"Warp Factor, Mr Sulu. Set course for Mars."

By: Henry M. Holden

NASA's Hubble Space Telescope snapped this shot of Mars on August 26, 2003, when the Red Planet was 34,7-million miles from Earth. The picture was taken just 11 hours before Mars made its closest approach to us in 60 000 years. (Photo: NASA/ESA).

FAMOUS WORDS from Captain James T. Kirk, to chief helmsman, Hikaru Sulu, aboard the Starship *USS Enterprise*. In the long running TV (and movie) series Star Trek, the warp factor was the primary means of measuring speeds faster than light speed.

Warp factor 3, for example, would allow the traveller to speed through space at four light years in just three days. A warp drive would get us to Mars in about 13-minutes.

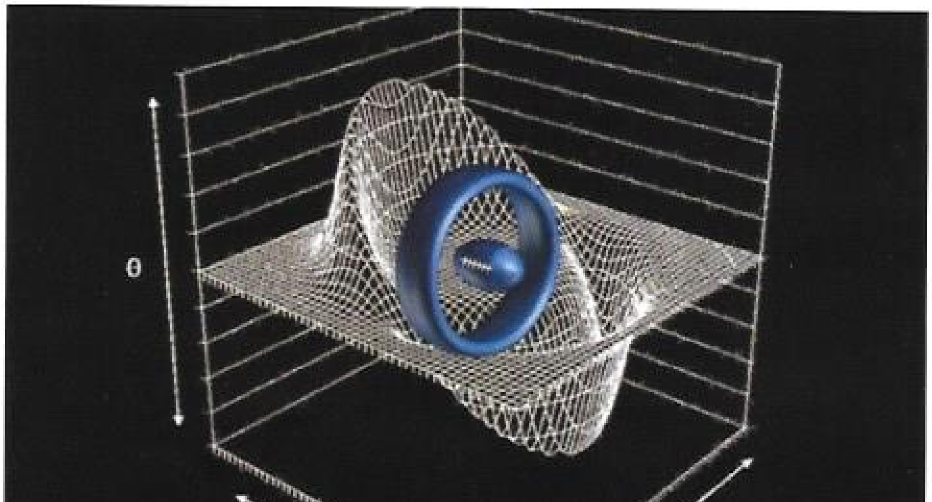
According to Einstein's theory of special relativity, published in 1905, nothing can exceed the speed of light (671-million miles per hour). That speed, explained Einstein, is a fundamental constant of nature: It appears the same to all observers anywhere in space.

In 1994, Mexican physicist, Miguel Alcubierre, advanced the theory that a spaceship can somehow warp the geometry of space around it — creating a kind of warp "bubble."

According to Alcubierre, this bubble in turn "creates a wave (of space time) which causes the fabric of space ahead of the spacecraft to contract and the space behind it to expand." The spaceship — at rest inside the bubble — rides this wave like a surfer on an ocean wave. And there is no limit to how fast the bubble, hence the spaceship, can go.

Einstein's general relativity theory, published in 1916, says space itself can contract or expand at any speed, even faster than the speed of light — as in the expansion of the universe.

Some readers by now are understandably sceptical, but not NASA. Based on Alcubierre's theoretical work, NASA has initiated its own warp drive project run by Harold G. "Sonny" White, head of advanced propulsion projects at Johnson



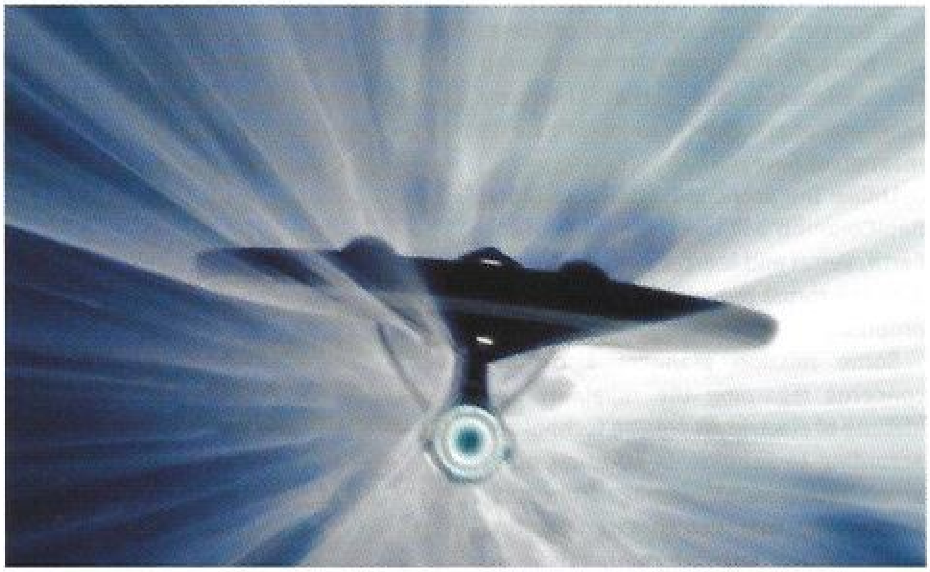
Alcubierre's design called for rugby ball-shaped spacecraft with a flat ring attached to the ship. Space time would warp around it, accelerating the ship to as fast as 10 times the speed of light without the ship itself ever breaking the speed of light. This would make a trip to Mars just a matter of days.

(Photo: NASA)

Spaceflight Centre.

White points out that space-time within the spacecraft is not affected. Here space is flat (not warped) and there is no time dilation.

According to White: "Your clocks (inside the warp bubble) are synchronized with mission control (on Earth)."



Starship Enterprise at Warp Speed (©Paramount / Bad Robot)

CURRENT REALITY

But we're in the 21st century and we're trying to get to Mars. We don't have Captain Kirk, Mr. Sulu, or the Starship Enterprise and we won't have anything out of NASA anytime soon. So how are we going to travel the distance to Mars from Earth, and how long will it take?

Sending spacecraft to Mars is all about precision. NASA has done it before, but never with humans. It is about blasting off from Earth with a controlled explosion, launching a robot into space in the direction of the Red Planet, navigating the distance between the two planets, and landing with incredible precision. This intricate and complicated manoeuvre means knowing the exact distance from Earth to Mars.

But this distance is always changing. On March 3, 2012, Mars was at a distance of 100,7-million km (62,6-million miles), the farthest point. On July 27, 2018, Mars will be the closest to Earth at 57,6-million km (35,8-million miles) or about 13 minutes at full impulse or 0,167-million miles/hour for all the Star Trek fans.

Getting to Mars as fast as possible is important. Twelve robotic missions (including fly-bys) to Mars yielded various arrival times. Nine of the missions took over 200 days, the longest was Viking 2 in 1975, which took 333 days, using contemporary propulsion systems. If we cannot use warp drive technology to get to Mars and beyond, what will we use?

PLANNING THE MARS TRIP

Solving the mystery of life on Mars requires robots to collect Martian samples for a return to Earth — a mission that may come with the astronomical price tag of $5-billion to $10-billion. That round trip to the Red Planet could become cheaper by using electric propulsion.

Most space missions burn chemical propellants to get a big boost up front that lasts as long as the propellant supply. Such chemical propulsion has allowed the huge Apollo rockets to escape Earth's gravity.

It would serve a similar purpose for launching any mission to Mars. But at some point the propellant will deplete.

"The Mars mission could then switch over to electric propulsion once it reaches Earth orbit and begins the journey to Mars," said Wolfgang Seboldt, a physicist at the German Aerospace Centre. "That would start slowly by converting xenon gas propellant into a stream of electrically-charged ion particles, but build up to high speed over time with an almost unlimited supply of electricity from solar panels.

"The Mars orbiter spacecraft could end up flying the Mars round trip cheaper and at least as fast as traditional chemical propulsion missions (if not faster), even if it has to carry the added mass of large solar panels," Seboldt explained. "The propellant mass saving over-compensates the mass increase from the large solar arrays."

MARS SAMPLE RETURN BY 2020

The Mars sample return (MSR) mission would require powerful electric thrusters and efficient solar panels which are presently under development.

Such technology would allow the Mars mission to lighten the load of chemical propellant carried by traditional rockets and spacecraft — and it is within reach for a mission to try recovering Martian rocks and soil in the next decade or two.

"The chances of having a reliable technology available for MSR in the timeframe beyond 2020 appear good," said Seboldt.

Electric propulsion could also speed up the round trip to Mars. But the trip to Mars will still be dangerous. The shorter the total mission time could prove helpful for the eventual human missions because of the risk that, for example, high-energy cosmic rays pose to astronauts during the journey.

HARNESSING SUNLIGHT

The conventional mission scenario reads like this: Two spacecraft would be launched separately from Earth — an orbiter and a lander. The lander sets down on the Red Planet to collect samples.

An ascent vehicle carrying the samples would then take off from the Martian surface using traditional chemical propellants, so that it can rejoin the orbiter for the return trip to Earth.

A hybrid version of the conventional mission scenario would involve the orbiter using electric propulsion. In an advanced scenario, the lander could ride the electric orbiter, piggy-back style, to reach Mars.

The lighter load of propellant would mean the electric Mars orbiter in the conventional scenario could launch from Earth aboard a medium rocket rather than the heavy rocket Ariane 5 ECA.

The leanest mission scenario would be a 20-kilowatt solar array with power requirements similar to those of communication satellites currently in geostationary orbit above the Earth.

SOLAR ELECTRIC PROPULSION RISKS

In the current scenario there are some risks and unknowns. For instance, there are a limited number of launch windows around the 2020 timeframe.

The cost of the electric Mars mission depends on the propulsion system's cost and whether or not it is more expensive than the possible saving of launch costs.

It also depends in large part upon whether parts from other spacecraft can be re-used — such as Europe's Bepi-Colombo mission to Mercury planned for late 2015.

It consists of two individual orbiters: the Mercury Planetary Orbiter to map the planet, and the Mercury Magnetospheric Orbiter to investigate its magnetosphere.

Unlike the proposed mission to Mars, BepiColombo will use the gravity of the Earth, Venus and Mercury in combination with the thrust provided by solar-electric propulsion.

Some mission planners also have concerns regarding the reliability and lifetime of electric propulsion technology, according to Seboldt. In addition, solar arrays face possible damage from solar cosmic rays that also threaten orbiting satellites and the International Space Station.

POWERING AHEAD

Solar electric propulsion technology has received a boost in recent years. Aerospace giant, Boeing, plans to use such propulsion in more of its geostationary satellites — both for moving into geostationary orbit and maintaining orbit. This will open up the market and push technological development for all spacecraft and satellites.

Boeing recently announced the 702SP communications satellite powered by Xenon Ion Propulsion System (XIPS). According to Boeing, the XIPS is 10 times more efficient than conventional liquid fuel systems.

On a XIPS-equipped 702 satellite, four 250 mm (9,8-inch) thrusters provide economical station-keeping, needing only five kilograms (11 lb.) of fuel per year, a fraction of what bipropellant systems devour.

An XIPS-equipped satellite can be used for final orbit insertion, conserving even more payload mass, as compared with using a traditional on-board liquid apogee engine.

According to NASA, several thrusters can be used on a spacecraft, but they are often used just one at a time. Spacecraft powered by these thrusters can reach speeds up to over 200 000 mph. In comparison, the Space Shuttles reached speeds of around 18 000 mph.

The European Space Agency plans to have solar arrays providing up to 30 kilowatts of power and thruster systems operating in the 20 kilowatt range beyond the 2020 timeframe. Meanwhile, tests on satellites and aboard the space station could boost confidence in the technology.

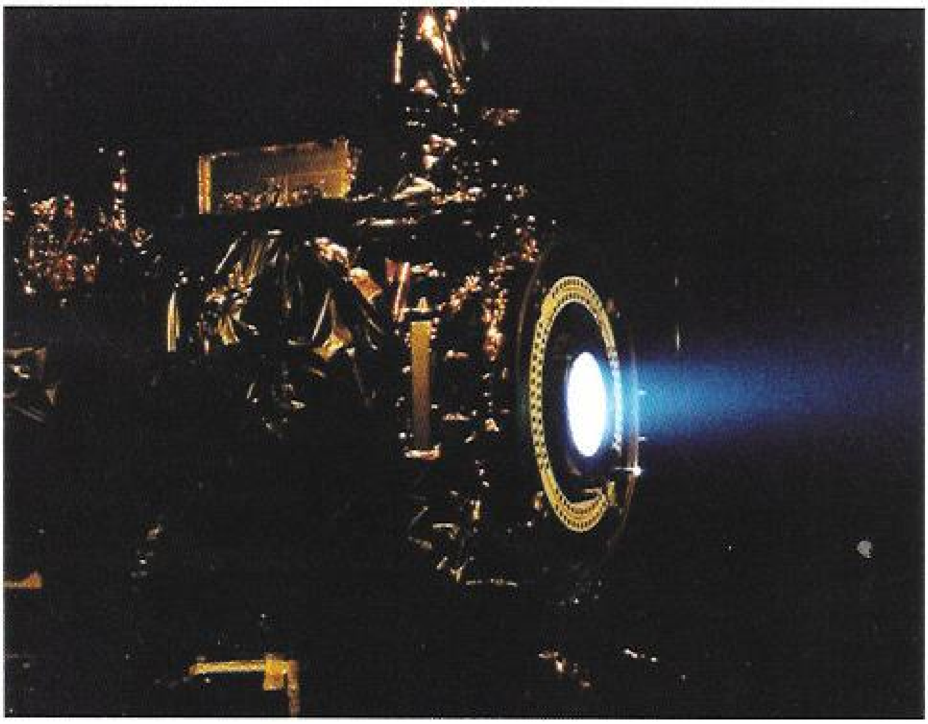
"Possibly the International Space Station may be a good place for testing newly developed thrusters under extreme space conditions," Seboldt said. "Also, the power supply with large deployable, lightweight and efficient solar arrays must be studied."

There are scientists both in NASA and elsewhere who do not agree with some details in this story. Alcubierre's theory allowed NASA to create a theoretical warp bubble that carries the spacecraft through space-time at 10 times the speed of light. We know from our observations of the universe that such deformation of space-time is probably possible.

For now, solar electric propulsion could do more than help shed light on any past life on Mars — it could also propel human missions beyond the Red Planet. But it is probably not the last word in deep space exploration.

Remember, someone once said: "Man can't fly."

An artist's impression of an astronaut at the controls of a warp speed spacecraft. (Image: NASA)



An Ion engine test firing. The ion propulsion engine is the first non-chemical propulsion to be used as the primary means of propelling a spacecraft. An ion thruster (or ion drive), one of several types of spacecraft propulsion, uses beams of ions – electrically charged atoms or molecules – for propulsion. (Photo: NASA)