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Humans beyond Earth

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ABSTRACT: Humans have been a wildly curious species for millennia. From traveling across unmapped oceans to the first lunar steps, mankind had the ambition to explore dangerous, uncharted destinations. In 1966, the NASA budget was 4.41% of the Federal budget. Fifty years later, NASA's budget was 0.50% of the Federal budget. While there is still strong interest in intermediate space, that's because it's in the comfort zone of commercial interests with profit motives. We as a species need to resist this sole motivation. Many companies and governments won't invest in a manned expedition to Mars since the profits would take decades to manifest (if there are any profits at all). However, recently a new breed of billionaires, including Elon Musk and Jeff Bezos, realized the importance of investing in a Mars mission because of the positive impact for humanity later. Making a habitable colony for humans on Mars will be extraordinarily difficult - Mars is a hostile environment, but over time, impossible journeys evolve from difficult challenges to success. A trip to Mars would represent a leap in our maturity, a revitalization of the human spirit that charges into the unknown to understand and use it. This paper will research the challenges of getting to Mars and why we should go there. Who knows, we may find life under the dunes of Mars and discover we aren't the only ones.

Keywords: mission to Mars, space exploration, NASA, NASA private partnerships, SpaceX, Falcon Heavy, commercialization of space, pros and cons of funding a manned mission to Mars, overcoming scientific challenges to space habitation, living conditions on Mars

Introduction

In April, 2019, the National Aeronautics and Space Administration (NASA) published a document outlining its vision for the road map of a manned mission to Mars. (NASA 2019). NASA reported that it's working with U.S. companies and international partners to "push the boundaries of human exploration forward to the Moon and on to Mars" (NASA 2019). NASA is working to establish a permanent human presence on the Moon within the next decade to uncover new scientific discoveries and lay the foundation for private companies to build a lunar economy (NASA 2019). The Mission to Mars is part of the revitalization and "second wind" of NASA's legacy—NASA has not had a manned space launch since the Atlantis Space Shuttle took off on July 8, 2011 (Chow 2011).

The path that led NASA to this point - History of Apollo and the drive

The 11th mission under the NASA Apollo program of the 1960's resulted in two men walking on the moon, a momentous achievement for humanity. It represented the first time humans were physically standing on another celestial body and both Neil Armstrong and Buzz Aldrin survived the experience to live a normal life back on Earth. 50 years ago in July, 1969, the United States proved that they had beaten its #1 rival—the Communist nuclear superpower the U.S.S.R—to the moon and in the immediate years following that day, the enormous expense of $24 billion invested in the space program ($100BN in current dollars) proved unsustainable for the overall US government's annual budget. Within 5 years, the US changed its priorities (The Editors of History.com, 2019).

The Russians had achieved great success in the first 8 years of space exploration starting in the mid-1950's, but its leadership could not be sustained and by the end of 1964, the Soviet Union had already lost the space race. Several years of technology failures occurred and with no strong export economy to support a military and space travel, the Soviets abandoned plans to send men to the moon by 1971 (Wilford 1989).

The decades since then were characterized by continued presence in space in the form of the Space Shuttle, Skylab, the International Space Station (ISS), Vikings 1 and 2 and deep space exploration probes. The enthusiasm from the public became ambivalent and complex after the catastrophes of the Space Shuttles Columbia and Challenger. But the US is ready to revitalize its space exploration designs.

Current plans to get to Mars and the obstacles they have to face

Of all of the publicly announced projects, the plans proposed by SpaceX - the privately held commercial enterprise led by entrepreneur Elon Musk—and NASA appear to be the most promising. The goal is to reach Mars in the next 15 years and to establish a habitable space for humans. The first step for NASA is their Artemis mission that will send humans to the moon again in the next 5 years to establish a permanent colony for humans, laying the foundation for a Mars mission (Davis 2019). There are a variety of reasons that having a presence on the moon with make interplanetary travel easier: 1) The knowledge of making the Moon habitable most probably will apply to future Mars colonization 2) Spacecraft bound to Mars could refuel at stations orbiting the Moon if the technology is sufficiently developed (Davis 2019).

Let's discuss the planned logistics concerning how the necessary resources and materials will get to the Moon. To deliver the resources allocated for infrastructure, NASA has been constructing the Space Launch System (SLS), the most powerful rocket the US has ever built (NASA SLS Fact Sheet, 2018).

SLS is an enormous collaborative industrial/technology project with more than 1,000 companies from across the U.S. working with all 10 NASA geographic centers supporting the development of what will become a rocket capable of transporting the heaviest payloads ever brought into space (NASA SLS Fact Sheet, 2018). The SLS Program at Marshall Space Flight Center in Huntsville, Alabama, works closely with the Orion Program, managed by NASA's Johnson Space Center in Houston, and the Exploration Ground Systems at Kennedy to coordinate testing for Artemis (Artemis is the mission name for the next Moon landing program, just as Apollo was the mission name in the 1960's), formerly known as Exploration Mission 1 (NASA SLS Fact Sheet, 2018).

As of May 29, 2019, NASA and Boeing engineers were working to assemble the large structural components of the core stage of the SLS (Editors, NASA Makes Progress Assembling Massive Space Launch System Rocket Stage). When this stage is finished, 4 out of the 5 essential components of the SLS will have been assembled (Editors, NASA Makes Progress Assembling Massive Space Launch System Rocket Stage). The final piece of the puzzle is adding four RS-25 engines, which will produce 2 million pounds of thrust for Artemis 1. When completed, SLS will enable astronauts to begin their journey to explore destinations first to the Moon, then Mars then maybe farther into the solar system by the turn of the 22nd Century (Editors, NASA Makes Progress Assembling Massive Space Launch System Rocket Stage).

NASA plans on combining the SLS thrusters with the Orion spaceship for future space missions, which will combine plans for habitats in addition to scientific studies. One of the first planned science missions for 2020 is BioSentinel, a very important monitoring program – the primary objective of BioSentinel is to develop a biosensor to detect and measure the impact of space radiation on living organisms over long durations beyond Low Earth Orbit (LEO) (NASA, BioSentinel Engineering Project, 2019).

NASA's New Spaceship

As part of the plans for the SLS construction and space habitation for humans, NASA is working with its aeronautics partners to design and develop a small spaceship that will serve as a home/office for astronauts will orbiting the Moon called the Gateway. (Nichols 2019).

The Gateway will have living quarters, laboratories for science and research, docking ports (like doors) for visiting spacecraft, and more. It will provide NASA and its partners access to more of the lunar surface than ever before, supporting both human and robotic missions. The Gateway will be built in stages with input from global space experts (NASA editors, 2018, Q&A about NASA's New Spaceship). The power and propulsion component will be provided by a private vendor, either SpaceX or Blue Origin (the large privately-owned commercial space start-up funded by Amazon entrepreneur Jeff Bezos), estimated for 2022. Large parts of the Gateway will be sent on multiple rockets for automatic assembly in space, requiring 6 launches compared to the 34 for when the Space Shuttle was built. Some parts may be sent on SpaceX or Blue Origin rockets, but NASA's SLS rocket will deliver most. Orion will transport the parts hundreds of thousands of miles to Gateway. The Gateway is forecasted to be completed by 2026 (Nichols 2019).

Astronauts will visit the Gateway at least once per year, but they won't stay year-round like crew aboard the International Space Station. The Gateway is much smaller than the ISS. Its interior is about the size of a studio apartment (whereas the space station is larger than a six-bedroom house) and designed for only 4 astronauts. Once docked, astronauts can live and work aboard the spaceship for up to three months at a time, conduct science experiments, and take trips to the surface of the Moon. (Nichols 2019, Real Clear Science)

A shining example of NASA's rejuvenated grand vision—reminiscent of the 1960's spirit of exploration—was unveiled on April 7, 2017, when NASA officially presented its plans for the Deep Space Transport (DST), which is effectively a miniaturized space station meant to travel to Mars and back, with a crew of four, for a duration of at least 1000 days. When this announcement was made, space travel expert Jason Davis wrote that, hardly anyone noticed (Davis 2017. NASA unveiled new plans for getting humans to Mars, and hardly anyone noticed). But "that's probably okay with (NASA Director Bill) Gerstenmaier. Wary of being buffeted by political winds, NASA treads lightly these days—at least publicly. Advisory Council meetings aren't really promoted, and the agency isn't exactly shouting the plan from the rooftops" (Davis 2017). Seven months later, President Trump had a ceremony in the Oval Office where he signed a directive ordering NASA to work on more Space exploration, including a manned mission to Mars (Tillet 2017).

NASA has viewed human missions to Mars as the agency's long-range goal, but senior management, backed by earlier guidance from the administration, strongly favors sending astronauts back to the moon first to gain experience and test the technologies needed to eventually reach the red planet. Ironically, as we write this paper, President Trump tweeted on June 7, 2019, "For all of the money we are spending, NASA should NOT be talking about going to the Moon - We did that 50 years ago." "They should be focused on the much bigger things we are doing, including Mars (of which the Moon is a part), Defense and Science!" the president tweeted (Harwood 2019, CBS News). Does the President understand the scientific and logistical reasoning behind NASA's plans?

Expert Appraisal on whether NASA's Plans are achievable, based on the budget

A report issued on April 17, 2019, ordered by Congress as part of NASA's 2017 Budget authorization for a Mars-mission by 2033 and its related costs (such as the SLS, Orion and the associated costs with supporting those projects), determined that the objectives are impossible to achieve. The report estimated that the total price for everything listed will add up to more than $120 billions of dollars through NASA's fiscal year 2037 (Link, Crane, Zuckerman, et al, 2019).

The report was prepared under NASA contract by the Science and Technology Policy Institute (STPI). In addition to estimating the higher costs, the STPI stated that given the forecasted budget and commensurate resources, it's not feasible to have a manned Mars mission by the target date of 2033 without significant cost overruns. The conclusion was based on the incremental changes in funding that would be necessary from both the government and from the privately-owned commercial enterprises (Link, Crane, Zuckerman, et al. 2019).

The Role of SpaceX in space exploration budgeting

SpaceX is a private company founded by billionaire entrepreneur Elon Musk, going by a business model to make everything in the space industry cheaper, thereby reducing the cost of space travel and logistics. According to a Time magazine report, SpaceX manufactures 80% of the parts needed to launch its Falcon Heavy rockets cutting a lot of the cost of manufacturing (Kluger 2017).

Elon Musk is quoted as saying that the rocket industry overcharged customers because of the cost plus system, lack of competition and because the manufacturers reused nothing (Chalkin 2012). To further reduce the cost of launches, SpaceX makes their rockets reusable by having the spent fuselage, empty of fuel, re-land at their facility after a successful mission. SpaceX uses this business model disrupt the space industry landscape with quoting customers very low prices to launch satellites. Their closest Nasa counterpart, the Space Shuttle, cost $450 million dollars per launch for 27 metric tons to low earth orbit, the Falcon 9 cost $50 million per launch for 13 metric tons in low earth orbit. The Falcon 9 costs $3,846 per ton in orbit while the Space Shuttle's costs were $16,666

per ton in orbit, meaning the Falcon was less than a fourth of the price. Published reports state no competitor, even the Chinese, can quote as low as SpaceX (Chalkin 2012).

Comparisons of the two organizations SpaceX and NASA

It's hard to compare the two organizations directly because they don't share the same history, structure, management style or future plans. The Space Shuttle had a 27,500kg payload capacity or 60,600 pounds while the Falcon Heavy has a payload capacity of 62,800 kgs or 140,000 lbs (Dodd 2018).

However, SpaceX plans to use three reusable boosters to launch payloads and each booster has 30,000 kgs or 66,000 lbs of thrust (Dodd 2018). The reusable boosters will most likely be SpaceX's published usable payload to orbit (Dodd 2018). To begin an analysis of the cost of the Space Shuttle compared to Falcon Heavy, one must consider that the second Space Shuttle was built with the safety of the astronauts in mind, especially when the lessons of the Columbia catastrophe was assessed. In the end, the refurbished Space Shuttles ended up being very expensive (Dodd 2018).

Professional subject matter experts calculate the total all-in (every cost included) to be 210 billion dollars. There were 135 Space Shuttle missions, so the average cost was over $1 billion. However, NASA charged customers $450 million to take something up on the Space Shuttle. SpaceX is charging $90 million dollars for payload launches. This makes SpaceX five times cheaper (Dodd 2018). NASA's next generation project SLS is based on the Space Shuttle technologies. Fuel engines and massive rocket boosters are also reused tech from the Space Shuttle (Berger 2019).

The Pros and Cons Concerning Mars Colonization

Though a manned mission to Mars would be a huge technological leap in human progress, many say that our main focus should be on the earth and current problems, namely global warming, reformation of the political structure, social problems and more in that vein. In fact, some writers lament that those enthusiastic about planning and funding a trip to Mars are met with incredulous reactions, as many people don't understand how anyone could deem it a priority and meritable idea to pay for a safe manned mission to Mars (Stratford 2010).

Here are some arguments against Mars colonization as summarized by the Guardian newspaper of the United Kingdom. 1) Man will contaminate Mars with earthly human microbes. The famous space physicist Carl Sagan said "if there's life on Mars, I believe we should do nothing with Mars. Mars then belongs to the Martians, even if the Martians are only microbes … the preservation of that life must, I think, supersede any other possible use of Mars." 2) Robots are better than humans. Robots have several inherent advantages. They are much cheaper than humans because they don't require a vast support infrastructure to provide things like water, food and breathable air. They are immune to the risks of cosmic radiation and other dangers inherent to space travel. And they won't get bored. 3) Spend the money on fixing Earth first. Although some people are motivated by Elon Musk, who says "we need a back-up planet", most Americans believe that the hundreds of billions of dollars in spend are not necessary (Barmaal 2018).

In a Pew survey, a majority of US adults—72% believed that NASA should remain a world leader in space exploration (Pew Research 2018). However, 62% still believe that the billions—if not trillions—of dollars needed to colonise Mars could, for example, be better spent investing in renewable forms of energy to address climate change or strengthening our planetary defences against asteroid collisions (Pew Research 2018). Even with in the pro-human colonization group, many debate whether Mars is the best choice. Some candidates for this are logical, our Moon, simulations of planets on earth, while others are more leaning to the side of science fiction. A prime example of this would be Titan, a moon of Saturn that has an atmosphere that's thicker than Earth's, with about a tenth of the gravity, and abundant with surface ice. Many argue that this environment lends itself more to humans than Mars could (Understand it All 2017 Four Alternatives for Colonizing Mars).

Ideas and criticisms of Mars bound technology

Getting to Mars and eventually permanently living on the planet will require new technology, most never used, let alone tested; everything will be experimental and newly introduced. Supporting humans for

extended periods of time will be difficult given the situations and difficulties they will face (Sharp 2017). For example, to comfortably live on the Martian surface, astronauts require radiation protection given that the Martian atmosphere is a 1/1000th of the density of Earth's, without this, astronauts would be constantly exposed to radiation (Staff Writers, MarsOne, 2014). In addition to protection from harmful radiation, their habitats need to be strong enough to withstand Martian dust storms, potential accidents and other hazards to durability, all while holding atmospheric pressure. After all the supplies have been sent to Mars in preparation for the manned mission, tests must be conducted to ensure the astronauts are not endangered on their seven month journey to Mars (Ornes 2018).

Providing the power for the long space voyage is a capsule made by the European Space Agency in Bremen, Germany. The capsule is the service module for the Orion spacecraft and, once out of Earth's atmosphere, it will extend solar panels stretching 19 meters across to power the vehicle (NASA.org editors, 2015, The Journey to Mars: Bridging the Technology Gap). Inside the Orion module, arranged like a dense 3D puzzle, are the wires, cables, devices and materials needed to support human beings as they voyage into deep space, including fuel, air, and water. Sitting atop the service module and measuring 3.3 m in height, will be the crew module, the astronauts' home for their long journey. This is cutting-edge science fiction now science fact technology (Ornes 2018).

The trip itself is arduous beyond comprehension and it's hard to imagine any human wanting to do it. According to NASA's plans, the space explorers will leave Earth perched on a powerful rocket and potentially rendezvous with a crewed space station called the Deep Space Gateway near the Moon – a kind of launchpad for missions to the Moon, asteroids and Mars (NASA.org. 2015). After a few days preparing at the DSG, the crew would board a spacecraft that shuttles people to deep space and back.

For six months or more, the crew will travel—sealed in a box the size of a small motor home, and with a view of Earth receding to a tiny pinprick of light—until they reach Mars and begin to orbit the red planet. Then, they'll move to yet another vehicle, parked in Mars' orbit, and plunge through the planet's thin atmosphere, landing near pre-built habitations, possibly 3D printed out of ice or regolith. They'll stay for 18 months, conducting geological research and maintaining the habitat, then head home (NASA.org. 2015).

NASA passed the latest Mars mission test - NASA's Mars Helicopter has proven its off-world mettle

On March 29, 2019, NASA successfully tested a model of the Mars Helicopter under simulated Mars weather conditions, according to NASA scientists (Wall 2019). The 4-lb. (1.8 kilograms) aircraft, a technology model that will be included in the next Mars rover in July 2020, aced its first-ever test flight under Red Planet conditions, agency officials announced Thursday (March 28) (Wall, 2019).

"Gearing up for that first flight on Mars, we have logged over 75 minutes of flying time with an engineering model, which was a close approximation of our helicopter," Mars Helicopter project manager MiMi Aung, of NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, said in a statement (Wall 2019).

The theoretical benefits from exploring

If a manned mission to Mars is executed, and successful, the technologies and researched for/on Mars can be beneficial to general space explorations and may find applications on Earth. This has happened before in the form of SkyLab and the ISS - since the original 15 nations signed the International Space Station agreement in 1984, 68 nations have participated in ISS activities in some capacity. This international cooperation produces beneficial results for developing economies (NASA 2013). NASA staff extensively researched the question of what positive outcomes would result from space exploration—ranging from cancer treatments, water recycling systems, agricultural innovation, alloys, tele-communications, and many more advancements (NASA 2013).

From Mars the most obvious examples of scientific benefits we could reap would be: advanced hydroponics, efficient recycling methods, lightweight and strong materials, robotics, material sciences, and insight into how cellular life evolved (NASA 2013). Mars could also be a major

resource of materials or technological goods if travel between the two becomes common place. The colonization of Mars, could single handedly kickstart humanities passion of exploration. The coverage of Martian life and development will undoubtedly inspire many to pursue many scientific fields in the hopes to be apart of something larger than themselves. A prime example of this is the climax of the Apollo program, where from 1961, physics PHD graduates increased by 200% by the end of the program.

We would also gain insightful sociological and psychological knowledge from the data and behaviors from the isolated colonists. How would they react to a new alien environment? Would they learn to be more politically autonomous or rather lend control to NASA, U.N or their origin country? Lastly, as we expand our influence on Mars, there is a small possibility of finding signs of life, whether it be through finding imprints of plants, or detecting a large amount of organic chemicals, this will fundamentally change our perspective of the universe and ourselves.

Conclusion

With all these benefits cited from the operation and the promising technology giving us the theoretical capability, we still have to hurdle over the actual execution of the manned mission to Mars. It will be a difficult endeavor—as all things are at the scale of space travel—but the benefits and knowledge learned from the Artemis, Orion, SLS, Gateway, BioSentinel and Deep Space programs will lead humans out of earth and into unclaimed lands. Mars, is however only the beginning, and a fitting start to unify humans behind the idea that we are not alone.

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