

To boldly go ...

How humans will Alpha Centauri

Long thought to be the province of science fiction, interstellar flight might not be as impossible as you think. **by Bill Andrews**

Space, we all know, is the final frontier. But given our current technological state, it might stay that way for some time. Unlike climbing the next mountain or sailing the next sea, exploring the next planet — let alone the next star system — will surely take humanity quite a while. The warp drives and wormholes of science fiction make for interesting stories, but in the real world the immensity of space appears unconquerable. But does it have to be that way? It's easy to shrug off the convenient but impossible propulsion systems of fictional starships, but let's not be too quick to discount our real achievements. In just over 100 years, our species has learned how to fly, how to launch into space, and how to begin working and living there. If we put our minds to it — if humanity prioritizes interstellar travel above all else — what would it take for us to reach Alpha (α) Centauri, the closest star system outside our own?

First steps

After millions of years confined to the ground, humanity first left our planet in 1961, more than 50

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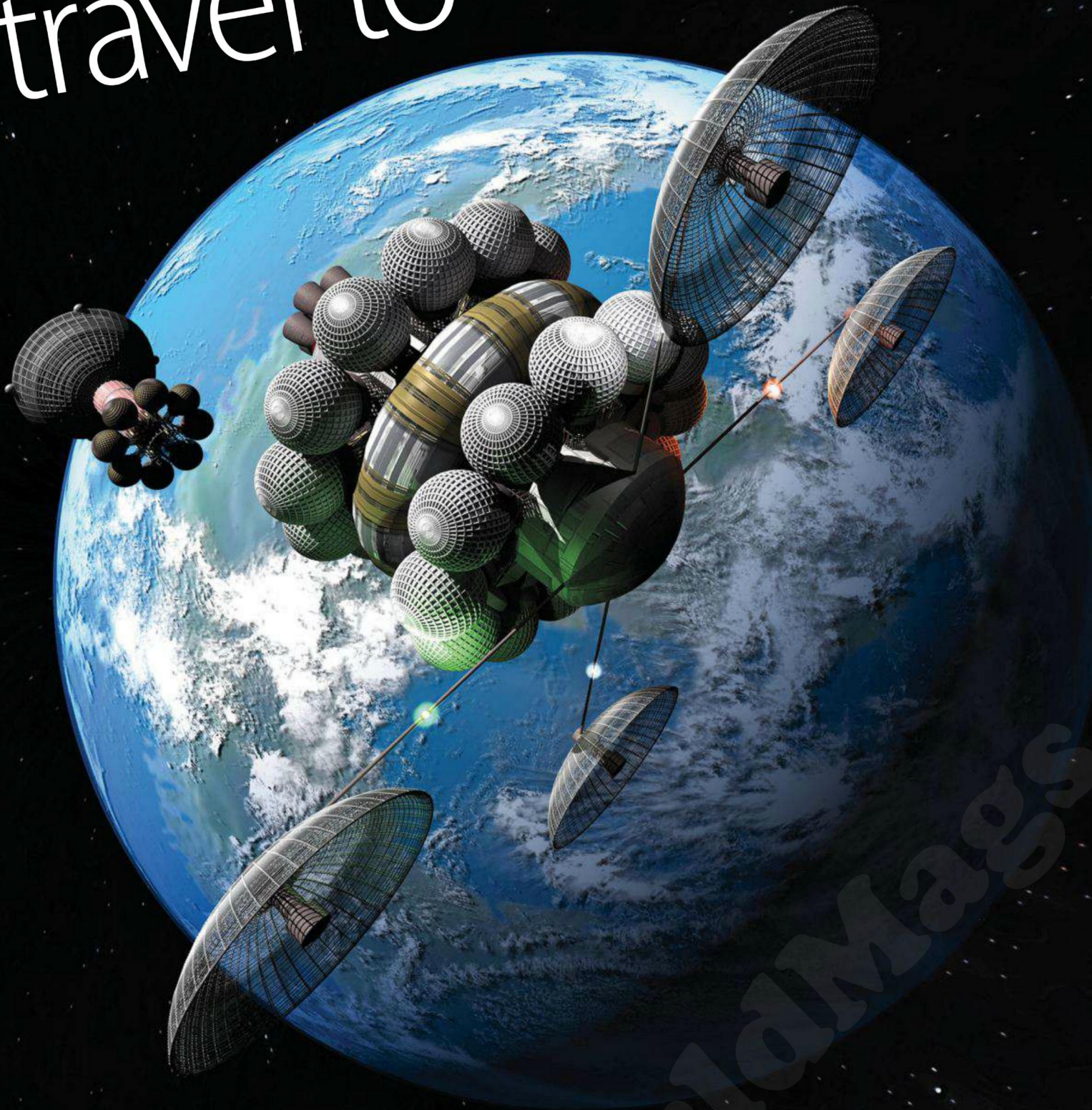
years ago. Starting just eight years later, a dozen men trod on the surface of another world, the Moon, for the first time in history. We were, briefly, a multi-world species. Since 1972, the closest mankind has gotten to the stars is low Earth orbit.

We've done much better with our unmanned probes. When the New Horizons mission explores Pluto and its surroundings in 2015, it will complete our tour of the solar system. All the major planets and the biggest moons (along with the Sun and certain asteroids and comets) have already had at least one robotic probe study them in detail. No one has set foot on Saturn's moons, but scientists can explore them virtually through these missions and learn almost as much.

We've done all this despite the daunting distances between planets. In many cases, the key is simply waiting. Although the 2.97-billion-mile (4.78 billion kilometers) trip the New Horizons probe has to take to reach Pluto is a long one, it'll get there given enough time — in this case, about nine and a half years. Of course, that's still a long wait, and this happens to be the fastest spacecraft ever launched, speeding away from Earth at some 35,800 mph (57,600 km/h).

Other probes have gone even farther, but it's taken them decades to do so. Currently, the Voyager 1 spacecraft is the farthest man-made object, an achievement earned from nearly 35 years of constant movement.

travel to



Traveling to another star has long been a sci-fi dream for humans, but such a trip may be closer than we think. Don Dixon for Astronomy



The nearest star to Earth, Proxima Centauri (at center), is still an enormous distance away: 4.22 light-years, or 24.7 trillion miles (39.9 trillion kilometers). Australian Astronomical Observatory/David Malin

And despite passing Pluto's orbit, the probe's current distance of more than 11 billion miles (18 billion km) from the Sun remains firmly within the solar system, which extends out to the Oort Cloud some 4.6 trillion miles (7.5 trillion km) away.

Given enough time, the probe will certainly leave our neck of the galaxy and begin an interstellar trip. That's when the real journey begins.

The nearest destination

The closest star to the Sun is a red dwarf called Proxima Centauri, which lies 4.22 light-years away — 24.7 trillion miles (39.9 trillion km). This dim star is likely a member of the Alpha Centauri system, which includes the binary stars Alpha Centauri A and B, themselves 4.44 light-years away.

To reach distances like that would take Voyager 1 a lot longer than a few decades. Even with the speed boosts it got from slingshotting around the most massive planets, the probe's present velocity is just 37,100 mph (59,700 km/h). Assuming Voyager was headed straight for the system, it'd take about 76,000 years to arrive. For context, that's longer than any known civilization has stood and almost half as long as Homo sapiens have been around.

And that's just to the nearest star! It has no known planets, and even if it did their habitability would be questionable at best because of Proxima Centauri's dimness and other unfavorable characteristics. The nearest known "interesting" stars, with possibly Earth-like planets in orbit, are many times

farther away. But Proxima's proximity to us still makes it a useful destination: It's far enough away to require a new mindset for space travel, but still close enough to be conceivably reachable.

So, we already know that a decades-old probe could, technically, reach the Alpha Centauri system if we're willing to wait long enough and it continues functioning. But could we do any better with today's technology? And, more importantly, could humans survive the trip?

Getting there

The best answer right now: perhaps. "Using the technology available to mankind today, yes, I'd say a manned interstellar spaceship

is possible," says Ian O'Neill, founder of Astroengine.com, Space Science Producer for Discovery News, and the holder of a Ph.D. in solar physics. "But is a mission to another star *practical*? Probably not."

Let's start with a familiar space travel technology, the space shuttle. Its main engine used a liquid oxygen/liquid hydrogen mix with an energy density of approximately 100 megajoules per kilogram; relatively speaking, that's not much energy (about a tenth of what a refrigerator uses in a year).

"To fly to Alpha Centauri in a shuttle in 100 years would require fuel tanks 55 times larger than the mass of the observable universe," says Andreas Tziolas of the University of Alaska Anchorage, and also a vice president at Icarus Interstellar, a nonprofit research organization aiming to create a realistic unmanned interstellar probe. "For a reaction engine, which carries its fuel, heats it up, and expels it for propulsion, we would want to use something with very high energy density."

Nuclear power, specifically the fission (or splitting) of uranium and plutonium nuclei, provides much more energy, about 100 terajoules/kg (TJ/kg), or a million times better than the shuttle's system. This would require hundreds of thousands of tons of gas (most likely hydrogen) to fuel the reactions. And due to the extremely high temperatures the components would be exposed to — on the order of hundreds of thousands of degrees Celsius — this technology requires more-advanced materials or ingenious cooling systems than we currently have. Nonetheless, Tziolas says, "As a power



The Voyager 1 probe is now the farthest man-made object, some 11 billion miles (18 billion kilometers) from the Sun, after traveling through the solar system for nearly 35 years. NASA/JPL

source, nuclear fission is very promising, especially for interplanetary transits.”

Even more promising, and problematic, is a nuclear fusion-powered propulsion method, which combines light atomic nuclei and can reach energy densities of 300 TJ/kg. Tziolas says deuterium-helium-3 fusion was “the reaction of choice” for Project Daedalus, a 1970s study that first showed that interstellar flight is possible with current or near-future technologies. (Project Icarus is a follow-up to Project Daedalus.) Unfortunately, Tziolas says a big problem is “the extreme scarcity of helium-3 on Earth, which would require us to mine the atmospheres of gas giants to accumulate sufficient quantities.”

O’Neill also points out that fusion propulsion may be too violent for any passengers on such a ship. “Humans are soft and squishy, so accelerating an interstellar craft to huge speeds rapidly may be detrimental to the health of those on board.” And then there’s the issue of radiation (also a problem for fission-based propulsion), which would require significant shielding. These all amount to engineering issues, though, meaning they’re likely to be overcome sooner rather than later, making fusion the propulsion method of choice.

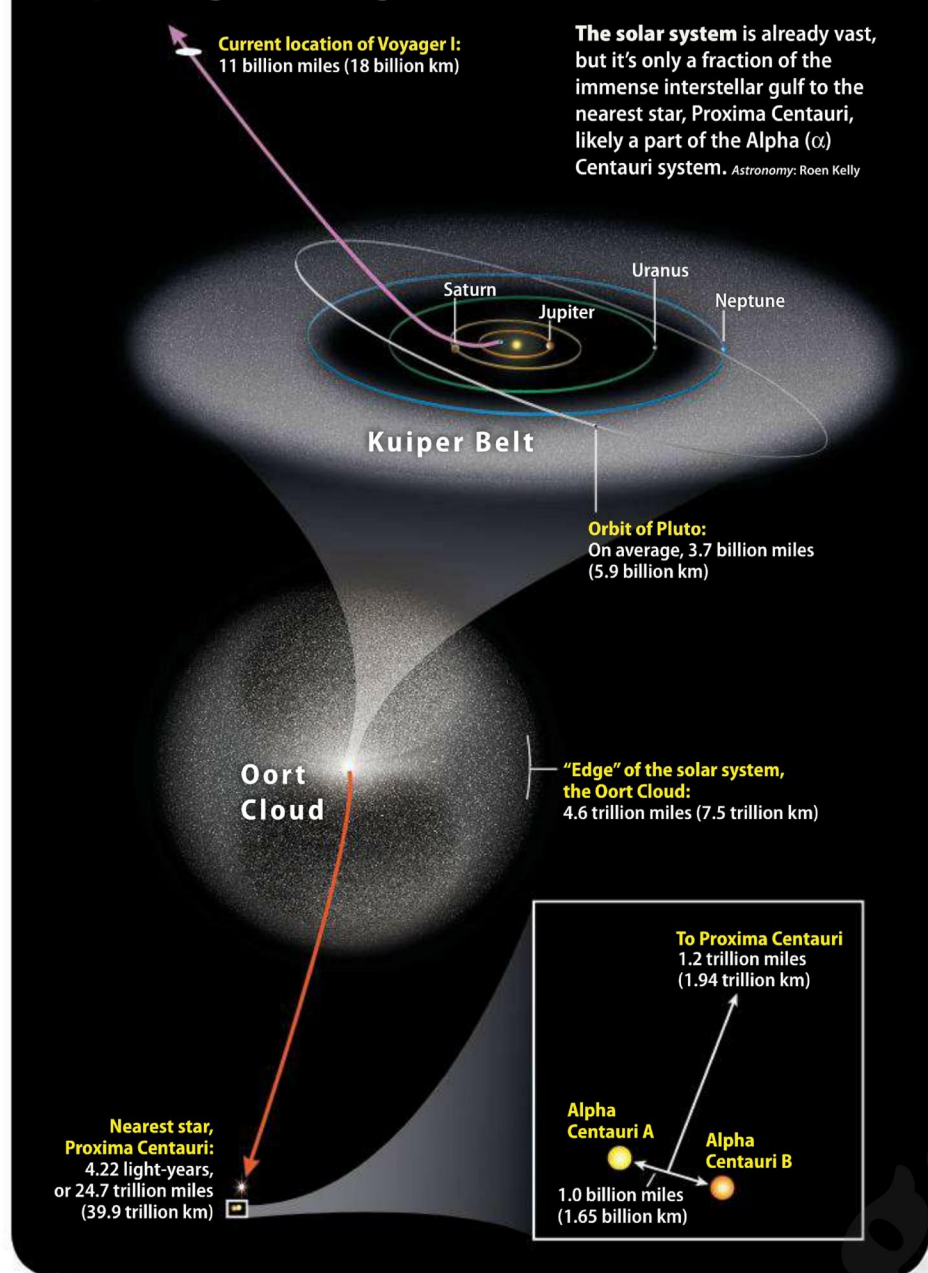
Other technologies, such as solar sails and matter-antimatter reactions, also have their merits, Tziolas says, but they all have fundamental physics problems that would need to be solved first.

Surviving the trip

Having thus established that humans could get to the Alpha Centauri system, the next problem is getting them there in one piece. “In the particular case of a crewed interstellar voyage, the trip time is, of course, the primary design concern,” says Tziolas. “The longer the voyage, the more resources the crew would occupy, making the spacecraft heavier, which makes it require more fuel, and thus the journey takes even longer.” It’s a perfect catch-22.

While we’ve already calculated an upper boundary on the possible trip time — some 76,000 years — under ideal circumstances, that figure could decrease significantly. “Some estimates indicate a fusion-propelled starship may reach 10 percent the speed of light,” says O’Neill. “In this case, the 4.4 light-year trip to Alpha Centauri could be accomplished within 50 years.” (Tziolas specifically suggests for the mission a ship

Exploring the neighborhood



with a futuristic-sounding “optimized antimatter-catalyzed fusion scheme, accelerating and decelerating at full thrust.”)

It’s an optimistic figure, to be sure, but a possible one using current physics and near-future technology. It would still take five decades, but, O’Neill says, “Crew members that started the journey may live out their lives to see an alien world.”

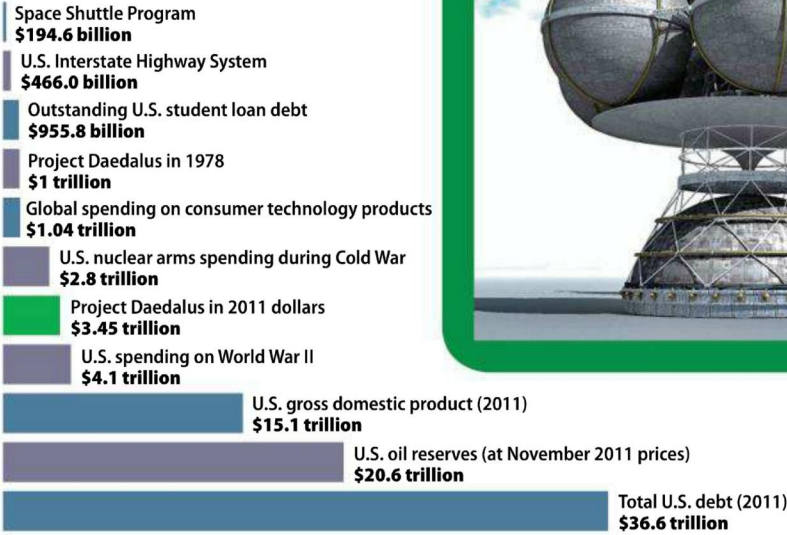
A long-duration journey like this would be less of a traditional space mission and more like a grand social experiment, according to O’Neill. To begin with, the “crew” should be an entire community to better handle and adapt to the rigors of a long trip. “The starship would need to be a self-contained town,” he says. “Our

interstellar travelers may have more in common with the early settlers of America than modern astronauts — they’d be living out an existence always looking toward a new land while trying to survive.”

Because of researchers’ years spent perfecting life off-Earth, they would be able to provide the travelers a moderately comfortable ride. Rotating cylinders could provide artificial gravity. Growing zero-g foodstuffs is already possible. Artificial intelligence could handle simple tasks like automated repairs and minor course corrections. A thick layer of ultra-light graphene, first suggested by Adam Crowl for Project Icarus, could protect the ship from collisions with the sparse gas and dust in

An astronomical price

The cost of sending humans to another star might seem staggering at first, but the tremendous sum wouldn't be an unheard-of expense. Further, the myriad spinoff technologies that such an endeavor would certainly provide could help the project pay for itself. *Astronomy: Roen Kelly*



Project Daedalus, a predecessor to the current Project Icarus study, determined in 1978 that interstellar flight was achievable using current or near-future technologies. The resulting plans called for an unmanned probe weighing 55 tons to make the 46-year, 5.9-light-year trip to Barnard's Star, where it would achieve a maximum speed of 12.2 percent the speed of light. *Concept: Project Daedalus design team; Design: Adrian Mann (bisbos.com)*

In other words, such an ambitious expedition may be possible, but it clearly wouldn't be easy. And that's not even taking into account the cost of such a mission.

the interstellar medium, which would otherwise erode its hull.

Communications with Earth prove a bigger problem, though, with no clear solution in sight. Tziolas suggests deploying "powered relay stations along the way" to maintain signal strength over the vast distances. But, even then, it would take years for any messages to travel such large expanses. "What would be the point of two-year-old messages being sent from Earth to a starship that is a couple of decades into its mission?" asks O'Neill.

The communications issue may feed into a problem that could be greater for such a project than any of these technical matters: the sense of isolation. "It's hard to imagine

how the interstellar colony will identify itself," says O'Neill, especially for longer voyages. What relevance does Earth have to people born inside a huge spacecraft, with no attachment to their ancestors' birthplace?

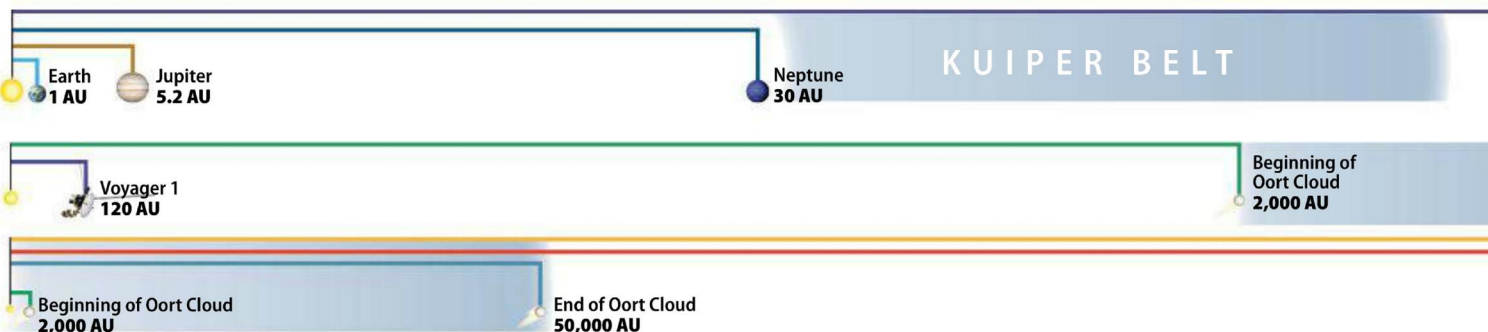
"The real wild card of a long-duration mission would be social rather than technological," says O'Neill. Will the crew provide a large enough gene pool to keep future generations healthy? Is there a possibility of social unrest? What if the travelers change their mind about the mission after 20 years? And, as O'Neill points out, "The ethics behind such a trip would be iffy at best." How fair is it for those born on board, who have no choice but to carry on the "mission" begun by their parents?

Is the price right?

O'Neill pegs the price tag of such an endeavor at "gazillions of dollars." In other words, he has no idea. Tziolas points out that the Daedalus team, in 1978, "estimated the cost of an interstellar mission to be on the order of \$1 trillion. Some say that estimate was extremely conservative." Adjusted for inflation, that's \$3.45 trillion in 2011, about as exact a current figure as he or anyone else can determine. No matter what, an interstellar trip wouldn't be cheap.

The reason for the astronomical cost is that building the ship requires not just enormous resources and expensive technologies, but also the infrastructure necessary to combine them. "The energy requirements for a starship to travel to a nearby star

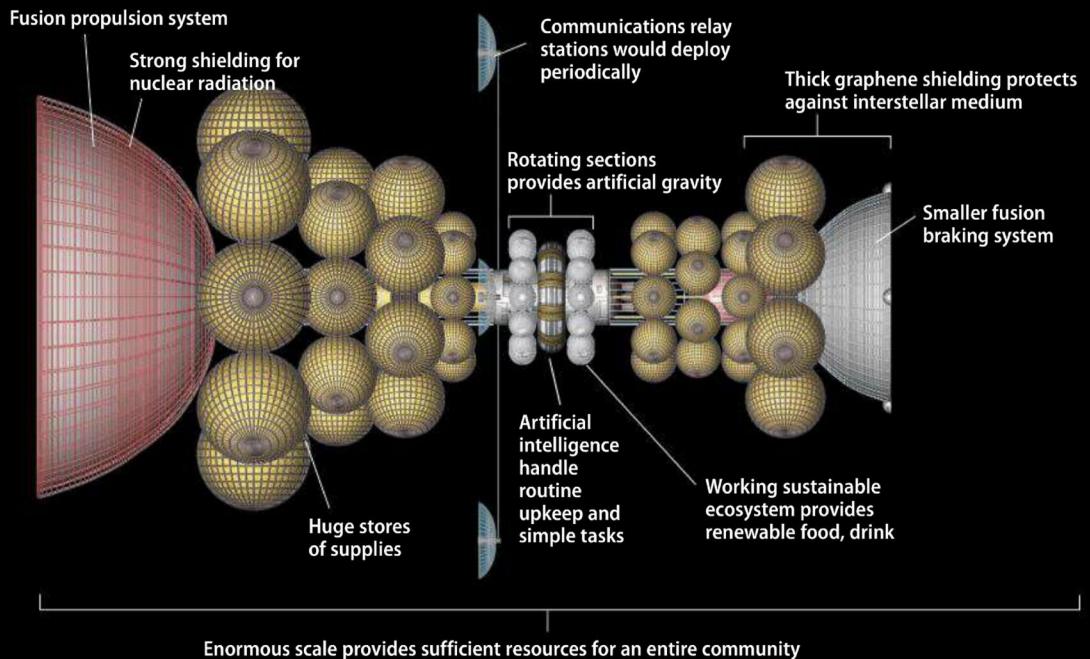
How far is the nearest star?



Interstellar tools

To safely transport human beings to another star system, a ship faces several physical requirements. Not all of these technologies currently exist, but we're close enough to developing them to keep this a currently viable design. Such a ship might be able to travel the 4.4 light-years to our nearest star system in a matter of decades.

Don Dixon for Astronomy



would be 100 times the energy output of our entire planet,” O’Neill says. The costs would quickly add up.

But perhaps the initiative could pay for itself. “If the thousands of technologies derived from interstellar spacecraft research are patented, traded, licensed, and commercialized, then an entire industry of technologies will emerge,” says Tziolas. Fusion systems could power the world cheaply and cleanly, advanced-materials research could have myriad commercial applications, and new scientific fields (such as interstellar engineering) could provide a new avenue for understanding the universe.

Then there’s the sheer economic benefits. “The technology-induced increase in 1975 on the Gross National Product was \$7 for each \$1 on research and development,” says Tziolas. A billion-dollar investment resulted in 20,000 jobs back then, with an increase in manufacturing output on the order of \$150 billion. Today’s estimates put it closer to \$40 back on every \$1. “Any endeavor which can even imply

this order of jobs and profit should be on any politician’s roadmap.”

Will it happen?

So, in the end, what’s the verdict? If we make it a priority, could our species reach another star system? Right now, it doesn’t seem likely. “Perhaps such a mission will be possible in the distant future, but using current technologies to push mankind to the stars, although feasible, would be very slow and laborious,” says O’Neill. “Sadly, I don’t think a manned interstellar mission would become a reality until we make a breakthrough in propulsion technology.”

And that’s assuming fairly unlikely levels of public and governmental support for the idea. After all, we currently have the technology, but not the will, to colonize much of the solar system. “The main reasons why we aren’t currently an interplanetary race,” says O’Neill, “are purely political and financial — mostly political.” It would simply be too hard to justify the costs of taking on these goals right now.

But there’s always the chance that those attitudes could change. Should some sort of catastrophe strike our planet, the value of knowing how to reach other worlds would immediately skyrocket. For Tziolas, this possibility should be enough to motivate us now. “Consider only how much care we take to secure data on our computers,” he says. “The very first thing we do is *make a backup*. A similar argument can be made here.”

So whether it takes 76,000 years or 50, the possibility of traveling to another star is closer than ever before. And given another 100 years or so, who knows? As Tziolas says, “Through reaching for the stars, humanity will incite a new era of thought and capabilities with potential to transform our culture and technology, heal the Earth, and enrich the human experience.” Whether or not we ever make the trip, it seems at least a discussion worth having. 🚀

 Learn more about Project Icarus at www.Astronomy.com/toc.

Traveling 4.22 light-years, the distance to the nearest star, wouldn’t be easy. Still, the dim red dwarf Proxima Centauri presents a useful hypothetical destination for thinking about the challenges that would accompany humanity’s attempts at interstellar travel. *Astronomy*: Roen Kelly

Voyager 1
120 AU 

OORT CLOUD

Astronomical Unit (AU) = 92,956,000 miles
149,598,000 kilometers

Proxima Centauri 266,000 AU 
Alpha Centauri A 279,000 AU 