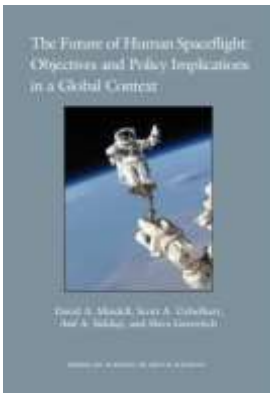

The Future of Human Spaceflight:
Objectives and Policy Implications in a Global Context

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Augmented with a Snapshot taken in August 2022
Compiled by the JSOC Editor Joachim J. Kehr

"Space has long been the setting of especially intricate encounters between human aspirations and the implacable laws of the physical universe. It is a natural laboratory of fundamental science, at once the source of seminal conceptual achievements and bewildering mysteries. It has been the venue for both spectacular feats of engineering and tragic accidents. It has been the locus of uplifting collaboration among nations as well as ominous confrontation. It is an ever-compelling template on which popular imagination plays out."

This preface-text of the AAA&S book "The Future of Human Spaceflight" explains perfectly the desire of mankind to explore space by sending men and women into the hostile and dangerous environment of space.

A comparison of policy ideas developed in 2008/2009 by MIT [1] and the American Academy of Arts and Sciences (AAA&S) [2] with a Texas State University (NASA STEM Engagement & Educator Professional Development Collaborative) [3] evaluation in 2019 and the actual status in mid of 2022 is presented.[8]

Status End of 2009
It can be seen that the baseline policy proposed in 2009 was fair enough, however could not be followed because of political, economic and unpredictable crises. The overarching goals are still clear: Make maximum use of the ISS, follow up the established international co-operations and expand them to include China, go back to the Moon and stay there and finally reach out for Mars.
When the book was published, the current scenario was the "Vision of Space Exploration" (VSE) announced on January 14, 2004 by President George W. Bush.

The VSE was a plan for space exploration conceived as a response to the Space Shuttle Columbia disaster, the state of human spaceflight at NASA, and as a way to regain public enthusiasm for space exploration. The Vision for Space Exploration sought to implement a sustained and affordable human and robotic program to explore the Solar System and beyond; extend human presence across the Solar System, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations; develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and to promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests based on the *Constellation* Program (2005-2009).

The open questions in the wake of the VSE, discussed in the book and published in 2009 were:
• When should the United States retire the Space Shuttle?
• How should the nation utilize the International Space Station?
• Should the United States return to the moon? If so, how and on what schedule?
• How should future plans balance the moon, Mars, and other possible destinations?

Ultimately, these decisions derived from the larger question:
Why fly people into space?

In the book the authors defined *Primary* objectives of human spaceflight as those that can only be accomplished through the physical presence of human beings, have benefits that exceed the opportunity costs, and are worthy of significant risk to human life. These include exploration, national pride, and international prestige and leadership. Human spaceflight achieves its goals and appeals to the broadest number of people when it represents an expansion of human experience.

Secondary objectives have benefits that accrue from human presence in space but do not by themselves justify the cost and the risk. These include science, economic development, new technologies, and education.

The authors argued that a new U.S. human spaceflight policy should use these objectives to balance funding, expectations, and acceptable risks to human life. Congress and the White House should reduce the "too much with too little" pressure that has led to disaster in the past and that characterizes NASA's predicament today.

As conclusion the authors recommended:
• NASA should continue to fly the Space Shuttle to complete the current manifest and then retire it.
• The United States should develop a broad, funded plan to utilize the ISS through 2020 to support the primary objectives of exploration.
• A new policy should direct the balance between the Moon, Mars, and other points of interest in future explorations.
• NASA should reopen basic research in the new technologies that will enable these explorations.
• The United States should reaffirm its long standing policy of international leadership in human spaceflight and remain committed to its existing international partners.
• The United States should continue existing partnerships within the ISS, including the sustainable partnership with Russia, and begin to engage on human spaceflight with China, India, and other aspiring space powers.

Meanwhile, as of summer 2009, a new presidential commission chaired by Norman Augustine (*Augustine Committee*) had been tasked to evaluate the U.S. human spaceflight program and potentially reconsider NASA's current direction. An excerpt of the committee's findings [3] postulated:

- Under current conditions, the gap in U.S. ability to launch astronauts into space will stretch to at least seven years. The Committee did not identify any credible approach employing new capabilities that could shorten the gap to less than six years.

- The Committee developed five alternatives for the Human Spaceflight Program. It found:
  - Human exploration beyond low-Earth orbit is not viable under the FY 2010 budget guideline.
  - Meaningful human exploration is possible under a less constrained budget, increasing annual expenditures by approximately $3 billion in real purchasing power above the FY 2010 guidance.
  - Funding at the increased level would allow either an exploration program to explore the "*Moon First*" or one that follows the "*Flexible Path*". Either could produce significant results in a reasonable timeframe.

Consequently the policy outlined by the "Vision for Space Exploration", was replaced first by President Barack Obama's space policy in April 2010 as recommended by the Augustine Committee and, later by President Donald Trump's "National Space Strategy" space policy in March 2018, which formally established the NASA *Artemis* program based on many *Constellation* program developments - and finally by President Joe Biden's preliminary space policy proposals in spring 2021.

Status November 1, 2019
After Trump's establishment of the Artemis program in this National Space Strategy the NASA STEM Engagement & Educator, Professional Development Collaborative published their assessments in 2019 [4]:
The future for NASA manned exploration, in the meantime, is up in the air.
While the Mars One mission put the world in a frenzy for colonizing Mars by 2027, the technology that would be necessary for such a mission is still being developed. The more likely and logical next step for manned NASA missions would first be to an asteroid or even back to the moon, as practice for the Mars landing. After putting man on an asteroid, the next step very well could be Mars or its moon, Phobos.
But creating a full-fledged colony on Mars in ten years is still a long shot by today's technological standards. According to NASA, more powerful propulsion systems and vehicles will need to be designed for the long-haul, six-month journey to Mars that could accommodate a crew.
"The biggest first step is a heavy lift vehicle. It's incredibly important. We're going to have to launch the equivalent of the full-up space station that we currently have in orbit to get to the Martian surface and back," said Cooke, NASA's associate administrator for ESMD.

Aside from improvements in NASA's transportation systems, other advancements would be needed for deep space travel. Communication improvements would be needed to able astronauts to report back to Earth without quality issues. Another necessary development is resource utilization, such as mining for ore. Another obstacle to the future of human spaceflight to Mars is the implementation of a craft that can both support deep-space habitation and efficient travel. With current technology, this craft would have to be designed similarly to the International Space Station, which cost $150 billion to develop.
Advancements in robotic technology would also give astronauts on Mars an advantage by providing assistance with physical tasks, such as drilling. There are also safety concerns that need to be taken into consideration. New landing systems and radiation precautions would be needed to safely send and return astronauts to and from Mars.

Current Status Mid of 2022
The Biden administration continued the Artemis program to send people back to the Moon

The Artemis program began in December 2017 as part of successive efforts to revitalize the U.S. space program. NASA's stated short-term goal for the program is landing the first woman and first person of color on the Moon; mid-term objectives include establishing an international expedition team, and a sustainable human presence on the Moon. Long-term objectives for Artemis are laying the foundations for the extraction of lunar resources, and eventually making crewed missions to Mars and beyond feasible.[6]

The Artemis program is carried out predominantly by NASA and U.S. commercial spaceflight contractors, in partnership with the European Space Agency and the space agencies of several other nations. Other countries have been invited to join the program through signing the governing Artemis Accords, which have remained open for signature since October 2020.

Global Human Spaceflight Activities
USA
On August 22, 2022, NASA gave green light for the first launch window of Artemis I.
From a technical point of view, the signs were good for the first flight of the new SLS heavy-lift launch vehicle with the Orion spacecraft on board. However the launch had to be scrubbed because of leaks then because of the hurricane Ian end of September. The launch is still expected to take place from Launch Pad 39A at NASA's Kennedy Space Center in Florida in 2022!
The Artemis I mission is scheduled to last 42 days and to return the Orion crew capsule to Earth safely after having orbited the Moon several times.

Russia
The nation announced in July 2022 that it intends to pull out of the International Space Station (ISS) consortium after 2024. The timing of that move is uncertain, but Russia wants it to dovetail with the readiness of the planned Russian Orbital Service Station (ROSS). [5]

China
China has followed up its Project 921 since the last 30 years to the dot and is currently operating its Taigong space station with a crew of three.
Tiangong (lit.Palace in the Sky'), officially the Tiangong Space Station, is a space station being constructed by China in low Earth orbit between 340 and 450 km (210 and 280 mi, inclination 41,470) above the surface.
The Tianhe core module with docking node was launched April 29, 2021 on a CZ-5B, then Wentian second core module, was launched July 24, 2022 on a CZ-5B, the Tianzhou-4, a robotic cargo craft, docked automatically to the Wentian module on May 9, 2022, launched with a CZ-7, and the Shenzhou-14 crew vehicle docked to the multiple port docking node on June 5, 2022.
Once completed, Tiangong space station will have a mass between 80 and 100 t (180,000 and 220,000 lb), roughly one-fifth the mass of the International Space Station (ISS). [6]

India
The Indian Human Spaceflight Program was initiated in 2007 by the Indian Space Research Organization (ISRO) to develop the technology needed to launch crewed orbital spacecraft into low Earth orbit. The first un-crewed flight, named Gaganyaan 1, is scheduled to launch no earlier than Q1 2023 on a GSLV Mark III rocket. [7]
India's space station is also planned to launch by 2030 and it will be an extension of the Gaganyaan program. Scientific and industrial research in areas of fundamental applied and engineering sciences will be conducted in the space station.

Europe (ESA)
Europe (ESA) and the ISS partners are cooperating with the USA in the Artemis program, the operation and maintenance of the ISS has been very successful despite many hurdles caused earlier by the retirement of the Shuttle (STS) system. It is currently scheduled to be active and funded until 2030.
The service and propulsion module of the Artemis Orion spacecraft is the European Service Module (ESM), mainly built in Germany.

Conclusion
Altogether the future of human spaceflight wouldn't look so bad, the overall principles and goals of the AAA&S study have been followed and kept alive through many unpredictable political and budgetary obstacles.

However it remains to be seen how the three dominating disrupting global crises, the Covid pandemic, climate change and the Russian military actions against the Ukraine which started on February 24, 2022, will influence and change the global economy and peoples living together on a broad scale and with it definitely also scientific and human spaceflight activities.

Let's hope, that the MIT study conclusion of 2019 might hold true after all! [2].
"The future of human spaceflight is an exciting prospect full of both possibility and danger. Thanks to the expansion of STEM programs, mankind is stretching the limits of exploration and developing our future in the stars. Science, technology, engineering, and mathematics have never been more crucial to the development of space travel."

Artemis I (August 2022)
At the dawn of a new spaceflight era?

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