in the life science fields were awarded to women, with even greater numbers in social sciences. In comparison, in 1970 women constituted only 13% of PhDs in life sciences. The relative growth is less pronounced, however, for women's representation in the more math-focused fields, with women having 8.8–15.8% of tenure-track positions in top universities and less than ten percent of full professors [12].

In this landscape, a number of women distinguished themselves, and these are just couple of examples.

- Nancy Roman is considered the "Mother of Hubble". She was among the very first high level executives at NASA and helped develop and manage the Hubble Space Telescope program. During a time when females in astronomy were relegated to administrative or menial tasks like cataloguing stars, she took a job with NASA in 1959. The agency had just been created with a focus on aeronautics, rockets, satellites and manned spaceflight. NASA hired Nancy to serve as its first astronomy lead, tasked to develop a non-existent science program. During this time, as one of few women at NASA, Nancy developed and managed multiple programs to include Orbiting Solar Observatories and Small Astronomical Satellites. She also made numerous discoveries about the nature of stars, and ushered in the age of space telescopes [36].
- Another woman blazing trails from a very young age, Joanne Simpson was a student pilot during World War II, and in 1949 became the first woman to earn a Ph.D. in meteorology. During the 1950s, she and her former professor devised the ground-breaking "hot tower" hypothesis of cloud and hurricane behaviour. She began working at NASA in 1979, and among her many contributions are serving as Study Scientist and Project Scientists for the joint U.S.-Japan Tropical Rainfall Measuring Mission (TRMM). In 2002, she was the first women to receive the International Meteorological Organization Prize [37].
- Thora Halstead is credited with helping to establish an entirely new scientific discipline: space biology. She published more than 40 published papers about the interactions between living cells and low-gravity environments. She also founded the American Society for Gravitational and Space Biology. It has also been mentioned that she served as a mentor to many young scientists, both male and female [36].

These women have been on the forefront of space innovation, from space telescopes that will allow us to better understand the universe, to observations of Earth and weather that improve life on Earth, to science that will help future explorers live and thrive in microgravity and on other worlds.

Competing for Science in Challenging Workplace

Although a small number of women have been incredibly successful, much work remains in retaining women in space-related science in academia and at science agencies. A data study of leadership and participation in NASA's Astrophysics Explorer-class missions for nine solicitations issued during the period 2008-2016, using gender as a marker of diversity: of 102 Principal Investigators (PIs) submitted Explorer-class proposals only four were female. Among the 102 PIs, (61 unique) only three were female. The percentage of females in the science teams in ranged from 10% to 19% with 14% overall participation by females in science teams. Eighteen of the proposals had no females in science roles, even on teams as large as 28 members [25].

"This data reveals a significant lack of participation by females in key NASA astrophysics missions. Why does this occur, and to what extent is this a problem? Lack of gender diversity can signal the absence of other types of diversity as well. Research shows that team excellence and diversity go together, especially for innovative activities. In addition, inclusive behaviors and practices—not just diversity—are essential to create a sense of community and enable all team members to contribute their best these are key ingredients for mission success. [25]"

An Historic Milestone in 2019

NASA noted earlier this year that women were in leadership positions of three out of the agency's four divisions within its Science Mission Directorate. They are: Sandra Cauffman, acting director of Earth Science; Nicola Fox, director of Heliophysics; and Lori Glaze, director of Planetary Science.

In addition, multiple women have served in the role of NASA's Chief Scientist, including France Cordova (1993-1996) who is now the administrator of the National Science Foundation, Kathie Olsen (1999-2002), Shannon Lucid (2002-2003) and Ellen Stofan (2013-2016).

10. Women at NASA Then and Today

According to NASA's Workforce Data site:

- "NASA employs nearly 17,000 people with diverse backgrounds. Seventy-two percent of NASA employees are White or Caucasian, 12 percent are Black or African American, 7 percent are Asian American or Pacific Islander, 8 percent or Hispanic or Latino; 1 percent are American Indian or Alaska Native, and less than 1 percent are more than one race. [38]"
- "Women account for just over 34 percent of the NASA workforce; however they comprise only 16 percent of those in Senior Level (SL) and Senior Scientific and Professional (ST) positions; 23 percent of those in Science & Engineering positions; and 28 percent of GS-14 and GS-15 employees and the SES. Among all women employed by NASA, half are in Professional Administrative positions and 43 percent are in S&E positions. [38]"

However, in the early 1970s, NASA moved slowly in response to civil rights and equal opportunity legislation, claiming the intent to deliver "the best equal opportunity program in the federal government," but proceeded using part-time and non-diverse organizations. Despite this stated goal, NASA's hiring and employment of minorities and women lagged behind the entirety of the rest of the federal government (5.6 percent minority and 8 percent female employees in 1973, versus a government average of 20 percent minority and 34 percent female). Of the 4,432 of NASA's women at the time, 310 were in science and engineering and just four were in the highest grades of the civil service [28].

Female and minority supervisors at levels of GS-14 and were rare until the 1980s. When NASA finally did decide to hire a director of Equal Opportunity, they demoted her immediately before her first day of work – having her instead be a deputy director reporting to a white male. Then they fired her, only rehiring her after she sued the agency. She was radical and an activist which was not a good fit for NASA, and her replacement Harriett Jenkins was more patient and allowed the changes to slowly happen over time [28].

In 1983 Harriett Jenkins reported "modest progress" in that "in a decade nonminority women had risen from 5 percent to just under 8 percent of NASA's total, while minorities had doubled from 6 percent to 2 percent. In the science, engineering, and technical half of NASA, the equivalent percentages were increases from 2.3 percent to 5.5 percent for nonminority women and from 3.9 percent to 8.3 percent for all minorities. [28]"

By 1999, things had improved to be more representative of society, with approximately about 2 percent of NASA technical jobs held by nonminority females, 4 percent by African Americans, 4 percent by Hispanics, and about 5 percent by Asian Americans. However, the National Science Foundation in 2000 found that the largest gender gap for any science and technology issue was in space exploration, particularly in physical sciences and engineering.

Despite these continuing challenges, a number of women have filled some of NASA's top leadership roles over the years.

- Shana Dale was NASA's first female deputy administrator (2005-2009), with Lori Garver serving in this role from 2009-2013 and Dava Newman from 2015 to 2017. Lesa Roe served as acting deputy administrator during 2017.
- Carolyn Leach Huntoon is the first woman to serve as a director of NASA Center: Johnson Space Center from 1994 to 1996.
- Ellen Ochoa, a Hispanic woman and former astronaut, was director of NASA Johnson Space Center (2013 – 2018)
- Christyl Johnson is an African American woman who became deputy director for science and technology at NASA Goddard Space Flight Center in 2010.

11. Lessons Learned about the Lack of Progress

An interesting example of steps forward and back can be seen in the gaps between aerospace achievements of women and men throughout history.

The smaller the investment and less structured the environment, the more women were enabled to participate in

the same activities as men – daring, dangerous and innovative all the same – either at the same time or not long after.
But the larger the aircraft, the bigger the investment, and the more organized the structure, the longer it takes for women to have a seat at the table.

Gaps in Progress (in Years)[18][26]

ACHIEVEMENT	MAN	WOMAN	GAP
Human balloon flight	1783 (de Rozier)	1784 (Thible)	1
Parachute jump	1797 (Garnerin)	1799 (Labrosse)	2
Dirigible flight	1852 (Giffard)	1903 (de Acosta)	51
Successful heavier-than-air machine flight	1903 (Wright)	1908 (Peltier)	5
Pilot license	1910 (multiple)	1910 (de la Roche)	0
Cross-Channel flight	1909 (Blériot)	1912 (Quimby)	3
Transatlantic flight	1919 (Read)	1932 (Earhart)	13
Supersonic Flight	1947 (Yeager)	1963 (Walker)	16
Flying in Space	1961 (Gagarin)	1963 (Tereshkova)	2
Flying in Space (USA)	1961 (Shepard)	1983 (Ride)	22
Conducting Spacewalk	1965 (Leonov)	1984 (Savitskaya)	19
Conducting a Spacewalk (USA)	1965 (White	1984 (Sullivan)	19
Landing on the Moon	1969 (Armstrong)	**2024 - Planned**	**55**

A Framework for Action
The key elements of the framework from the "Findings and Recommendations from the American Astronomical Society (AAS) Committee on the Status of Women in Astronomy: Towards Eliminating Harassment in Astronomy" report are summarized below [25].

- **Take Action on Harassment** by classifying harassment as a form of scientific misconduct, require institutions to report harassment by their funded investigators, provide awareness materials and points of contact for identifying and reporting harassment, and require related training for receiving federal funding.
- **Create Inclusive Organizations** by implementing best practices to include "vision statements, frameworks, communication, reporting, ongoing engagement, and further research."
- **Make Graduate Admissions Fair** by eliminating barriers in pre-/early-college access and discriminatory hiring and promotion practices; and ensuring equal accessibility to institutions, facilities, and data.
- **Create Inclusive Environments** at astronomical workplaces by ending harassment; ensuring access to health care; facilitating support of family and work-life; establishing procedures to report, monitor and analyze progress; enabling mentoring and networking; and supporting marginalized students.
- **Other Recommendations** include actions related to access to power, policy, and leadership as well as establishing a community of inclusive practice.

12. The Power of Communication and Perception

Since the 1960s, the human spaceflight community has capitalized on the historical milestones that inspired and changed the nation and the world. More than just technology and policy breakthroughs, the lunar landings were a galvanizing moment in shared human history. For those first footsteps on the Moon, it was clear that "it is not important who is standing there. What is important is that man is standing there. [50]"

Humanity's inherent interest in space was both leveraged and fueled by a significant public relations effort by NASA. Apollo Astronaut Eugene A. Cernan later remarked, "Along the way, and totally unexpected by us, we astronauts became very visible public figures. This wasn't NASA's initial intent, but they adapted quickly. It was the press, and in turn the public, who declared us "heroes," and from that followed the inevitable responsibility to 'market' the space program. [40]"
However, public interest does not always equate to public support. As a result, , a number of commissions and studies during the past several decades have advocated for continued human exploration of various destinations in the solar system.

National Academies' Pathways to Exploration Report
The Aeronautics and Space Engineering Board of the National Academy of Engineering released this extensive study in 2014 [27] that outlined a set of principles and best practices for future human exploration of deep space. Among its findings based on technical analysis is that the Moon, asteroids, Mars, and the moons of Mars are viable and reasonable future targets for eventual human exploration, and that Mars should be considered a long-term "horizon goal". The study provided several pathway principles which included: 1) identifying and pursuing a clearly defined long term goal, 2) collaborating with international agencies, 3) developing a series of steps that will build upon prior milestones to achieve sustainable progression of capabilities, 4) utilizing a partnership approach to solving the most challenging issues that arise, 5) establishing risk mitigation for unexpected issue, and 6) Establish exploration pathway characteristics that maximize the overall scientific, cultural, economic, political, and inspirational benefits without sacrificing progress toward the long-term goal.

The report noted that "the level of public interest in space exploration is modest relative to that in other public policy issues. At any given time, a relatively small proportion of the U.S. public pays close attention to this issue, and an even smaller proportion feels well informed about it. Space exploration fares relatively poorly among the public compared to other spending priorities. No particular rationale for space exploration appears to attract support consistently from a clear majority of the public. Those trends—generally positive views of space exploration and human spaceflight but low support in terms of funding and low levels of public engagement—have held true over the past few decades, during a time when the nation developed, flew, and retired a winged, reusable space vehicle and led a consortium of nations in building a large, orbiting research facility" and that "In this survey, sex and race were the strongest predictors of support for the space program: men tended to be more positive about the space program than women, and whites more than blacks. [27]"

Marketing Lunar Exploration
When considering the impact and opportunity related to the first women on the Moon, one must consider the incredible power the first Moon landings had to influence an entire generation of people.

Although girls and boys did view the event in different ways – with boys being much more likely to see the space program as something they could strive for, the interest clearly was universal. The Moon landing was watched by an estimated 600 million people around the world [40]. In July 1969, ninety-four percent of American televisions were tuned to coverage of the Apollo 11 mission to the moon. Considered one of the most successful marketing and public relations campaigns in history: the selling of the Apollo program. NASA and its many contractors marketed the facts about space travel—through press releases, bylined articles, detailed background materials, and fully-produced radio and television features –now called "brand journalism. [40]"

The 2017 Eclipse as a Model
In stark contrast to the TV/print/radio communications reality of the 1960s, the decade prior to the 2017 Great American Eclipse saw the merging of technologies and platforms for entertainment, commerce, education, work, news and interaction within an increasingly globalized society. This technological blending is called digital convergence – "magazine articles, radio programs, songs, TV shows, video games, and movies now available on the internet through laptops, tablets, and smartphones [47]." This phenomenon has transformed the ways that people share information and interact.

NASA effectively addressed scientific literacy and scientific contributions to society with its highlight technical information sharing, citizen science activities, and access to world-class experts and facilities. Similarly, the agency also delivered a truly broad, accessible, and culturally popular activity that the general public both embraced and owned.

According to Miller (2018) "154 million American adults – 63% of all adults age 18 or older – viewed the eclipse directly…An additional 62 million adults who did not see the eclipse directly viewed the eclipse electronically on a television, computer, tablet, or smart phone screen…A total of 216 million American adults viewed the eclipse directly or electronically, or 88% of American adults. [23]"

NASA similarly reported that "more than 90 million page views on nasa.gov and eclipse2017.nasa.gov, we topped our previous web traffic record about seven times over. For much of the eclipse, we had more than a million simultaneous users on our sites. On social media, we reached more than 3.6 billion non-unique users, and Twitter reports there were more than six million eclipse Tweets [24]."

In the end, the agency was able to reach billions through its eclipse communications campaign. While this paper considers lessons from the Apollo years in terms of engagement and impact, it is imperative that those involved with sending the first woman to the Moon also examine recent mass media events to determine relevant and modern best practices from a communications standpoint.

13. **The Role of STEM Education**

Over the past 30 years, researchers have pursued the study of gender differences in career choice. The Eccles' expectancy-value theory provides one of the most comprehensive theoretical frameworks for studying the psychological, behavioral and contextual factors underlying gender differences in math and science academic motivation, performance, and career choice [1] [2]

Drawing on principles of identity formation, achievement theory, and attribution theory, expectancy-value theorists propose that the path to a STEM career is a composite of a series of choices and achievements that begin in middle childhood and adolescence. It seems that achievement related behaviors such as academic performance and choice of profession directly correlate to expected rate of success, value attached to the discipline and perceived availability of potential options. These competence and task-related beliefs are directly influenced by societal norms, behavior genetics, social experiences, aptitudes, and the success to failure ratio of previous experiences [2]. Simply put, individual traits, beliefs and experiences associated with STEM-related activities influence how each individual develops self-efficacy, interests, and long-term life goals, which in turn, influence educational and career choices in STEM and non-STEM fields [3]. Therefore, it is probable that gender differences in STEM profession selection are associated with gender differences in motivational beliefs (e.g., self-efficacy, interests, value assigned to the discipline, etc.) [4].

According to expectancy-value theory, achievement-related choices (e.g., academic course and college major selections) and career aspirations are most directly influenced by ability, expectations for success and the subjective task value associated with available options. Subjective task value is a composite of four complex factors that interplay differently within each individual. These factors are 1) interest value (liking or enjoyment), 2) utility value (helpfulness in fulfilling personal goals), attainment value (the link between the task and one's sense of self and identity), and cost (the anticipated psychological, economic, and social investment of the pursuit). When individuals feel confident that they can develop the aptitude and be successful in particular subject areas such as math and science, the likelihood of persisting in deeper-level academic cognitive exercises increases [2, 4] [5]. Value related beliefs are predictors of achievement and academic engagement and are even stronger predictors of career aspirations in STEM [1, 2, 4] [6].

Gender differences in aptitudes have been studied for years. Over time, the number of girls achieving high test scores on math aptitude tests has dramatically increased, suggesting that ability levels in general are not static, but rather subject to educational and societal change. Thirty years ago, the ratio of boys to girls scoring above 700 on the SAT math exam at age 13 was 13:1; in 2010 the ratio had shrunk to 4:1 [9]. Moreover, by 2009, approximately 43% of bachelor's degrees and 30% of PhDs in math were earned by women [10]. Women also earned 27% of all degrees in computer science, 20% in engineering, and 36% in physical sciences. At the graduate level, females represent 30% of masters and doctorates in math, 25% in computer science, 23% in engineering and 31% in physical sciences [10].

Researchers conclude that intellectual aptitude, is not the primary factor contributing to the underrepresentation of females in STEM [8] [11]. Aptitude patterns and success rates do, however, influence career choice specifically, among males and females of comparably high math aptitude.

Expectations for success directly influence how individuals choose tasks, courses of study and career fields [1]. Extensive research has confirmed the role that poor math self-efficacy or perceived competence plays in female underperformance in mathematics [1]. Both girls and boys who rate their math competence highly are more likely to enroll in advanced math courses, choose a quantitative college major, and embark on STEM careers [14].

Understanding and intentionally targeting beliefs and barriers that steer females away from STEM is necessary to eradicating the disparity of men to women in STEM career fields. Research findings suggest that introducing and embedding aerospace science in grade four academic curriculum and educational activities (including after school hours), will not only increase girls' interest and confidence in science, but also builds foundational interest and shapes attitudes about STEM disciplines as they transition to middle school [15] [16].

Multiple studies agree that the STEM interest gender gap reveals itself in grades six, seven and eight, and girls' intellectual self-efficacy dips dramatically, resulting in loss of confidence and engagement in STEM [16]. Thus, addressing the topic of girls' engagement in science before the transition from primary to middle school is paramount to the future of science and technology, especially during this current time of innovation and rapid technological advancements [15].

The lack of female presence in STEM professions feeds the masculine stereotype surrounding math and is another prevailing factor perpetuating the gender disparity in science. There are subtleties in society which deliver the message that girls are inferior in science disciplines, despite documented evidence that contradicts this belief. The lack of visible female STEM professionals perpetuates this myth and allows girls to continue receiving and believing the subliminal message they are not intellectually suited for math and science disciplines. Additionally, "research indicates that the sex-role stereotyping of science as a masculine endeavor is one of the most powerful deterrents to adolescent girls enrolling and excelling in science courses" [17].

Seeing women in STEM careers can be an powerful accelerant that ignites and maintains female interest in STEM disciplines and pursuing a STEM-related career field. However, a great lack of female scientists as role models remains. One of the prevailing reason for this could be that retention in STEM career fields is low for women [15]. In 2012, the US Department of Commerce discovered that only 26% of women graduating with STEM degrees actually entered STEM careers [7].

With an increased awareness and of sexism surrounding the world of science, combined with the need for more gender inclusivity, the current generation of young elementary and middle school [1, 15]should be targeted for a deliberate attempt to increase in self-efficacy toward science, as well as engagement in STEM overall.

14. The Future

Artemis

In 2018 and 2019, the White House released a Space Policy Directive-1 to lead innovative and sustainable lunar exploration and further direction to do so by 2024. NASA is working to establish humanity's presence on and around the Moon by sending payloads to its surface, assembling a Gateway outpost in lunar orbit, and ultimately conducting the first human lunar landings since 1972. NASA's Artemis program is implementing a multi-faceted, coordinated approach focusing on the lunar southern pole, which will demonstrate new technologies, capabilities and business approaches needed for future exploration, including Mars.

Importantly, it has been emphasized that this mission will send the next man and *first woman* to the Moon by 2024 [49].

Of 38 NASA astronauts currently active as of October 2019, 12 are women and it is reasonable to assume that the female astronaut that will take a giant leap for womankind is already known [46]. Four of the 12 are women of color.

Expedition 60 All Female Spacewalk
Two female astronauts aboard the Space Station, Christina Koch and Jessica Meir, performed the first all-female spacewalk in history in October 2019, as part of an ongoing project to upgrade the batteries on the space station [48]

NASA Active Astronauts [46] a: female astronaut b: personal of color

#	Name	a	b	#	Name	a	b
1	Acaba, Joseph M.		x	20	Koch, Christina H.	x	
2	Arnold, Richard R.			21	Lindgren, Kjell N.		
3	Auñón-Chancellor, Serena M.	x	x	22	Mann, Nicole Aunapu	x	
4	Barratt, Michael R.			23	Marshburn, Thomas H.		
5	Behnken, Robert L.			24	McArthur, K. Megan	x	
6	Boe, Eric A.			25	McClain, Anne C.	x	
7	Bowen, Stephen G.			26	Meir, Jessica U.	x	
8	Bresnik, Randolph J.			27	Morgan, Andrew R.		
9	Cassada, Josh A.			28	Pettit, Donald R.		
10	Cassidy, Christopher J.			29	Rubins, Kathleen	x	
11	Dyson, Tracy Caldwell	x		30	Tingle, Scott D.		
12	Epps, Jeanette J.	x	x	31	Vande Hei, Mark T.		
13	Feustel, Andrew J.			32	Walker, Shannon	x	
14	Fincke, E. Michael			33	Wheelock, Douglas H.		
15	Glover, Victor J.		x	34	Wilson, Stephanie D.	x	x
16	Hague, Tyler N.			35	Williams, Jeffrey N.		
17	Hopkins, Michael S.			36	Williams, Sunita L.	x	x
18	Hurley, Douglas G.			37	Wilmore, Barry E.		
19	Kimbrough, Robert Shane			38	Wiseman, G. Reid		

7. Conclusion

During the 1960s, girls were inspired and enthralled by space –just as much as boys but this interest came with a caveat. Words like "even though" and "just a girl" used by girls writing letters to the Apollo astronauts go hand in hand with language like "less than", "alternate", and "instead of" used by NASA managers then and even now.

It is common knowledge that the Apollo program inspired a generation of scientists and engineers which for the most part has exhibited a lack of diversity reminiscent of society then and now. The prospect of sending the first woman to the Moon is an opportunity to influence the sense of possible selves that is so important during the formation of career aspiration as well as professional recognition, momentum, attrition and achievements.

NASA should, in practice, put in place mechanisms to ensure that this step forward for women in spaceflight and STEM will be long-term, and actively communicate its commitment to doing so, which will alleviate any mistaken perception that the first woman on the Moon is a marketing ploy or a single event that will not be sustained. Consistent strategic messaging approaches should be implemented, because what is being said about women and their contributions is just as important from a societal standpoint, as the actions being taken to be inclusive. This includes:

- Talking points and training for all senior level institutional staff and representatives regarding language that does not inherently and subconsciously label women as "less than".
- An acknowledgement of the past challenges related to inclusion that institutions and society have faced, with a positive view moving forward – rather than making excuses for past and current inequity.

As we look to travel to the Moon sustainably, we should consider supporting activities that engage and cultivate women and diverse teams in a long-term and sustainable fashion, to include: STEM education and awareness activities that leverage female role models and address confidence and self-efficacy; long-term engagement and outreach opportunities on a program level beyond single promotional activities that are dependent upon external advocacy, mentors or policy; opportunities on a personal level to increase experience, knowledge, growth, and self-confidence; mentorship and career support for women in STEM workplaces; and analysis and support beyond adding women's stories to the historical record, to include incorporating analysis and context of the contributions of women at all levels, and considering oral history conducted as an ongoing part of the program.

Governments, institutions, communities, supervisors, workers, families, educators and communicators all have a key role to play in this incredible opportunity to inspire an entire generation, meet future workforce needs, and transform the human experience by living on another world.

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