The science and vision behind a mission to Mars

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If you were more than 5 years old on July 20, 1969, you probably watched the live broadcast of the first astronauts to land on the moon. And you have never forgotten the thrill.

Hundreds of millions of people from around the world were sitting in rapt attention before their TVs, watching and listening to every word coming from the NASA feed. Since no one had ever done it before, even NASA didn't know exactly what to expect. This made the attempt to land the lunar module, named the Eagle, even more dramatic. Some scientists speculated that the surface of the moon was covered with dust, many feet thick. The previous missions to the surface of the moon by the Surveyor spacecraft found that a manned landing could be made safely. But not all doubt was removed. If the dust were softer and deeper than planned, the lunar module's legs might sink into the surface. The craft would either have disappeared, or tipped over. And that would have been the end of the mission and probably the end of the astronauts.

We all held our breath as the lunar module approached the surface. Fortunately, the dust layer was not a problem. Instead, we all watched as the Eagle landed safely onto Tranquility Base. And, later that night, as Neil Armstrong set foot on the moon's surface and said, "One small step for (a) man, one giant leap for mankind," an unforgettable moment in Earth's history.

Well, sometime in the 2030s, about 20 years from now, we will experience a similar event. Men will land on the surface of Mars; the first to ever set foot on another planet. It will be a much more difficult feat than landing on the moon. For one thing, the moon is about 250,000 miles from Earth. Whereas, Mars is about 250 million miles, or 1,000 times farther. But, Charles Bolden, NASA administrator, says he is confident that we can accomplish the mission by that time. The many technologies necessary for a successful manned mission are all under development and planned to be perfected in time for mission launch.

Last year, an award-winning movie, "The Martian," showcased realistically these technologies. They include the ability to make oxygen from the Martian atmosphere, to grow plants for food in a non-Earth environment and to recover water from the Mars surface. Yet another is the development of deep space propulsion systems to get the astronauts to Mars and back to Earth.

The chemical rockets with which we are all familiar will not be adequate for the Mars mission. Yes, they will be used to get the spacecraft into Earth orbit. But for the long, energy-consuming journey from Earth orbit to Mars, the limits of chemical rockets are exposed. The spacecraft, with the required payload and carrying the most energetic chemical propellant available, would still not be able to carry enough of that propellant to make the trip to Mars and back. So, a new type of propulsion system is needed to overcome this problem.

In the movie "The Martian," an ion propulsion system was used to go to Mars from Earth orbit. This is exactly the type of system that NASA is going to use for the real-life mission. An ion engine uses electric power to ionize a gas (breakdown the gas atoms into positive and negative components). Then, a strong electric field is employed to accelerate the positive particles (ions) out of the engine at super high speed. The result is a miniscule, but positive, thrust. In zero gravity space, however, even this tiny thrust can accelerate the spacecraft. The acceleration will be very slow. But, it will be continuous, and over time, the craft can reach a very high speed. And that is the secret to the success of ion propulsion. It can operate continuously for months, or even years, with very little consumption of fuel compared to a chemical rocket.

The first NASA mission to use an ion engine was the space probe Deep Space 1, launched in 1998. A more recent application was the ion propulsion system for the Dawn spacecraft, launched in 2007. Dawn is now in orbit around the dwarf plant Ceres (diameter of 587 miles). Ceres is found in the asteroid belt between the orbits of Mars and Jupiter.

A key to the use of ion engines is to have adequate electric power to operate them. To generate the electric power, NASA has some options. The first option that comes to mind is solar panels. However, with today's technology, solar is unlikely to play a significant role in a Mars mission. This is because as the panels move farther away from the sun, the energy available is reduced exponentially. Given that the Earth is 93 million miles from the sun, and Mars is about 250 million miles farther out, the solar cells' production of electricity would only be a small fraction compared to the amount they generated in Earth orbit. To get the same amount of power in Mars orbit as in Earth orbit, the area of the solar panels would have to increase dramatically.

Solar cell technology development programs are working toward making the cells much more efficient. So, even with the smaller amount of sun power available in Mars' orbit, more of that power would be converted to electricity. If the efficiency improvements are great enough over the next 20 years, solar panels may be able to play a more significant role in a manned Mars mission.

Another power source used for many past Mars missions is a radioisotope thermoelectric generator. It is a self-contained device, so it doesn't have the problem associated with the solar panels. This generator uses a small amount of plutonium-238, a relatively safe radioactive material. The isotope is naturally decaying and produces heat energy with the decay. The heat is then transformed into electricity using a device called a thermocouple. The amount of power produced by these units is adequate to operate the ion engine during the flight. Upon landing on Mars, the power sources can then be used to operate ground-based equipment.

It now looks like, from a technology point of view, we can undertake successfully a manned mission to Mars. But should we? There is a perennial argument from people with a near-term view of the world that the resources required to go to Mars would be better applied to solving Earth's problems like disease and poverty. For those with a long-term view of our future, however, there is no question. In their opinion, we need to leave Earth and colonize another planet. Our long-term survival as a species may ultimately depend on it.

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