# Likelihood of Technical Life

by Dick Suiter

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At a meeting [i.e., in late 1995] I presented how the Drake equation could be used to estimate the likelihood that extraterrestrial life exists in the Galaxy and is identifiable. (That is, it calculated the chance of finding life reasonably like our own – air breathing, carbon-based, using liquid water – which is the only form we are likely to be able to recognize anyway.) We came up with estimates ranging from one technical civilization per galaxy to thousands.

The high-number viewpoint is similar to the views of many physicists and "hard" scientists, who hold that if a process is not physically forbidden by the laws of the Universe, it is common. Since we exist, life is not forbidden. Thus, life must be common.

There is another side and, oddly enough, it is a viewpoint held by more biologists than physical scientists. In this view, life is unbelievably rare. It is so rare that it may well have happened only once in the whole history of the Universe. Physical scientists, the biologists contend, are so ignorant about what constitutes life that they have taken an overly optimistic view. In fact, a great deal of time and perhaps many Universes may have had to occur before life occurred even once. (Because no one was around paying attention, this process was on "fast-forward." This is called the *anthropic* view.)

What is the problem? After all, we work fine. Why can't life be all over the place? The problem is not in the life, but where it sits. Life is in a very precarious position once it is formed, and there is no guarantee that it will persist as far as multi-celled organisms before a permanent ice-age, the drying of the oceans, the loss of the atmosphere, or any one of a number of disasters befalls it.

Of course, "life" does not imply intelligence, and intelligence does not imply a technical civilization. But all of this is speculation, and that is the point. You can speculate all you want and you'll get no closer. Are there any other approaches?

What some people try to do is prove that technological life is not common by elimination. Say technical civilizations likely to attempt spaceflight are as numerous in the galaxy as lice on a sparrow. What would they do? Would they come here?

Maybe a good fraction of them wouldn't be motivated by spacefaring or even be capable of doing so (intelligent undersea life, for example, would be unlikely to invent fire). Even so, many of those civilizations would have been forced to travel because their parent stars would have edged closer to the red-giant phase. There is nothing like a swelling sun to convince even the most laid-back hippie civilizations to become starship troopers.

Maybe they *are* here and we don't know it. After all, UFO reports seem to indicate that they're here in droves. The reality of UFO reports has come into question by looking at the statistics. For example, you would expect the incidence of UFO reports to be different in amateur astronomers than in the population as a whole. If UFOs are really alien spacecraft, you would anticipate the extra hours under the stars by trained observers would lead to more unexplained reports. But the incidence is statistically the same, leading some people to conclude that the fraction of amateur astronomers that is overly excitable or downright crazy is the same as the general population! I prefer to think that the reports that are unexplainable from lack of information are the same.

Others look at lights-in-the-distance UFO reports as unprovable and concentrate on J.A. Hynek's "close encounters of the third kind." They point out that the credibility of third-kind reports drops off sharply and that they seem to be largely promulgated by people with (how can I delicately put this) a *looser* grip on reality. There may be a correlation to people pretty far out on the fantasy-prone personality (FPP) spectrum that affects around 2 to 4 percent of our population (according to the psychologists who study such things). I would tend to dismiss FPP as an artificial grouping, but I have personally met an individual who was capable of believing anything that had been internally rehearsed a few times, and who became angry if others disagreed.

Some researchers have pointed out the similarity of the "UFO alien" body construction to our own. Two eyes set at the upper side of a head, two arms and two legs in a more-or-less humanoid arrangement are NOT necessary for technological life. *Star Trek: The Next Generation* notwithstanding, believable aliens do not resemble people with little ridges on their heads and perfectly normal bodies. It seems that such alien observations have more to do with human psychology than interstellar visitors.

After I wrote this article, *The News-Herald* in the Nov. 26 [1995?] issue conveniently published the interesting statistic that up to 2 percent of adult Americans believe that they have been abducted by aliens. The logistics of the supposed abductions alone disproves them as real phenomena. The aliens would have to not only be here but be here in great numbers. Kidnapping and probing that many people would make the UFO-aliens busier than the Atlanta airport.

Most scientists agree that the evidence that we are being visited right now is thin or non-existent. Have we ever been visited? We can dismiss von Daniken's *et al.*'s [1] assertion that primitive megalithic structures could not possibly have been constructed by natives of whatever country they were found in. The persistence and ingenuity of ancient peoples is sufficient to explain megaliths, and piled-up rock structures are *exactly* the kind of things that would be attempted by low-tech cultures who wanted to impress visitors. But is there any other evidence that they have ever been here?

The logical process dealing with this matter is more straightforward than you might think. To travel between the stars in such ephemeral and tender forms as human bodies (and by extension, alien bodies) requires at least three things:

a) vast quantities of energy to accelerate the craft to high velocities,

b) extraordinary patience from the travelers or methods to decelerate metabolism, and

c) massive radiation shielding.

Now I know that things like "hyperdrive" and "warp drive" and other devices have been envisioned, but they run up against a relativistic concept called "causality" or the requirement that cause precede effect.

Faster-than-light drives were invented primarily by science-fiction writers who required their protagonists to flit like hummingbirds from star to star, thus keeping their stories moving. They were not invented by scientists. Scientists, being avid SF readers themselves, have come along and filled in the gap to a small extent by coming up with kinds of faster-than-light drives (at least to the people on board), but these are pretty unlikely and require great masses or energy. [see Wiki on *Alcubierre drive* – DS 2017]

If we were ever able to violate causality then we would have hyperdrive and time travel besides. I'm not saying this is impossible, but sufficiently difficult that there is no evidence that it will ever be done. For now, it is safe to assume that going at under light-speed is the only way.

Scientists have also envisioned "wormholes" and relativistic time-dilation. Wormholes are the statement that there might be at least two more-or-less straight lines connecting two places in the

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1 and half the programs on the "History" channel.

Universe and that one path may be *a lot* shorter that the other. A macroscopic wormhole is very much like a black hole, however, and that is not a nice place to be. They need exotic matter with strange properties (such as negative mass) to plug inside the wormhole, keeping it open like a salesman's foot in the door. Even if wormholes exist and can be used, they are not likely to be found in convenient locations. It doesn't help should the nearest wormhole be halfway to the Andromeda Galaxy, for example.

Relativistic time-dilation is the observation that time is a function of the reference frame. Putting it simply, as you are accelerated to near the speed of light, your clock seems (to outside observers) to tick slower than theirs. Relativity doesn't help the vast energy requirement, however. You have to go a large percentage the speed of light if you are going to get any help from relativity, and that takes fabulous quantities of energy. See Figure 1.

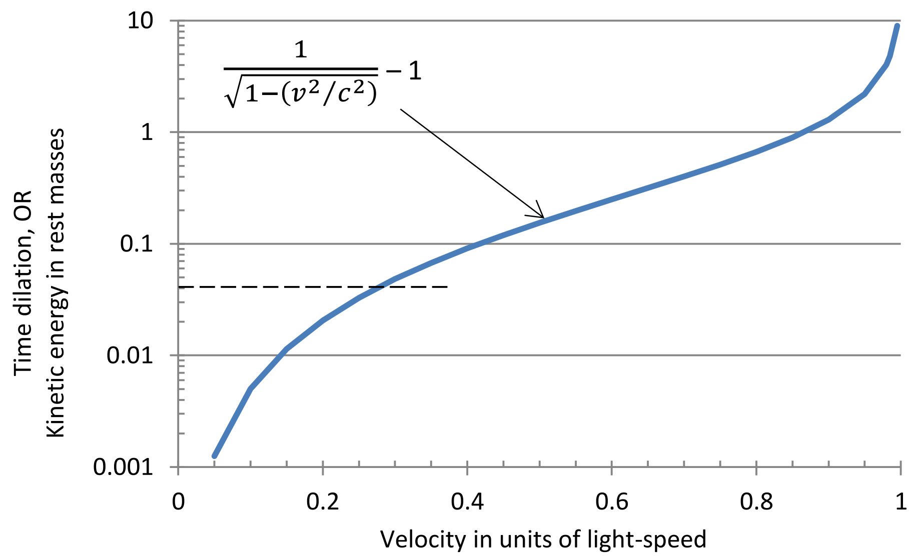


Figure 1. Time dilation or kinetic energy. Logarithmic plot.

The way you read this is to add 1 to the plotted value to derive the improvement. Say you traveled an apparent 1 year at 0.866c. You look at the chart and realize that back home 1.0 + 1 years has gone by. Thus, you've gone 2 x (0.866) = 1.73 ly and you've only aged 1 year. But look at your kinetic energy. The 1 means also that you have an equal quantity of kinetic energy to rest energy: E = $\underline{2}$ $mc^2$. Fusion energy is only about 4% efficient. If you fused an equal mass of hydrogen to your body weight and somehow turned it into kinetic energy without waste, you would only be going about 27.5% the speed of light (dashed line). To get to 86.6%, you have to come up with 25 times that much energy! And that only results in a mild time dilation. Say we really want to cheat and go 10 light years in one on-board year. Look at Figure 1: your total energy is mostly kinetic. Where are you going to get it?

Condition c) above is perhaps the most difficult condition. Even if you could put people to sleep for a hundred years, you still must protect them from the radiation sleeting through their bodies. Every bit of matter the ship encounters is a radiation source, not because it is moving, but because *the ship is*. Massive radiation shielding worsens the need for huge quantities of energy. Biological bodies are extraordinarily delicate vessels for star travel. Isn't there a more indirect way of exploring the galaxy?

Many years ago a mathematician named John von Neumann wrote a paper on the computational requirements of self-reproducing automata. The key to exploring the galaxy is found in this work and others extending the concept to space-traveling machines.

Now, *we* can be viewed as a self-reproducing automaton (actually, we reproduce in pairs, but that is just semantics), but it seems that it will be possible to deliberately make such a device within 50 to 500 years. You might well ask what the purpose of this automaton would be, since we are obviously so much more flexible at dealing with strange situations than any robot would be.

The purpose of such a device is to live a very long time and travel between the stars. It need not do this faster than light, just fast enough to survive the radiation and boredom. It travels in tiny egg form. Once it arrives in another star system, it metamorphoses like a butterfly into a reproduction and planetary exploration machine. Settling down on resource-rich asteroids or comets, the egg hatches into a factory form (or the small factory that builds the larger factory) and makes multiple copies of itself, plus many explorers and landers which fan out across the new star system.[2] Once it collects enough data it sends back beamed reports and settles down to observe and record. If it sees anything interesting it may make another report.

If you are feeling a sense of *déjà vu* here, that is natural. You've seen this story before in *2001: A Space Odyssey* and *2010*. The black obelisks are the symbols of such self-reproducing automata.

It launches the fresh copies of itself as soon as they are made and fueled. I would imagine that final testing would probably involve sending an egg out to a likely spot in our own outer solar system and seeing how well it does on the reproduction part with no help. It need not be very large, breathing, eating food, or awake during the trip between the stars, a condition which lessens the energy and shielding requirements considerably.

Such devices propagate exponentially. At first this process seems to crawl, but soon the process of reproduction has caught up. At some point, the new system reports can even come in uncomfortably fast. Beyond that, we just let them go or stop them after a given time or distance. As they get farther away, communication becomes more difficult. The chance that the machines will find an Earth-type system is remote, but if they do we have knowledge we can use when our sun chokes on its own ash.

In Figure 2 we see the general shape of the curve if we assume an average moving speed of 0.05c (c = lightspeed)[3] and another period of time equal to the transit time to gather enough materials to reproduce, yielding a net propagation speed of 0.025c (it is the net speed to which we have to pay attention). The average distance between stars in the solar vicinity is assumed to be about 4 light years.

After about 350 years, only 10 systems have been explored. This model incorrectly assumes that the curve is smooth where it would actually be jerky, especially at first. It smooths out as the numbers go up. The distance is proportional to r (of course), the volume to $r^3$, and the new reports to $r^2$.

After 740 years, the machines have explored 100 star systems and the rate of new reports is a comfortable one system every three years. The outer shell is only 18.5 light-years away.

After 1600 years, 1000 total star systems have been explored, the outer shell of "known space" is 40 light-years away.[4] The shell is beyond the radius of the star Arcturus. We are receiving new reports at the rate of 2 per year.

When the outer shell is 100 light-years away, 4000 years have passed. The total number of system reports collected during the entire mission is over 15000 and the current rate is nearly 12 new systems explored every year. Statistically, this is once per month at the end.

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[2] Self-reproducing automata are a lot easier to comprehend with the advent of 3D printers – DS 2017

[3] Lest you think 0.05 c is slow: it is 9300 mi/s or 15000 km/s. The fastest outbound gravity-assisted spacecraft so far have a speed of roughly 50 mi/s or about 80 km/s, depending on the reference frame you measure it in.

[4] See wikipedia on science-fiction author Larry Niven's *known space* stories.

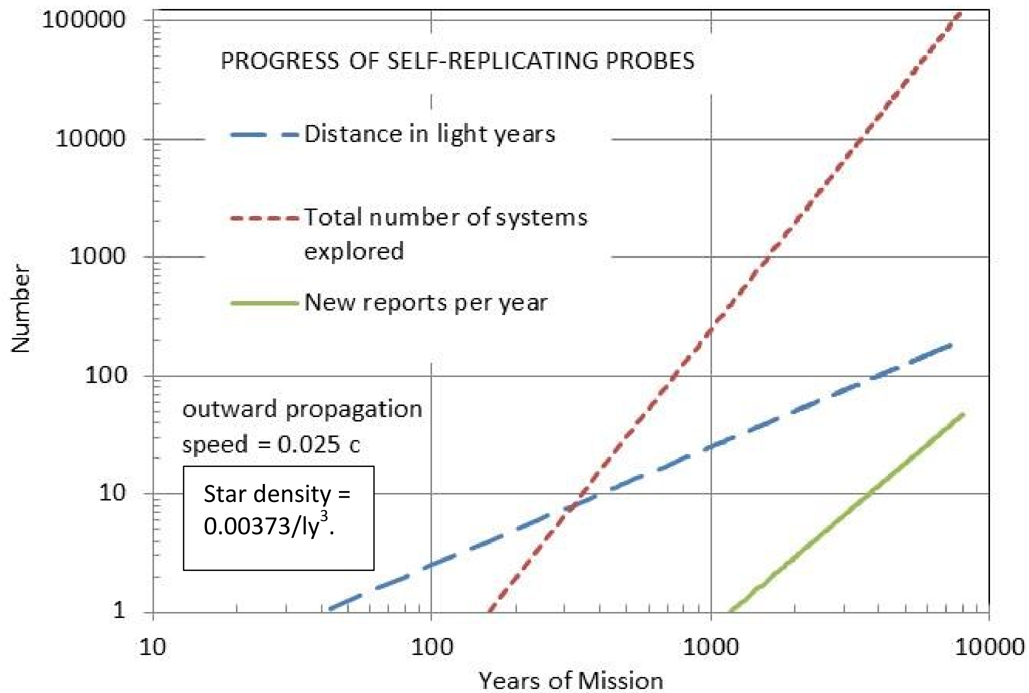


Figure 2. (Blue – long dash) Number of light-years out. (Red-dash) The number of stars explored as a function of time. (Green - solid) The number of reports per year exceeds one after about 1100 years.

I have graphed up to travel time of 8000 years and with the shell 200 light-years away; 125000 stars will have been explored and the rate of new reports is becoming intense at 47 per year. New info is becoming hard to digest at one system per eight days. Our known space in this case is still somewhat less than 0.00005% of all the stars in the galaxy.

I haven't modeled effects like a speed-up of the outward progression. As the envelope shell expands it gets flatter and the extra child automata have nowhere to go. Either the automata reproduce less or the local machines would communicate with each other – that is easier and faster than communication with Earth. They would tell their neighbors to send their copies to the following two or more stars because they already have the next ones covered. Any misses can be backfilled later. The propagation speed would crawl up toward 5% the speed of light again. Still, it's slow.

A space program that last 4000 years is taking the very long view. Four thousand years ago, the Egyptian Pharaohs were building their last pyramids. The Old Assyrian Empire was over and the Hittites had not yet invented iron smelting. People in Mesopotamia still used cuneiform tablets. Eight thousand years is longer than written history. It would take something like the sun getting bigger and hotter to make people fund something like this. But once they do it's like an eye-blink compared to the lifetime of a star.

The second function of these might be more than exploration. If it gets to a planet that is close to ideal but lifeless, it can be instructed to begin the process of terraforming, perhaps by even seeding primitive life forms of the type that changed earth's atmosphere from a reducing one to an oxidizing one. It depends on whether our understanding of life is sufficient so that that the automaton can construct a cell from pure information. Then, if we do find a quick and safe method of star travel later, we might have some planets to travel to.

And we also have to ask whether we can carry human consciousness in the automata themselves. Maybe by that time the Mind Upload will have taken place and there will be no impetus to seed planet-borne life. The automatons will *be* us, permanently living in space. I would think, however, that the exploration automaton's life would be a very hard existence for even a modified human being. We have to design these automata to be inured to danger, numbing tedium, relentless toil, and loneliness.

Would a primeval or any subsequent exploration automaton be detectable in our solar system? Perhaps. They are out in the comet cloud or the asteroid belt if they are anywhere. Maybe someday we'll find them, but they're unlikely to be there.

Here's why. Say we send out automata at 5% the speed of light. There is some inefficiency, but certainly in four to six million years they would be capable of reaching every star in the galaxy. As long as they stayed the simple, innocuous machines we sent out, that would be fine. However, they are as subject to software mutation as biological life is, and soon their numbers would be sufficiently large that some mutations would be viable. Indeed, our success at building such automata may depend on the life-science and nanotechnology revolutions taking place right now. They would probably resemble radiation-hardened living things more than machines.

It is not unbelievable to assume that at any one time several tens of millions machines might be active. To assume that the automata will remain static for such a long time is optimistic. In fact, that is one of the points in the Von Neumann work. The complex automata will mutate and evolve.

One thing to expect of such mutation is that they will "go wild." They will develop a drive toward self-preservation and will lose any desire to perform the wasteful operations involved in reporting back. (Not that anyone is willing to listen to a hundred thousand new-system reports per year anyway, even if the radio dishes could be made that huge.)

They would also become pests. It makes more sense from an independent automaton's perspective to reproduce to fill a given star system before jumping to the next. They would strip star systems of their low-gravity "nutrients" (asteroids and comets, i.e. silicates, metals, and light elements) and in general make themselves completely obnoxious. If ever the solar system had been invaded by wild space-faring automata, I think it would be painfully obvious now. The asteroid belt would be devoid of metals. There would be no comets spraying tasty ices into the solar wind.

The automata might develop predation. If you were a wild machine, which is more efficient: to smelt metals from the ore and process softer materials yourself, or to steal them from a neighbor? Even better is to "kill" the other automaton and use its refined materials and parts. Perhaps the best proof that wild alien automata have never been in the solar system is the fact that we can launch fat, juicy, unprotected geosynchronous satellites without them being "eaten" for their silicates and refined metals.

Now I can hear all your protests: "Of course, we would have the good sense to limit the number of generations in our machines. We would explore out to less than a few hundred light-years and then shut them down!"

Any advanced civilization would be able to predict the consequences of unlimited automata, *but what if a tiny fraction does not care*?

That is the argument that technological civilizations are not as thick as flies. If the number of civilizations that have ever existed in the galaxy were numbered in the thousands, the probability that just one of them would be so egotistical or uncaring to have loosed unconstrained automata would be great. And then in a galactic eye-blink – less than 10 million years – they are everywhere. On the other hand, if only a few dozen technical civilizations have ever existed, we could easily imagine that every single one of them could have decided not to release unlimited self-reproducing machines. Each civilization that reached interstellar spaceflight was or is surrounded by an explored bubble one or two hundred light-years across, but the bubbles of each known space seldom intersect in the complete 100,000 light-year diameter and average 1000 light-years-thick galactic disk. See Fig. 3.

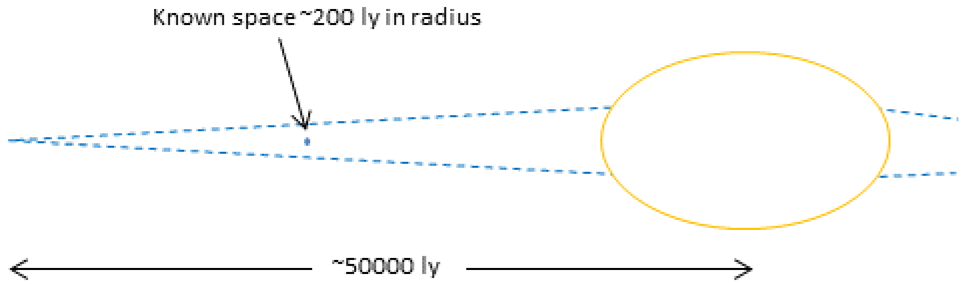


Figure 3. Known space as a dot on a stick-figured Milky Way galaxy. How likely do a few dozen such dots intersect?

If only a handful of civilizations have existed since the birth of the galaxy, then it is almost certain that we are the only one that is alive right now. It may be argued that one might exist in a distant galaxy, but we would never be able to communicate with it. If this is true of our galaxy, we *are* alone.

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