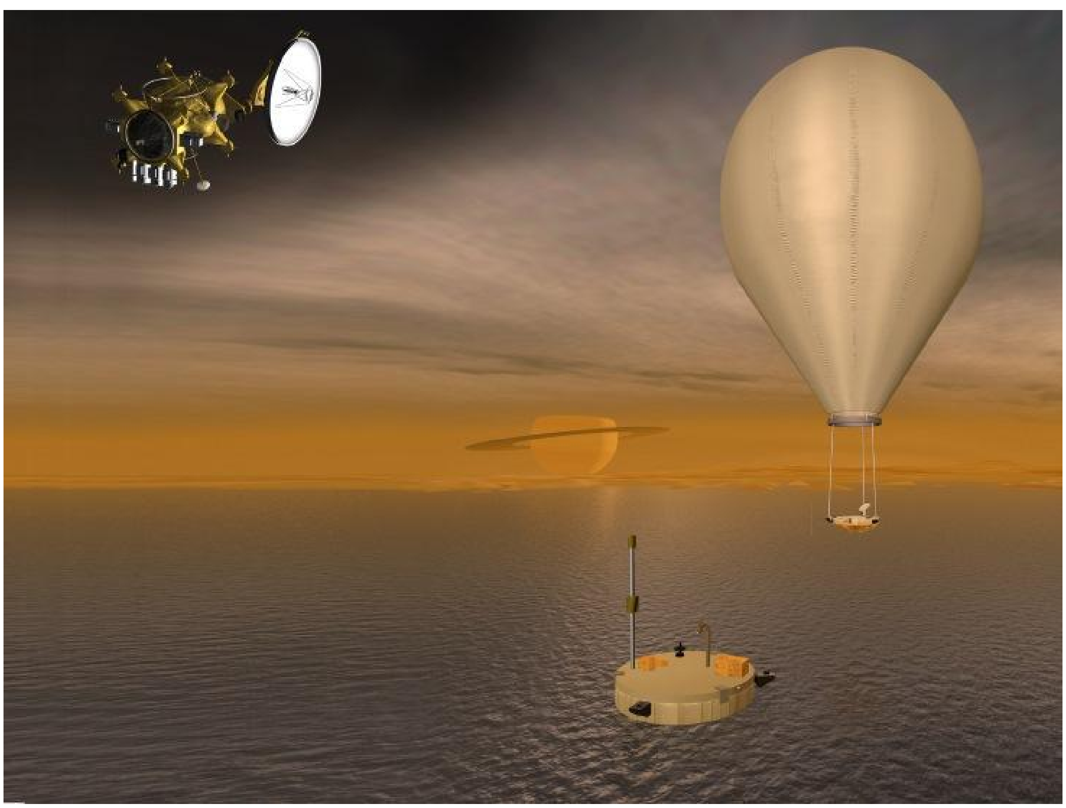
NAUTILUS

FACTS SO ROMANTIC ON IDEAS

Here's What We'll Do in Space by 2116

POSTED BY EMILY LAKDAWALLA ON FEB 02, 2016

In a mere 60 years, we of Earth have gone from launching our first spacecraft, to exploring every planet and major moon in our solar system, to establishing an international, long-lived fleet of robotic spacecraft at the Moon and Mars. What will we do in the next 100 years? With such rapid expansion of capability, it may seem difficult to tell what the next 60 years will bring, much less the next century. But we never do anything in space without first imagining what we *could* do, so in that spirit, here is an attempt to predict—and nudge us into—the future.



An artist's conception of the Titan Saturn System Mission, including an orbiter, boat-like lander, and atmosphere-exploring balloon.

European Space Agency

So far, almost all of our exploration of worlds beyond Earth has been through the senses of robotic emissaries. Everyone wants to go to Mars: It's NASA's stated goal, and rocketeer Elon Musk says he wants to retire there. But the number of humans that will land on Mars or any other planet is likely to remain small; I can tell you right now that I probably won't be one of them. The fact is that bringing humans safely to the surface of another massive planet with a thin atmosphere is mind-bogglingly difficult. In order to do it, we will have to accomplish several other, slightly less difficult things first, like surviving long-duration space flights away from Earth, somehow keeping our fragile DNA safe from cosmic rays and solar storms.

Although Mars has an environment superficially similar to Earth, it's the most difficult planet to land on. Like Earth and Venus, it has an atmosphere, but unlike those other planets, the atmosphere isn't thick enough to slow a descending spacecraft to subsonic speeds on its own. Yet the atmosphere is thick enough for incoming spacecraft to turn into fireballs as they enter with interplanetary velocity. Mars, unlike any other world in the solar system, requires both heat shields and retrorockets for safe landing; it's the worst of both worlds, so to speak. All that landing gear comes at a high cost in terms of launch mass and technology investment. Still, we could see humans on Mars in 20 years, give or take.

Some here on Earth have proposed one-way missions. This is not how NASA or ESA would do it, but it's dramatically simpler and cheaper to plan a one-way trip than a round trip. Which means it's likely that the first humans on Mars will not have been sent there by NASA or ESA. With lower budgets and less aversion to risk, private companies are also more likely than public agencies to suffer disasters in space. It is quite possible that the first humans to land on Mars will not have survived the trip.

Because of the costs and risks of physical human spaceflight, I'm personally more excited about a different kind of space exploration. Advances in miniaturization have made it relatively cheap to launch lots of microsatellites to near-Earth space. These craft will soon be sent further out, and it won't be long before there are lots of little spacecraft landing on the Moon. From our homes on Earth, we could all take virtual joyrides across the lunar surface, with these mini explorers acting as our distant eyes.

It's possible that this is how humans will first explore Mars, too—with a robotic body that needs no food, water, shelter, or sleep, serving as the avatar of human operators. The humans working the robot will still need to be located near Mars, not Earth, because of the significant delay in radio communications between the two planets. (The lag between commands sent and data received would range from eight to 42 minutes.) But the humans need not undertake the risks and challenges of landing on Mars: People in orbit at Mars could directly and immediately control Mars robots, all while staying in a ship or station tricked out with everything our delicate bodies need to survive.

Then again, depending on how technology advances, it may be that the division that we now draw between "human" and "robotic" exploration will be archaic in 50 years. To speculate ambitiously, in 100 years, we may be able to see with human consciousness from manufactured bodies. In that case, these new kinds of people may not find it so difficult to roam the alien environment of Mars.

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Farther out than the Moon and Mars, we'll likely see only scientific, rather than human, exploration for quite some time—until we get our robot bodies, that is. The distances are so great that it takes decades, not years, to cruise from one destination to another. So we'll rely on robots to be our eyes.

Because the lead times are so long, some of this exploration plan is already mapped out. In the 2020s, we'll launch our next robotic missions to Jupiter; they'll arrive and do science in the 2030s, and will hopefully persist for a decade or so. The 2030s could see the first launch of a dedicated orbital mission to Uranus or Neptune, the "ice giants" beyond Jupiter and Saturn. These would take between 10 and 20 years to arrive, so could still be doing their science in the 2060s. Most of the planets that we've discovered beyond the solar system are Neptune-sized, so it would behoove us to understand how this size of world works by visiting one with an orbiter. Uranus is closer, so quicker and easier to get to; but because of its extreme tilt, it's best to visit near its equinox, an event that happens only once in 42 years. The last equinox was in 2007; I will be sorely disappointed if we do not have an orbiter at or approaching Uranus in 2049. But we may choose to orbit Neptune before we travel to Uranus, because Neptune has an additional draw: its moon Triton, likely a captured Kuiper belt object, and a world where Voyager 2 saw active geysers.

Speaking of the Kuiper belt, New Horizons' fast flyby of Pluto last year whetted our appetite for the exploration of more worlds out in the far reaches of the Solar System. We already know from telescopes that they're as varied in appearance as the moons of the giant planets—possibly more so. There's cigar-shaped, fast-spinning Haumea and huge, frosty-white Eris, for example. But Haumea is currently one and a half times as far away from Earth as Pluto is, and Eris is about *three times* as far. The announcement last week of a possible, distant, ninth planet has prompted many people to ask me if we can conceivably explore it. But if "Planet X" exists, it's likely more than 10 times farther away than Pluto; it'd take 100 years to get there, give or take, unless there is some revolution in spacecraft propulsion.

So our near future in space will likely stay closer to home, but there are plenty of enticing nearby possibilities we're already imagining and working toward. There are thousands of near-Earth asteroids, each of them unique, many of them possible prospects for mining. They could help the establishment of an in-space economy that would help us venture out further.

Some people have suggested floating balloons under the Venusian sulfuric-acid cloud deck to search for active volcanoes, or sending similar balloons under the smog of Saturn's moon Titan to watch its methane rivers flow and possibly even touch down in a Titanian ethane lake. We've dreamed of touring the populations of icy worlds that float ahead of and behind the giant planets in their orbits; many of these worlds have binary companions, and some of them have rings. We've suggested setting up lunar bases on polar crater rims where the Sun always shines, and sending rovers into crater bottoms where the Sun never does, where water ice may have been preserved over the age of the solar system.

No matter how boldy we imagine, there will always be more within our own solar system to explore.

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