How (and Why) SpaceX Will Colonize Mars

August 16, 2015 By Tim Urban

Part 2: Musk's Mission

e rest of us, Elon Musk has a handful of life goals. Unlike the rest of us, one of those life goals is 1,000,000 people on Mars.

ast few months, as I've explained to friends what I'm doing with this post series, there's always stinct moment when I mention the whole...Mars thing. The facial reaction ranges from ttttt nooooo" to "Oh too bad, up till now I was thinking Elon Musk sounded pretty awesome and realize he was a silly wacky billionaire" to "Can I laugh or is Tim all serious about this and he'll be ed?"

action I haven't seen is, "Cool, that makes sense."

I get it—I felt the same way until pretty recently. Typically a sentence with the word Mars in it is about some esoteric astronomy thing or some geeky science fiction thing. And the word colonization usually comes up in sentences about history. The two words aren't supposed to go together in the real world.

To explain why Musk wants to put a million people on Mars, I'm going to introduce you to two aliens living on an Earth-like planet on the other side of the Milky Way—Zurple and Quignee:

Zurple and Quignee's planet, Uvuvuwu, formed 1.2 billion years later than the Earth, but because it only took 300 million years on Uvuvuwu for simple single-cell organisms to evolve into complex single-cell organisms (it took 1.6 billion years on Earth), life on Uvuvuwu beat us to the punch and reached human-level intelligence 11 million years ago. Today, the creatures on Uvuvuwu are far more advanced than anything we could dream of on Earth.

Zurple and Quignee have been friends since meeting in grad school 2.4 million years ago, and one of their favorite activities is observing emerging intelligent life forms throughout the Milky Way and betting on whether they'll go extinct or "make it through" (they have ways to see all planets in real time because of technological advances we wouldn't begin to understand).

Recently, Zurple and Quignee have been glued to what's happening over on planet 143-Snoogie—which is their name for Earth. Their interest in 143-Snoogie began about 350,000 years ago, when Zurple got an alert on his IntelligenceWatch app:

Life on 143-Snoogie has reached fetal intelligence.

He was at lunch with Quignee at the time, and when he mentioned the alert, Quignee said, "I'll give you 2-1 odds they go extinct." Zurple shook on it. Why not? It was always fun to have a group of species to keep track of and root for.

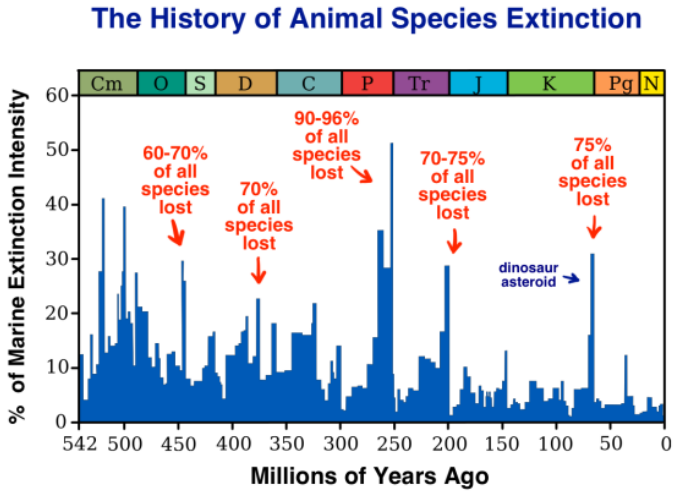
But recently, starting about 100 years ago, the two aliens have been paying much closer attention to the life forms on 143-Snoogie, and today, they're positively riveted by what's happening on the planet.

To figure out why, let's think about their bet and what might lead to a victory for one of them. Quignee wants the human race to go extinct. Badly. Zurple wants them to "make it through," whatever that means. We'll come back to that.

One thing they're probably paying attention to is the pattern of extinction events throughout the history of life on 143-Snoogie. Let's take a look.

The Scary Thing About the Universe

Species extinctions are kind of like human deaths—they're happening constantly, at a mild and steady rate. But a *mass extinction event* is, for species, like a war or a sweeping epidemic is for humans—an unusual event that kills off a large chunk of the population in one blow. Humans have never experienced a mass extinction event, and if one happened, there's a reasonable chance it would end the human race—either because the event itself would kill us (like a collision with a large enough asteroid), or the effects of an event would (like something that decimates the food supply or dramatically changes the temperature or atmospheric composition). The extinction graph below shows animal extinction over time (using marine extinction as an indicator). I've labeled the five major extinction events and the percentage of total species lost during each one (not included on this graph is what many believe is becoming a new mass extinction, happening right now, caused by the impact of humans):[1]



Naturally-occurring extinction events can be caused by a lot of things. The universe is a violent, hostile place and we're a group of fragile organisms living in a delicate balance of precise conditions. We're around, for now, because the universe is currently allowing us to be. Some things that might wipe us out:[2]

- **A nearby supernova.** Supernovae, the universe's largest explosions, happen when giant stars die. If one went off within 30 light years of us—which happens about once every 250 million years—it would probably do us in.

- **A gamma-ray burst.** Gamma-ray bursts are the universe's brightest events. They occur when a massive star's core fuses into heavier and heavier elements until it eventually can't fuse anymore and the star collapses into a black hole, ejecting a two-way burst so ridiculous that it releases as

much energy in a few seconds as the sun will over its 10-billion-year lifetime. Gamma-ray bursts are much rarer than supernovae, happening in each galaxy only a few times in a million years, but unlike a supernova (which happen about twice a century in a galaxy like ours[3]), a gamma-ray burst could badly ruin our day from much farther away, anywhere in our galaxy—if it happened to be pointed in our direction. It's hypothesized that the first of the five mass extinctions on the chart above may have been caused by a gamma-ray burst.

- **A solar super flare.** Solar flares happen all the time, and the Earth's magnetic field typically shields us from them (this is what produces the Northern Lights), but we've observed in other sun-like stars the occasional super flare *millions* of times more powerful than a normal solar flare. A super flare from our sun would suck. Speaking of the Earth's magnetic field—

- **The reversal of the Earth's magnetic field.** This can happen at any time, whenever the Earth's magnetic field is craving attention—on average it happens about once every half a million years. The reversal itself isn't the problem—it's the *transition* that's dangerous. While the field is in the process of reversing, there is a stretch of time between 100 and 1,000 years long during which the magnetic field is reduced to about 5% of its normal strength. Since we rely on the magnetic field for protection, this can be devastating for life. Scientists have shown links between magnetic field reversals and mass extinction.

- **A rogue black hole.** Once in a while, one of these creeps wanders into a solar system uninvited and wreaks havoc. Even without passing close to the Earth, if one passed even as close as a billion miles from us, it would fling the Earth into a more strongly elliptical orbit, turning our summer temperatures up to about 150 F (65 C) and our winter temperatures down to around -50 F (-45 C). Not okay.

- **Aliens being dicks.** I'll let late physicist Gerard O'Neill sum it up: "Advanced western civilization has had a destructive effect on all primitive civilizations it has come into contact with, even in those cases where every attempt was made to protect and guard the primitive civilization. I don't see any reason why the same thing would not happen to us."[4]

- **A global epidemic.** *Outbreak* without the convenient Hollywood ending.

- **An asteroid.** Duh. Too much to say for a bullet, so here's a Blue Box:

Asteroid Impacts Are Unpleasant Blue Box

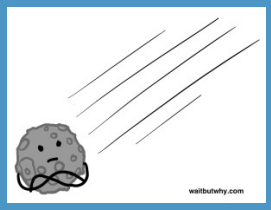
There are asteroids and comets[1] roaming around all parts of the Solar System, ranging from the size of a pebble to the size of a dwarf planet, but most of them are in three places—1) the asteroid belt between the orbits of Mars and Jupiter (which might have congealed into its own planet but never could because of the energy from Jupiter's nearby gravity), 2) the much larger Kuiper belt surrounding Neptune's orbit, and 3) the much, *much* larger Oort Cloud, a huge sphere of objects surrounding the Solar System.

Quick size orientation: If the Solar System is a penny (diameter = 2 cm), with Neptune a little pinprick circling around the edge of the penny (and Earth's entire orbit so small it just looks like a tiny dot in the center), the asteroid belt is a sharpened pencil-drawn thin circle in the center of the penny with a diameter of about 2 millimeters. The Kuiper belt is a flat circle around the outside of the penny (like Saturn's rings), drawn as thick as it would be if you painted it with your fingertip. The Oort cloud isn't a disk like the other two, it's a sphere, starting about 30 centimeters (1 ft) away from the penny in all directions, but continuing outward for 30 *meters* (100 ft) in all directions, making it a little bigger than Spaceship Earth.[2] While we're here, the nearest star is 90 meters (295 ft) away from the penny—a little under three times the distance between the penny and the outside of the Oort cloud sphere. So if the Solar System penny is in one endzone of a football field, the nearest star is a pinprick in the other endzone, and Voyager 1, the fastest-moving manmade object, which has been whizzing away from us for 38 straight years, has traveled only 4 cm away from the penny—making it the farthest away manmade object ever. I need to cut myself off and get back to the post, but it's hard because I'm enjoying the shit out of this paragraph.

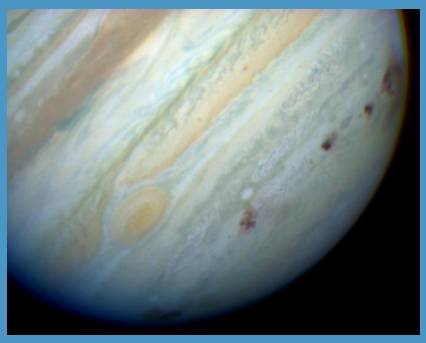
Anyway asteroids.

We can be hit by an asteroid or comet (I'll just use "asteroid" to refer to both for the rest of this) that's been nudged out of its normal orbit by a collision or some gravitational

perturbation (probably caused by either Jupiter or a passing star).

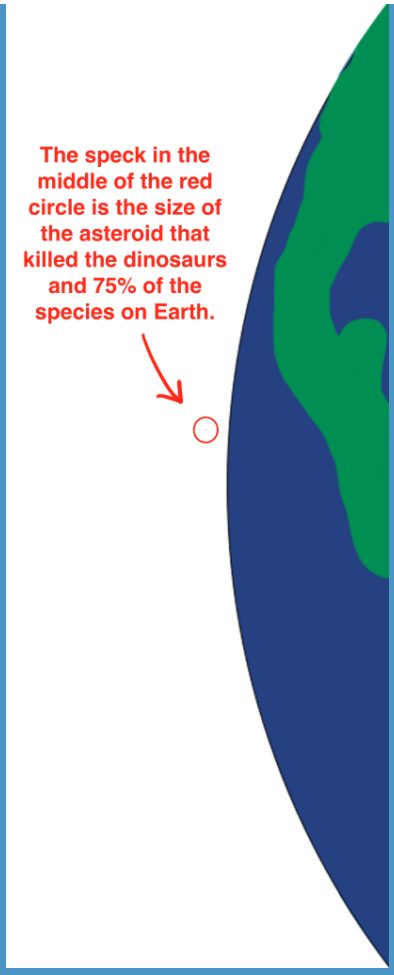


An asteroid doesn't need to be huge to ruin everything. In 1908, a tiny, 60-meter asteroid exploded in the sky 3-6 mi (5-10 km) over Siberia. Even from way up there, it flattened 80 million trees. If it had made it down to the Earth, it would have exploded with the force of over 1,000 Hiroshima bombs.[5] An asteroid with a diameter of only half a mile (.8 km) would kick enough dust up in the air to lower the Earth's temperature by multiple degrees for multiple years, which would have all kinds of dramatic effects. In 1989 an asteroid about this size passed through the Earth's orbit, exactly in the spot the Earth had been in six hours earlier. And the effect of an even larger asteroid impact? Well just note that each of these asteroid impact scars on Jupiter is about the size of the Earth:[6]



The famous asteroid that made the dinosaurs sad was about 6 mi (10 km) in diameter. If we're hit by one of those, we'll be treated first to a searing wave of heat ten times hotter than the surface of the sun in the area near the impact site as the asteroid, racing down from the sky at 100 times the speed of a bullet, compresses the air beneath it. Then a nearly-instantaneous shockwave will ripple outwards, flattening everything for hundreds of miles in every direction. At that point, with the force of over a *billion* Hiroshima bombs, the blast will send a thousand cubic kilometers of rock from the asteroid and the impact site splashing upwards into space, creating a wall of black higher than the clouds in front of anyone in that part of the world. When all this rock rains back down through the atmosphere, it'll turn into thousands of huge fireballs, which will set cities and forests on fire all over the Earth. Soon, the entire Earth will be blazing hot, a chain of earthquakes will be set off, volcanoes all over will erupt, and unthinkably large tsunamis will pummel every coast. This will be followed by a worldwide cloud of dust that'll rise up and block the sun for months and maybe years, cooling the Earth considerably—and the climate won't be back to the way it is now for over 1,000 years.

All this from being hit by something that, if the Earth were the size of a three-story mansion, would be the size of a pea.



The Earth itself wouldn't be too affected by the impact—but the *conditions* on the Earth's surface would be hugely affected because of how immensely fragile they are. Here's a stressful video depicting what I just described.

The extra-scary part is that asteroids are almost invisible in space and very hard to detect. Space agencies and amateur astronomers are tracking some of the potentially-threatening asteroids out there, but in many cases, we wouldn't know an asteroid was coming until it was billowing down from the sky.[3]

So even though it seems like we're on our safe little planet in a silent and still universe, it's actually more like being in a forest that's *currently* calm and peaceful—but where every once in a while, a terrifying bloodthirsty carnivore bursts out of the trees and ravages most of the life here, wiping it from existence. The mass extinction event graph above tells five horror stories from the past when our quiet Earth became the setting for an unspeakable nightmare for everything that lived here at the time. And it'll happen again—right here, where you sit. The only question is when.

Let's take a look at the 600 million-year history of animals and the mass extinction events along the way:

Looking at that timeline, we see that while there are definitely bad things looming in the future, the timescales in question are *huge*, so the probability of a catastrophic existential natural disaster happening in the near future is very low. How low?

To wrap our heads around it, let's surmise from the past that there's a good chance of a mass extinction event sometime in the next 50 million years, which means that there's about a 1 in 50,000 chance there will be one in the next 1,000 years. Proportionally, that's the same as someone drawing an X on the ground and telling you that it's likely that lightning will strike that one particular spot sometime in the next month. 1/50,000th of a month is about a minute, so the chances of lightning striking the spot in the next minute is the same as a mass extinction event happening on Earth in the next millennium. In other words, being on Earth over the next 1,000 years should feel as safe as standing in the lightning spot for the next minute, knowing lightning will strike the spot sometime this month.

If a millennium is one minute in the lightning example, a human lifetime is about five seconds. So the question is, how would you feel stepping onto the X for five seconds? I wouldn't be especially thrilled to spend *any* time on the X, and those five seconds would probably be a little stressful—but I would also know that I'd almost definitely be fine. That's the way we should feel living on the Earth during our lives—at least as far as existential natural catastrophes are concerned.

And if you're just thinking about your own life, or even the lives of the next ten generations of your descendants, being bound to Earth is not a huge deal.

But if you care about humanity as a *species*, you have to think about things differently. If humans stay confined to Earth as a species forever, it's the same as a person who plans to stand right on the X for many months. Since the extinction graph above shows us that lightning strikes the X about every two months, that's not a great long-term plan—right? Maybe our technology can help us survive a few lightning strikes to the face, but it'll still be horribly unpleasant to go through it, and any single lightning strike has the potential to wipe us out.

Let's look at it another way. Let's imagine the Earth is a hard drive, and each species on Earth, including our own, is a Microsoft Excel document on the hard drive filled with trillions of rows of data. Using our shortened timescale, where 50 million years = one month, here's what we know:

- Right now, it's August of 2015
- The hard drive (i.e. the Earth) came into existence 7.5 years ago, in early 2008
- A year ago, in August of 2014, the hard drive was loaded up with Excel documents (i.e. the origin of animals). Since then, new Excel docs have been continually created and others have developed an error message and stopped opening (i.e gone extinct).
- Since August 2014, the hard drive has crashed five times—i.e. extinction events—in November 2014, in December 2014, in March 2015, April 2015, and July 2015. Each time the hard drive crashed, it rebooted a few hours later, but after rebooting, about 70% of the Excel docs were no longer there. Except the March 2015 crash, which erased 95% of the documents.
- Now it's mid-August 2015, and the homo sapiens Excel doc was created about two hours ago.

Now—if you owned a hard drive with an extraordinarily important Excel doc on it, and you knew that the hard drive pretty reliably tended to crash every month or two, with the last crash happening five weeks ago—what's the very obvious thing you'd do?

You'd copy the document onto a second hard drive.

That's why Elon Musk wants to put a million people on Mars.

Why a million people? Because that's Musk's rough estimate for the minimum number of people it would take to create a *completely self-sustaining population.* In this case, self-sustaining has a simple definition—it means that if Earth vanished from existence, the Mars population would still be able to survive and thrive and grow. They wouldn't be dependent upon Earth for anything. Mining needs to be done? The Mars population needs people who know how to construct a mine and miners to do the work. Need to build a new hospital? A rocket launch to fix a broken internet satellite? Expanded agriculture to deal with a food shortage? Emergency measures because a war has broken out? The Mars population alone needs to have all of that covered. Musk doesn't think 10,000 or 100,000 people will be sufficient—but that a million people should be enough.

This concept—making human life multi-planetary in a self-sustaining way—is often called "planetary redundancy." Musk calls it life insurance for the species. I call it backing up the hard drive.

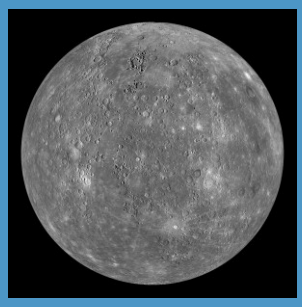
Of course, the Mars hard drive is no more reliable than the Earth hard drive. It would be vulnerable to most of the same catastrophes as Earth and it would also crash every month or two. But in most cases, the hard drive crashes would happen at different times. If one crashed *really* hard and our Excel doc on that drive was lost, the other would still be around—and it would probably have plenty of time to plan a new backup.

So now you've put the precious Excel doc on two hard drives. You'd feel *much* better. But if the doc were important enough to you, you probably wouldn't be satisfied having it on just two hard drives. You'd want to copy it onto a bunch *more* hard drives. But what other options do we have? Good time for a blue box:

Which Planets Sound Good to Live On?

Let's go through them.[7]

Mercury



Mercury had the bad luck of being the closest planet to the sun, which is like being seated at a table next to a 450-pound, aggressively horny man. And if you were on Mercury, your day would be spent in 800 F (430 C) weather—so hot that you could put a chunk of lead on the ground and it would melt into a puddle. There's almost no atmosphere on Mercury, so while you were burning to death, you'd also be standing in a near vacuum, which would rip the air immediately out of your lungs and begin to vaporize the moisture in your skin. The lack of atmosphere would also mean you'd be badly poisoned by radiation from the sun (which would look 2.5 times bigger in the sky than it does on Earth). On the plus side, Mercury's gravity is only 38% of Earth's, so you could jump around in a silly way as you died instantly. At this point, you'd be highly anxious for nighttime to arrive, and you'd be unhappy to learn that a Mercury day/night cycle is 58 Earth days long.

A month later, when night *finally* arrived, you'd be in the best mood ever for a minute before you realized that now it's -280 F (-170 C), which is 152° F colder than the coldest recorded temperature in Earth's history (Vostok Station, Antarctica). This is because there's no atmosphere to trap any of the sun's heat or distribute it around the planet. You'd also still inconveniently be standing in a vacuum. You'd have to spend a whole month deeply frozen to death before you could finally burn to death again upon sunrise.

Your best bet on Mercury would be near the poles which, while freezing and eternally dark, at least have ice on them so you could keep hydrated. In theory, a human base could be built near there, but the upside would be small.

When I asked Musk about Mercury, he called it a "hellhole," which abruptly ended the conversation.

Venus

Venus, not to be outdone in dickishness, manages to make living on Mercury sound like sitting on the beach in Maui eating a grilled shrimp.

It turns out that a vacuum is a lovely place to be compared to the exact opposite situation Venus has going—an incredibly dense atmosphere. Here's how a Venus visit would go:

First, the air is 96% CO_2 and poison to breathe.

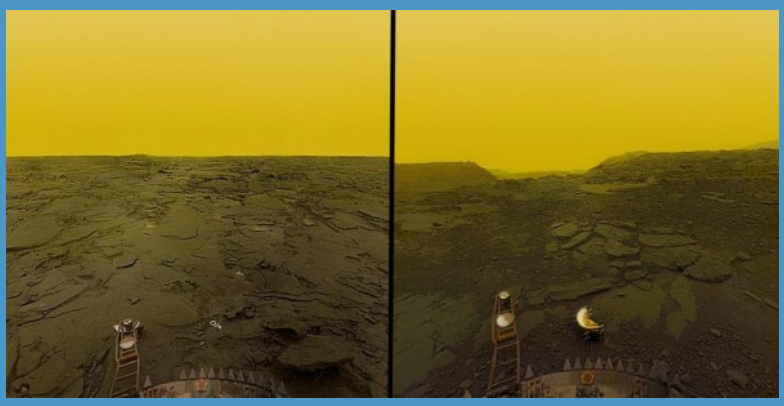
Second, who cares about the air's breathability when you'd be immediately flattened by the atmosphere, which would weigh down on you with more than 90 times the Earth's surface air pressure. The pressure would be the same as you'd feel if you were 1 km under the ocean—three times deeper than the scuba diving record depth. If you somehow could stay upright, the air resistance would be so strong that moving your arm would feel like moving it through water.

Third, who cares about either the first and second thing because *it's 870 degrees Fahrenheit (465 C).* Imagine heating up an oven so blazingly hot that it melts lead, then heating it up *another* 138 degrees—and then making that *the temperature of the entire planet.* At night (which again takes a while—Venus's day is longer than its *year*[4]),

Venus's temperature stays exactly the same because the thick atmosphere traps the heat inside.

During the day, you'd experience all of this in dim light, under a reddish-orange cloud cover. The sun would only be seen as a hazy, brighter, yellower part of the sky. At night, you'd live in utter starless blackness—all while being flattened in a sizzling furnace. At least there wouldn't be any bugs.

Given everything I just said, I'm super impressed with the badass lander of Soviet probe Venera 13 that descended all the way to the surface of Venus in 1982 and managed to stay alive for 127 minutes—long enough to snap these two photos, the only images we have of Venus's surface:



Wind is one problem you don't have on Venus's surface, where you'd only feel a light breeze—but as you ascended up through the atmosphere, that would quickly change. The upper atmosphere of Venus is a new kind of hell—constant winds double the speed of our most powerful hurricanes, and droplets of sulfuric acid (the same acid used to unclog drains) everywhere, whizzing into your face. Typical Venus.

Curiously, though, if you got all the way to the *top* of Venus's miserable atmosphere, you'd be rewarded with—shockingly—pleasant, livable conditions. Randomly, at the top of Venus's clouds is a layer where the temperature and pressure are similar to those on Earth, and because oxygen and nitrogen both rise in Venus's dense atmosphere (like helium does on Earth), the air in that layer might actually be close to *breathable*. That's led some scientists to actually discuss human *colonization* of Venus's high atmosphere, building "cities designed to float at about fifty kilometer altitude in the atmosphere of Venus."[8]

When I asked Musk about Venus, I was surprised to hear him actually suggest that the planet could be made livable "with extreme difficulty." He says that way down the road, with advanced enough technology, there could be ways to clear out most of Venus's atmosphere and *possibly* make it a far-future option for colonization.[5]

Mars

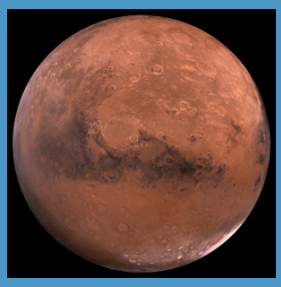
If Mars were a place on Earth, no one would ever want to go there. But in a discussion of inhabiting non-Earth planets, all of which are a total nightmare to live on, the prospect of moving to Mars sounds oddly okay.

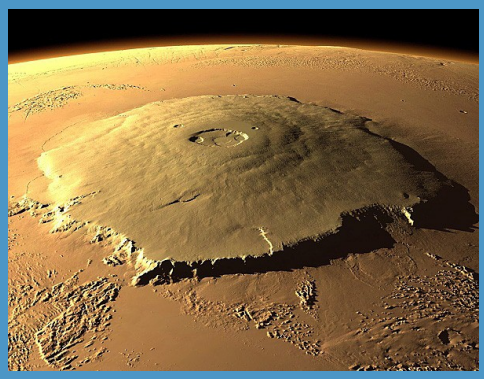
Mars is basically a colder Antarctica that looks like the Arizona desert with air you can't breathe and a sun that radiates you to death if you're exposed to it for long. Every part of Mars is dramatically less livable than the least livable place on Earth. But the conditions are reasonable *enough* that with a man-made "hab" to live in, a little greenhouse garden, and a good enough spacesuit, you could actually exist on Mars without dying. There's even water on Mars—lots of it—tied up in ice on the poles, and if you're in the right part of the planet at the right time of year, you can enjoy glorious *70 F (21 C)* weather. Or you can at least know that it's nice out while you're looking out the window of the hab.

A Mars day (a "sol") is about 24.5 hours, which would work nicely for both humans and plants. And with 38% the gravity of Earth, you could kind of function normally. There would be some fun low-gravity perks, like being able to dunk on a 15-ft hoop or living on the second story of an apartment building and leaving for work in the morning by jumping out the window (roughly 1/3 the gravity means that whatever jumping from an X-foot ledge would feel like on Earth would equal the impact of jumping from a 3X-foot

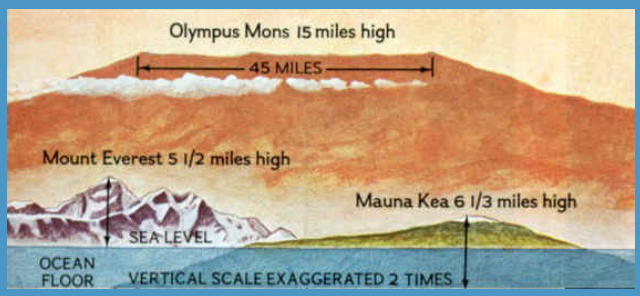
ledge on Mars.)

The coolest tourist attraction in the Solar System is also on Mars—the Solar System's tallest mountain, Olympus Mons: [9]

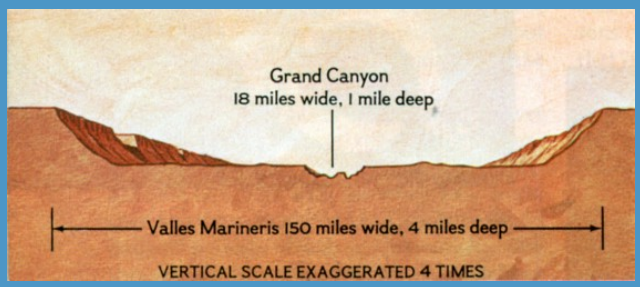




Which would cover Arizona and makes Everest look like a foothill: [10]



Not to mention Mars' canyon that makes the Grand Canyon look like a paper cut: [11]



We'll get into this more later, but in theory, with enough effort and technology, humans could *terraform* Mars and sometime down the road have a somewhat pleasant planet to live on, with trees and oceans and no need to wear a spacesuit outside.

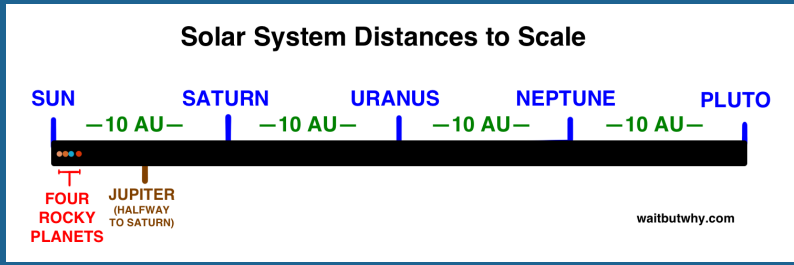
Relative Planet Distances Bluer Box

We're about to head much farther away from the sun, so let's put these distances in context. To do that, you can divide the Solar System into three roughly equal thirds, each about 1 billion miles, or 10 AU long (an AU is the distance from the sun to the Earth):

1st third: Sun to Saturn
2nd third: Saturn to Uranus
3rd third: Uranus to Neptune [6]

So if the Solar System is a yard long, Saturn, Uranus, and Neptune lie at the end of each of the three feet. Jupiter is 6 inches (about 5 AU) from the sun,

cutting the first third in half, and the other four are all crunched into the first two inches of the first foot:



Jupiter and Saturn and Uranus and Neptune

I hope you've enjoyed floors, because none of the other planets have one. Here's how the four faraway planets ended up being so weird:

4.6 billion years ago, there was a huge cloud of gas existing in space when some perturbation triggered the process of it condensing on itself. The universe's matter knows full well what that means—it's suddenly Black Friday and it's a frantic race to scoop up as much of the matter as possible. As every star and planet will tell you, the key is to get the lead early. If you start off with the most mass, you'll have an easier time collecting more and becoming even bigger, further increasing your advantage. Once there's a clear early leader, they're hard to catch.

The eventual winner gets to become a star—everyone else will end up as gawking paparazzi planets revolving around the star for 10 billion years until finally the star becomes washed up and retires and then a new game starts.

In the case of our Solar System, the sun pulled out the victory, scooping up about 99.8% of the gas cloud's total matter in the process. At that point, it becomes a bloody battle over the remaining scraps. Those who can gather enough will at least have the dignity of being a planet. Those who try and fail will end up suffering the shame of spending 10 billion years as a *planet's* paparazzi—a lowly moon.

The hapless matter who manages to fail to become a star, planet, *or* a moon will be doomed to become either an asteroid—the Solar System's homeless man—or be absorbed into a larger body and lose their identity altogether. It's a tough world out there.

During this rat race, an awkward thing can happen. Sometimes there's certain matter not experienced enough to know the golden rule of solar system formation—*know when you're beat*. Mercury, Venus, Earth, and Mars clearly read the signs early, could see that the sun had too big a lead, hung up the acting career and moved on. They switched gears and started working on becoming a planet.

The four *gas giants*,[7] on the other hand, continued on in vain, collecting gas in a sad and desperate attempt to turn the tables. And when you do that, you end up in a bad situation—as a bizarre "almost-but-not-quite-star." Jupiter's composition is hydrogen and helium, just like the sun, but unlike the sun, Jupiter doesn't have enough mass to ignite fusion, only enough to forever remind everyone of its failed attempt at stardom.

The gas giants won't admit it, of course. Once it became entirely clear that they would not become stars, all four of them quickly changed their tune, pretending they had been trying to become planets all along. Now they're left in a depressing no-man's land between star and normal planet and will spend 10 billion years as bloated planets with no surface. No one wants to be a planet with no surface.

We're not sure exactly what goes on inside of a gas giant like Jupiter.[8] If you tried to go find out, you'd zoom down through the outer clouds as the strong gravity (2.5x Earth's gravity) pulled you in faster and faster. As you fell, things would get darker, hotter, and the pressure would grow higher and higher. Eventually, you'd be in the pitch black, the temperature would exceed the temperature of the sun's surface, and with a massive amount of atmosphere above you, the gas around you would be so pressurized that you wouldn't be able to distinguish it from a liquid (this is called a "supercritical" state).[9] The hydrogen would then become *so* condensed that electrons would begin to flow from atom to atom, turning it into a liquidy sea of electricity-conducting *metallic* hydrogen. Whether at the very center of Jupiter you arrive at a solid core is up for debate.

What's not up for debate is that humans will never move to Jupiter. Or Saturn. Or Uranus. Or Neptune.

Where humans *could* possibly move to are the large, rocky, ice-covered *moons* around Jupiter and Saturn. But it wouldn't be warm. We could maybe move to our own moon, but it's just a milder version of the Mercury situation—daytime temperatures that can boil water into gas, nighttime temperatures that can condense oxygen into liquid, and no protection from the sun's radiation. And the 28-day rotational cycle means plants need to endure two weeks at a time in the dark—not easy.

When I asked Musk about where other than Mars humans could potentially move to, he said there were a handful of places that could work if our technology becomes advanced enough—several moons, a few of the largest asteroids, even Mercury and Venus if you really want to get crazy, but he finished by saying, "I mean, Mars is by *far* the best option."

Before we go back to the non-blue world of the normal post, can we just acknowledge how good living on *Earth* sounds right now?? Imagine the privilege of living in *room* temperature weather, one atmosphere of pressure, *g* gravity, light breezes, watery rainstorms, plentiful liquid oceans, magnetic and atmospheric protection from the sun, food everywhere, and air you can just *breathe in*. You need a huge number of different conditions to be *precisely* correct in order for you to be able to just stroll around outdoors without a spacesuit. So let's all appreciate the *luxury* of living on Earth for the next seven minutes until we all simultaneously forget to give a shit about it again forever.

Let's reorient. So far, we've established:

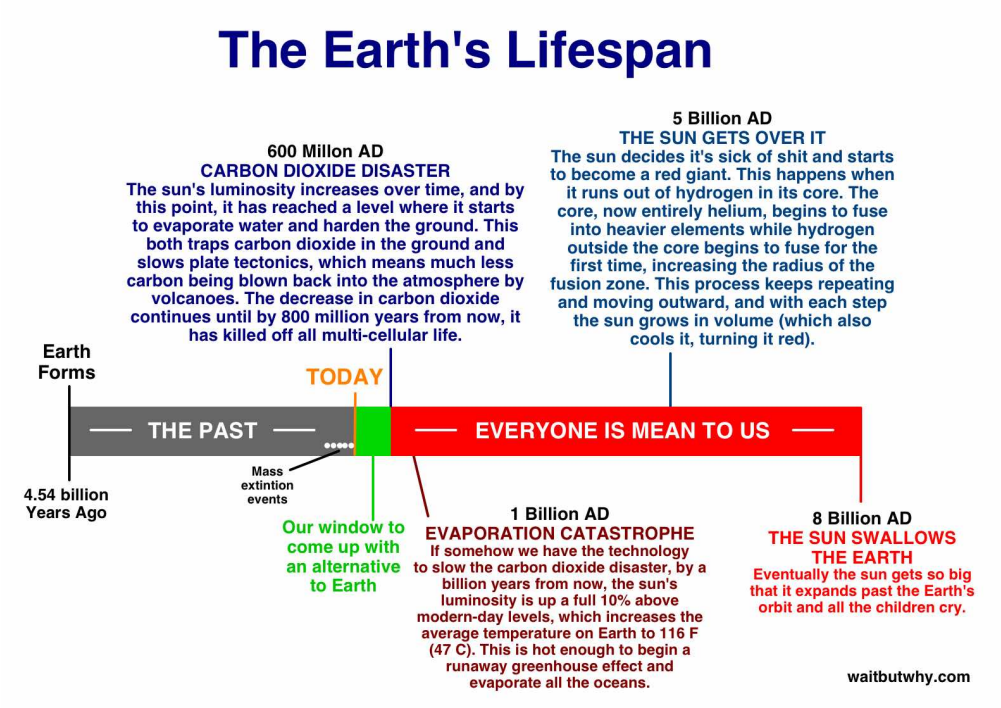
- Backing up the humanity hard drive is a critical and necessary thing to do at some point—by having all of our eggs in one planet basket, we're leaving ourselves vulnerable to extinction.
- Mars is by far the best place to back up the humanity hard drive.
- But with enough technology, we *could* create many more backups by colonizing as many as ten or more moons, asteroids, and planets in the Solar System.

One other fun option: Scientists have explored a bunch of ideas for fun-seeming artificially-constructed space habitats. While the existing ideas are limited by our current imaginations, I can envision a future when living on planets seems as primitive to future people as prehistoric people living in caves seems to us today. In the last few thousand years, humans invented the concept of being "inside," and now almost all people think of home as somewhere indoors—maybe in the future, a giant, artificial space habitat that has mountains and rivers and trees and millions of people will be the equivalent of the invention of "inside" as it applies to an entire *world.* And the thought of worrying about weather and earthquakes and being hit by asteroids will seem like cavemen worrying about being attacked by a pack of wolves while you sleep. Maybe.

Either way—once there are millions of humans on several different bodies or habitats, the Excel doc is pretty secure, and humanity should be able to survive nature for a long, long time.

Oh But Also

Of course, all of these hard drives are still housed in the same Solar System, and if all of your backups are in the same house, it's problematic if that house burns down. And just like we're unfortunately using a hard drive that's destined to crash, we're also living in a house that's certain to one day burn down. The sun is about halfway done with its life. Here's the script of Act II:[12]



After terrorizing the Earth, the sun will move outwards and, one by one, make each of our other potential homes unlivable. Luckily, we have the green window, which gives us a chance to do something about it. Musk points out that we're currently about 90% of the way from the beginning of the Earth to the point where the oceans evaporate, the heat becomes unlivable, and all complex life dies off—"so if intelligent life had taken only 10% longer to develop, it would never have developed." [10] When it comes to our evolution, we arrived in the ninth inning, just in the nick of time—and now we have to figure out how to expand beyond the planet, and eventually the Solar System, before we're swept back into eternal non-existence.

A piece of good news in all this is that the timescales here are huge. The sun's bad behavior doesn't start for an insanely long time, and I'm assuming that if we make it all the way to the end of the green window, our technology by that point will enable us to either A) easily move around to safe parts of the Solar System as needed, B) become a multi-*solar* species that can spread out to other life-friendly solar systems in the galaxy, and/or C) create safe space habitats that make energy without the need for stars—either through nuclear technology or, much more likely, some advanced technique we can't conceive of.

So our to-do list is:

1) Get ourselves Earth-proof (by going multi-planetary) before something extincts us on Earth. Which will give us plenty of time to:

2) Get ourselves Solar System-proof before the sun ruins the Solar System.

And when it comes to Item 1, yes, the next mass extinction event could happen anytime, but if we take the next few thousand years to figure out how to expand beyond Earth, odds are we'll be able to back ourselves up before anything too catastrophic happens.

So that seems reasonably under control—but back to Zurple and Quignee. If we're still thousands, and likely millions, of years away from any kind of dire event—why are the two of them so riveted watching what's happening here on 143-Snoogie *right now*?

The Scary Thing About Humans

In order to emphasize the utter magnitude of what becoming a multiplanetary civilization would mean, Musk often talks about how zooming out on history exposes all events for their true *significance.* The further you zoom out, the "bigger" a turn of events has to be in order to remain significant on that scale.

You can play the zoom-out game with the physical world. From where you're sitting, streets, houses, and cars are significant objects. But from an airplane, they all melt away, and only larger things like cities, lakes, and mountains can hold up. From the ISS, only continents and oceans are significant. Farther away, only planets and stars. Farther still, only entire galaxies.

The same concept applies when you zoom out on the history of life (which we did once, in this post). To make the daily news, an event can be the latest in some scandal, the movement of financial markets, a robbery, a protest, a sporting event, a meeting of two politicians. Those events are fairly small, but so are the holes on the "significance filter."

When we zoom out to the span of a year, it's like going from the ground to an airplane—we're too far away to see most of each day's newsworthy events anymore and most of them blend into the background. From that distance, only the year's most impactful events are visible, and the larger overarching storylines that may have been hard to grasp up close begin to take clearer shape—a heinous terrorist attack, a big election, a new product or service that sweeps the world.

Looking at a whole century is like seeing the planet from the ISS. The big stories of the century are like the continents and oceans that can't be fully seen from an airplane—sweeping cultural or political shifts, wars and other large tragedies and how they change things, groundbreaking scientific breakthroughs, world-altering technological advancements.

If we zoom out further to a few thousand years, even larger storylines take shape—the rise and fall of empires, the arc of worldwide religions, new iterations of scientific understanding or technological advancement, phenomena that affect the world for many centuries like the Age of Imperialism, the Industrial Revolution, and the birth of the nation-state.

Zooming out to 100,000 years, we can see our species' entire storyline. We see major migrations, the development of language and farming and writing and the eventual birth of the industrialized world.

Still, though, even at this epic scale, we're far too zoomed-in to begin to see the outline of the storylines of life as a whole. Life history moves far more slowly than human history.

Even backing up to 10 million years, we can only see traces of life-scale storylines. In our own evolutionary line, we can see an increasing diversification of the great apes, the human-chimpanzee tribe split, and the progression of the homo genus that eventually led to humans. And that's the kind of thing you'd see in other parts of the life story on a scale of 10 million years—nothing major, mostly just tweaks of existing biology.

With a 500-million-year lens, we can now see the great story of animals. The growth in complexity, as fish, then insects, then reptiles, and then mammals emerge, along with the rise and fall of the dinosaurs. Here, the five extinction events are vivid in our sights.

And when we zoom all the way out—3.8 billion years—where we can see the origin of life on one end and the present day on the other, what do we see that qualifies as significant?

We see simple cells, then we see complex cells, then we see multicellular life. We see life explode into diversity, emerge from the ocean onto land, and eventually, through the advent of mammals, rise into high intelligence.

Including mammals and intelligence on a list of life's most significant leaps may seem self-centered, but it's not, because it's only through consciousness that life can make a new great leap—becoming multi-planetary.

If humans become self-sustaining on Mars, it would be a turn of events, for all Earthly biology, that would hold up under even the largest zoom lens—it's on *that* level.

And when you look at it this way, you realize that Neil Armstrong calling the moon landing "a giant leap for mankind" is not the correct wording. Landing on the moon is in the same category as putting the first man in space or the first person climbing Mt. Everest—it's a great *achievement* for mankind. But if the first ocean animal to touch dry land simply lay there for a minute before being washed back into the ocean, it would not qualify as a giant *leap* for life, and the moon landing shouldn't either. It's only when certain mutated fish began to *live* on land in a *sustainable* way that life as a whole made a giant leap. It's *colonizing* Mars permanently that will be a giant leap for mankind.

But shouldn't we pause for a minute and note that it's a little *weird* that after 3.8 *billion* years—38,000,000 *centuries*—that I'm claiming that *this century*, we may witness a giant leap on par with the six or seven greatest leaps in history? How could that possibly be?

And wait, this reminds me of something. When we dove into artificial intelligence, it certainly seemed like A) something that might explode into superintelligence in the next century, and B) something that might permanently and *dramatically* affect all life on the planet (for better or worse). Would *that also* qualify as a potential giant leap?

And—as our understanding of the human genome advances and the science of genetic engineering races forward, isn't it conceivable that in 100 years, science may have figured out how to keep humans alive for much longer than a normal biological lifespan and put people through legitimate reverse-

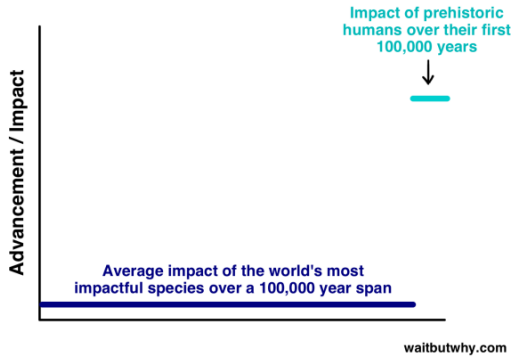
aging procedures? If that happened and we conquered aging, *wouldn't that also* make the big, big list of significant events in life history?

What the hell is going on??

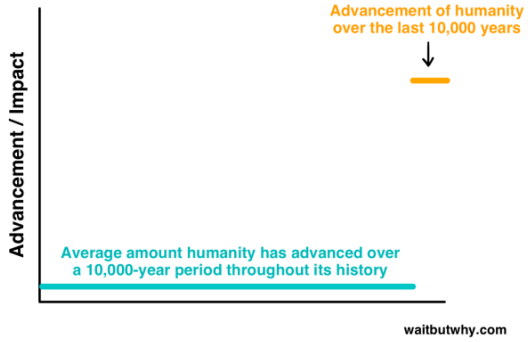
Either I'm being hopelessly naive or this is a *very* intense time to be alive. Here's what I think is happening:

As we've discussed, the rate of progress can grow exponentially, because as more progress happens, it enables *faster* progress to happen, and this starts a cascading chain as progress explodes upwards. We can see this happening in a series of increasingly-explosive growth rates:

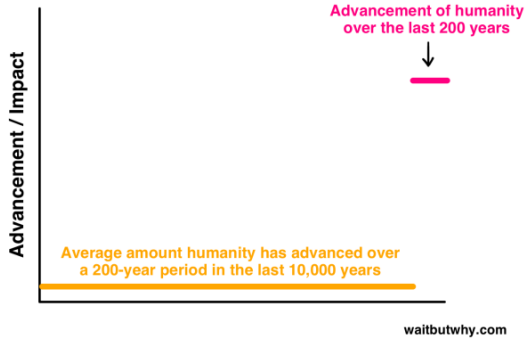
- The impact of the prehistoric human species on the natural world was *much, much larger* than normal in a span of only 100,000 years—no other species has ever changed so much, so broadly, so quickly.



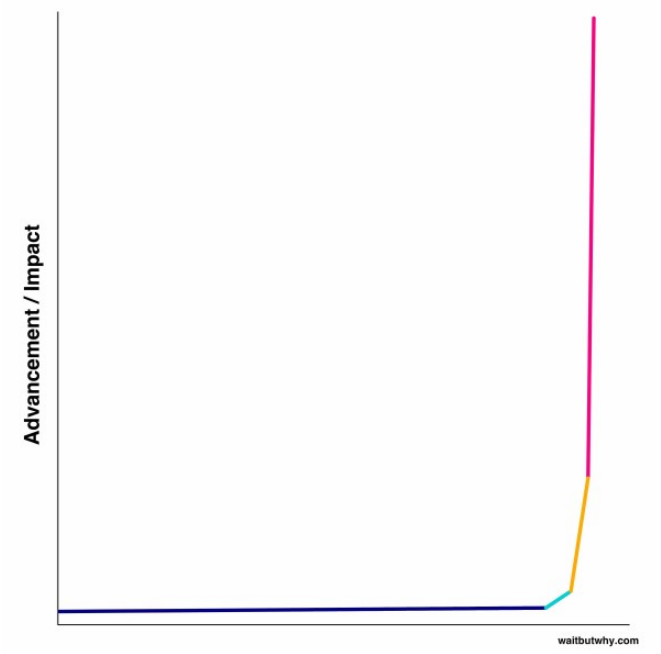
- Zooming in, the advancement of humanity in the last 10,000 years, since the Agricultural Revolution, was *much, much greater* than the advancement of humans over any other 10,000-year period prior.



- Zooming in again, the explosion of industry and technology in the last two centuries since the Industrial Revolution, between the years 1815 and 2015, *far, far exceeds* the advancements of any 200-year period before that.



When you put those graphs together, you end up with a *serious* one of these trends:



So maybe I'm not being naive—maybe there's good reason to believe that we're living in the upswing of an exponential curve of progress unlike any that life has ever experienced. And since with progress comes power, our species now has an unprecedented amount of power to influence things.

And at some point, that power grows so great that the kind of colossal leaps that took microbial and animal life hundreds of millions of years to achieve can be accomplished in under a century.

When a species becomes so powerful that they can achieve giant grand-scale life leaps in under a century, they can essentially play god, in many different ways. Let's call that reaching the God Point. If progress is indeed accelerating, it makes sense that an advanced species would eventually hit the God Point, and there seems to be plenty of evidence that humans are either already there or very close—advancements in fields like space travel, artificial intelligence, biotechnology, particle physics, nanotechnology, and weaponry open the door to a long list of unthinkably-dramatic impacts on the future.

On that long list are a number of positive developments that could lift humanity into possible unextinctable territory and an even larger number of horrific doomsday scenarios that could wipe out the species, cause a mass extinction, or even put an end to life altogether—everything from an engineered plague to a particle collider catastrophe to an out-of-control nanobot chain reaction to an accidentally-unfriendly artificial superintelligence to runaway climate change to a bunch of things we can't conceive of because the technology isn't quite here yet.

Most of both the good and bad massive-impact scenarios discussed today won't end up happening, but some very well might—especially as technology continues to advance—and the reality is that we're living in a time when we could witness *multiple* events in our lifetimes as impactful as life going from the ocean to land. Not only might we be on the cusp of the great leap of life becoming multi-planetary, we may be on the cusp of a *bunch of other great leaps as well.*

There are other signs pointing to this being an extraordinarily unusual time to be alive:

- For 99.8% of human history, the world population was under 1 billion people. In the last .2% of that history, it has crossed the 1, 2, 3, 4, 5, 6, *and* 7 billion marks.
- Up until 25 years ago, there had never been such a thing as a global brain of godlike information access and connectivity on this planet. Today we have the internet.
- After barely using any energy for the first 99,800 years of human history, in the last 200 we've suddenly thrust ourselves into the Fossil Fuels Era, blowing through a huge chunk of stored underground carbon energy, without fully understanding the implications of doing so.
- Humans walked around or rode horses for 999 of the last 1,000 centuries. In this century, we drive cars, fly planes, and land on the moon.
- If extra-terrestrial life were looking for other life in the universe, it would be dramatically easier to find us this century than in any century before, as we project millions of signals out into space.
- With an average of one mass extinction event every 100 million years since animals have been around, we may be currently engineering a sixth one by accident.

If we take a step back and just look at the situation, it should be clear that *nothing that's happening right now is normal.* Current humans have FAR more power than any life on Earth ever has, and it seems very likely that if in a billion years, an alien history major writes a term paper on the history of life on Earth, the time we're living in right now—however it turns out—will be a major part of that paper.

And *that's* why Zurple and Quignee are so locked in right now. They looked at their phones and saw a new alert from the IntelligenceWatch app:

Life on 143-Snoogie has reached the God Point.

Zurple and Quignee aren't waiting for an asteroid to hit or the sun to die or a nearby supernova—*they're waiting to see what happens in the next 100 years.*

That's what their bet was about. When a planet's life reaches high intelligence, it usually means they're a couple hundred thousand years away from their do-or-die moment. Their progress will accelerate faster and faster until finally they hit the God Point, when they simultaneously gain the power to forever end species vulnerability or drive themselves accidentally extinct—and it's all about which comes first.

And that's why the first IntelligenceWatch alert said that life here had reached "fetal intelligence"—because looked at through a zoomed-out lens, reaching initial intelligence is the conception of a fetus, but only reaching the God Point will determine whether there will be a miscarriage or the birth of a new long-term intelligent species. Those species who hit the God Point, then enter the chaos that inevitably ensues, and somehow come out alive on the other side have "made it through," and they can officially join the universe's community of grown-up, immortal, intelligent species.

Zurple and Quignee have been aware of 143-Snoogie for a while because of their bet, but any galactic life hitting the God Point is a big deal and a great spectator sport, so recently, 143-Snoogie has become a notable piece of news all over Uvuvuwu, as everyone follows the story, to see whether the life on 143-Snoogie will make it through or not.

And if there's even a small chance that what I'm saying is right and we really have hit some kind of tipping point of advancement, one where we have all kinds of new powers, with unknown and unpredictable consequences—and we're total amateurs at having this kind of power…

Isn't now probably a pretty great time to back up the hard drive?

All you have to do is put yourself in Quignee's shoes—imagine you're rooting against some faraway species. You have a *ton* of money on the line, and you *really* want them to go extinct. In that situation, how *bummed* are you if that species manages to become successfully multi-planetary? Humans colonizing Mars is the *last* thing Quignee wants to happen. Sure, certain types of disasters could wipe out the species even if it's on multiple planets, but it's *much* easier for a species to go extinct when all the eggs are trapped in one basket together—and backing up the hard drive would be a huge blow to his chances.

Meanwhile, across the table, Zurple's staring intently at the screen, muttering under his breath, "Come on come on come onnnn." His screen is zoomed in on an industrial-looking building in Hawthorne, California—the SpaceX headquarters.

———————

It's not only Musk who's thinking about Mars.

Stephen Hawking has said:[13]

I don't think the human race will survive the next thousand years, unless we spread into space … We face a number of threats to our survival, from nuclear war, catastrophic global warming, and genetically engineered viruses; the number is likely to increase in the future, with the development of new technologies, and new ways things can go wrong … We need to expand our horizons beyond planet Earth if we are to have a long-term future, spreading out into space, and to other stars, so a disaster on Earth would not mean the end of the human race. … Once we spread out into space and establish independent colonies, our future should be safe.

Princeton professor J. Richard Gott:[14]

In 1970 everyone figured we'd have humans on Mars by now, but we haven't taken the opportunity. We should do it soon, because colonizing other worlds is our best chance to hedge our bets and improve the survival prospects of our species. Sooner or later something will get us if we stay on one planet. By the time we're in trouble and wish we had that colony on Mars, it may be too late.

Nasa Administrator Michael Griffin:[15]

In the long run a single-planet species will not survive … If we humans want to survive for hundreds of thousands or millions of years, we must ultimately populate other planets … One day, there will be more human beings who live off the Earth than on it.

Science fiction writer Larry Niven may have said it best: [16] *The dinosaurs became extinct because they didn't have a space program. And if we become extinct because we don't have a space program, it'll serve us right!*

What worries Musk the most is the Fermi Paradox. The curious fact that we've never seen any evidence of alien life makes him suspect that there are "lots of one-planet dead civilizations" out there. He warns, "If we are very rare, we'd better get to the multi-planet situation fast, because if civilization is tenuous, then we must do whatever we can to ensure that our already-weak probability of surviving is improved dramatically."

That was Musk's mindset in 2001 when a friend asked him what he planned to do after PayPal. Musk recounts the conversation: "I said, well, I'd always been really interested in space, but I didn't think there was anything I could do as an individual. But, I went on, it seemed clear that we would send people to Mars. Suddenly I began to wonder why it hadn't happened already. Later I went to the NASA website so I could see the schedule of when we're supposed to go." [17]

But when he looked around the website, he was shocked to find…nothing there. Ever since the first round of slashes to NASA's budget in the early 70s, the plans to go to Mars kept being pushed back again and again as battles for increased funding failed. Now, there were no plans at all.

So Musk came up with a way to help—he'd put a plant on Mars. The plan—called Mars Oasis—was to perform a charitable mission to Mars that would carry a small robotic greenhouse to the planet. The greenhouse would use an arm to scoop some Martian soil, plant a seed, and then once a plant had grown, the greenhouse would send back what Musk calls "the money shot"—a photo of a sturdy green plant amidst the alien red background and the first (known) life on Mars.

The idea was that the stunt would get a lot of attention, wake the world up to the excitement of space travel again, inspire a bunch of children to seek out careers in aerospace—and ultimately, Musk hoped, this renewed public interest would lead to an increased NASA budget. Musk believed—and still believes—that around .25% of US GDP, or about 1% of the budget, should be dedicated to space. He makes it clear that he's not suggesting a return to the 4%-of-the-budget days of the 60s—just an increase from the less-than-.5% level it's at today. "For 1%," he says, "we can buy life insurance."

Musk, who was winding down his time with PayPal as the sale to eBay neared, brought together a team of space people to work with him on Mars Oasis. To make it happen, they would need a rocket, which Musk would buy with part of his PayPal earnings. The cheapest US rocket at the time cost $65 million, but in Russia, a used rocket would be a fraction of that price—so off to Russia Musk went to negotiate for the purchase of three refurbished intercontinental ballistic missiles. Musk was willing to put up $20 million for all three, but the Russians wanted more. He left the country empty-handed.

And that's when he made the decision—he'd do it himself.

Not the plant project—the *big* project.

He had spent months voraciously reading about rocket technology and what it would take to make them himself, and he believed it was possible.

He'd put 1,000,000 people on Mars.

Part 3: How to Colonize Mars →

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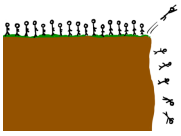

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936 Comments Wait But Why Login

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Name

maria juchkov • 23 days ago

Absolutely love the series! But I have a few questions...
If Mars is to be the Plan B for Earth, why send people back to Earth? And when the time does come that Earth will become uninhabitable will SpaceX & Mars be able to cope with a mass exodus?

And further more, does Elon have any plans for what type of economic system will be on Mars? After all, what's the point colonising Mars, only to live unsustainability & trash it too...

Reply • Share ›

stephenshenfield • 2 months ago

The author neglects the medical effects of switching between different gravity environments. Even with well-designed exercise routines, astronauts who spend any length of time in space suffer serious physical disabilities on return to earth. Among other things, this will deter people from returning to each after even a couple of years on Mars (plus 6--12 months in space).

Another problem is the selection of colonists by ability to pay initially very high fares rather than by possession of needed skills, good physical and mental health, age, etc. If selection is based on criteria such as these most of those selected will not be able to afford the fare, so a lot of money will have to be raised from wealthy people who will not themselves be able to go to Mars.

The technical aspects of development of extraterrestrial colonies are outlined, but there is hardly any discussion of political and economic systems. The assumption seems to be that these will resemble those on earth, which is likely to be impracticable, especially at the early stages, and would also be undesirable, seeing what a mess these systems have made of earth. If two or more space powers set up their own colonies on the same planet what will the relations between them be?

Reply • Share ›

Summer of Love (bob) • 5 months ago

Tim, I'm afraid Musk sold you a load of manure on Mars. It is unlivable for humans and always will be. Reference the failure of the earthdome projects and you'll quickly realize domed cities don't work even on Earth, muc

1 Reply • Share ›

2ndGenSunRoad • 5 months ago

We on Earth are not in Energy paradise to sustain life on other planet, but actually in Energy prison;

"No device can generate energy in excess of the total energy put into constructing it".

https://the-fifth-law.com/p...

1 Reply • Share ›

GregWA • 6 months ago

"measuring contest"...have you actually read the history of Nazism or Communism? They weren't measuring anything...they were and are evil totalitarians hell bent on killing those who disagreed or would not submit (like radical Islam). And if you think this level of evil is restricted to modern times, read some more history. Musk and his family colonizing Mars as a modern day Ark story would not result in evil being excluded. I like science and I like science fiction, speculation, the rest, but please keep religion and politics out of it. Scientists, myself included, are typically no more qualified to expound on these things than anyone else. So I offer this post in that spirit: just one guy's opinion based on a little knowledge and much less wisdom.

p.s., Americans weren't horrified by the Soviets larger penis (first satellite/human in orbit), they were horrified that the Soviets could now deliver nuclear weapons to America, with no warning or protection possible. Did

you miss that bit of history or does that just boil down to a "penis measuring contest" for you? Sorry for the attitude, but I'm an old guy losing patience with how little people have learned from all of humanities mistakes.

2 • Reply • Share ›

The_Unknown • 8 months ago

What about the reduced gravity on Mars? It's 38% of the gravity on earth if I recall correctly. Research has shown that microgravity in the ISS has a detrimental effect on muscle mass and bone density and even on organ function. Sure the first two can probably be solved by exercise but the organ function can't. And even if there's a big difference between almost no gravity and 38% of earth's gravity, there's no telling what the effect of long term (years or decades) exposure to this reduced gravity will be on human organs.

Reading these series of posts I do believe in the colonization of Mars but this reduced gravity has gotten me wondering about the long term feasibility of all this.

1 • Reply • Share ›

Ante Renic • 9 months ago

Tim, take note. Your "what is an orbit" blue box gets several things wrong.

1) You said ponds have no high and low tides due to their lower mass than that of oceans. Their mass is completely irrelevant as acceleration is always the same, regardless of mass. Ponds don't experience high tides because there is no water that comes over from the back of the planet. Similarly there's no low tides because the water has no route to take to the other side of the planet.

2) The trajectory of a ball being fired at too high a speed would not look like that. It's not like it would circle for a bit and then start moving straight through space. The Earth is still acting on it, regardless of distance. As it moves further away, the curvature of the trajectory will become lower and lower, but it will always curve a little bit, it will certainly never become straight, not in the manner depicted, anyway.

3) Thrown objects would only fly in a circle if the source of gravity was in the center of the circle. This means that the trajectory of thrown objects isn't a circle even before they hit the ground. If the ground was a straight line (which it is if we zoom in enough, as in most physics problems) and gravity acted exactly downwards all the time, the trajectory would be a parabola (no air resistance). If the direction of gravity changed such that it's always perpendicular to the velocity, the trajectory would be a circle, as I've explained above. If the gravity, however, does change direction but is not always perpendicular to the trajectory, as is the actual, realistic (and drawn) case here, the trajectory would be something between a parabola and a circle.
Note that trajectories can also be ellipses; in fact, a circle is mathematically merely a special case of an ellipse (just as a square is a special case of a rectangle).

For the third note you can just add a blue square thing which says that the trajectory isn't exactly circular, but whatever.

Also note: Tesla started with 30 million, not 70 million. Elon's share of Paypal's sale was 130 million, so 100 went to SpaceX.

• Reply • Share ›

Ralph Fischer • 9 months ago

Main reason for bad wind and temerature on Venus is the fact that it got almost no rotation.

In order to colonize Venus i assume first it needs to be hit by some pretty big Asteroid to start a rotation.

Might even need a mass close to the moon.

2 • Reply • Share ›

Ralph Fischer • 9 months ago

I think you got that one wrong: "Humans have never experienced a mass extinction event, and if one happened, there's a reasonable chance it would end the human race"

Humans faced black death and that took quite a bite into population.
Not to mention that we WITNESS a mass extinction event right now while reading. It is caused by many many humans totally ignorant to the fact that their actions are about to kill loads of liveforms, including bees. High chance that the mass extinction event for humans is just waiting for new years day.

• Reply • Share ›

Nicole Song ➚ Ralph Fischer • 9 months ago

Right, but the bubonic plague only killed about a third of Europe's population. It didn't even spread to any other continents. I'd say we're fine, it was not a huge event in humanity, unless you're strongly Euro-centric.

3 • Reply • Share ›

Brandon • a year ago

I'm wondering whether the Martian calendar will start at year 0 from the day the first human set foot on the planet. That would be so huge. Finally not a religious calendar, but a true scientific calendar celebrating every 669 martian days the moment the first humans set foot on the planet.

5 • Reply • Share ›

Hans Nelson • a year ago

Have you seen the "Economics of Airline Class" video by Wendover Productions on YouTube? I just happened to have seen this the other day, and it seems like it would be an interesting idea to toy with on the Mars Colonial Transporter. Thoughts?

Reply • Share ›

Michele • a year ago

How much space debris was added when the United States shit on the world's collective face in 1985 by destroying a satellite in orbit, and again in 2008?

4 Reply • Share ›

Isabella Pintor • a year ago

great article it took me an hour to read it but.. it was worth it

1 Reply • Share ›

Nicolas Stabilini • a year ago

I'm really concerned about horoscope... how would astrologyts get an astro-chart for a human born in Mars? (btw: I think horoscope is big big ball of bullshit)

Reply • Share ›

ImmortalWind • a year ago

Hey Tim, I was researching a little bit about Voyager's destination and it's actually NOT heading to Proxima Centauri as you seem to imply (unwillingly) in the Voyager section above. You might want to change this sentence.

3 Reply • Share ›

Blaine • a year ago

One thing I haven't yet seen anyone address is how the 38% Earth-gravity on Mars will affect humans that live there for long periods of time. Would a Martian-born-and-raised person who traveled to Earth be weak and unable to walk (or walk with great difficulty, bearing three times their normal weight) under the influence of the heavier gravity? If their muscles had only experienced the lighter gravity of Mars, wouldn't living on Earth be incredibly difficult for them? I feel like Martians would be at a physical disadvantage if they ever left their home planet. Am I wrong here?

8 Reply • Share ›

Michael Pang ➚ Blaine • a year ago

Yes I'd imagine that to be the case - although they're genetically the same so it's nothing a few months of working out shouldn't be able to fix.

Reply • Share ›

IamGrimalkin ➚ Blaine • a year ago

How 38% gravity will affect humans is unknown, because no-one has ever been in 38% gravity for long periods. However, research in the ISS and other space stations does give an idea of what zero gravity is like. Bone density and muscle mass does increase after long periods in zero-g, but it is possible to mitigate that by using the right exercise machines for 2 hours a day (if I remember correctly).

Reply • Share ›

Drabes ➚ IamGrimalkin • a month ago

I think you mean muscle mass and bone density decrease...

Reply • Share ›

IamGrimalkin ➚ Drabes • a month ago

Yes, I did mean that, thanks for the correction.

Reply • Share ›

Babette • a year ago

You said : "The spacecraft provided the rest of the boost after the rockets dropped away, using fuel from the big, for-some-reason-orange fuel tank."
At first they wanted to paint it white, until they found out that it saved 3000 kilo's not to. That's the reason why the thing was orange. Funny I remembered that detail but pleased to fill you in :-)

5 Reply • Share ›

iykcvth • a year ago

good article ;)

Reply • Share ›

guest • 2 years ago

The article talks about a lot of awful people in positions of power who weren't using space technology for positive things like Musk wants to, but for "measuring contests" like America vs. the Soviet Union, and other destructive military applications that continue the international measuring contest and line the pockets of politicians like Mr. Shelby. Now the US only wants to improve their space tech because another measuring contest is on the horizon -- and it's with some very scary people who are mixing mythology in with their measuring contest.

The Middle East is a mess enough to begin with, but now we've got Iran to deal with, firing off rockets for their moon god? As if that wasn't bad enough, there's the perpetual Iran-Saudi (Shia-Sunni) divide in Islam, vs. the Jewish government in Israel and whatever's left of millennialist Christianity in the United States government (not millennials as in teenagers with smartphones, but a sect of Christianity that believes in ushering in the Revelation through a massive, population-culling war in the Holy Land).

Imagine a sequel to the US-Soviet space race that boils down to a holy war, using cutting-edge technology to fulfill the prophecies of Bronze Age storybooks. 100 million people already died as a result of the global US vs communist "measuring contest." 100 million more died before that because Adolf, Tojo and Benito had a measuring contest with Franklin, Winston and Josef. On the micro level, a young man, the nephew of a local legislator, was brutally murdered in Chicago over the weekend because of a "measuring contest" over who had the better pair of sneakers. People have been assaulting each other over having the opposing US presidential candidate's bumper sticker on their car. This is what you call intelligent life?

Why the $#&% does Elon want to save a species of $%&#-flinging monkeys who are hard-wired to pursue these immature, but globally destructive, "measuring contests," whether in the name of money or ego or the claims of their gods? Why doesn't he focus on making the Martian mission a real-life Noah's ark instead? Just him and his family taking the animals and plants on a trip to get away from the god-botherers and their "measuring contests."

Reply • Share ›

Ed Jagger ➚ guest • a year ago

It's because Elon Musk is a very astute businessman. The radiation and low gravity environment will not allow long-term human survival on Mars, even with an artificial atmosphere, hydroponics, underground shelters. Human physiology and development did not evolve to exist in such an environment. Musk secretly knows this. It's the reason there are no plans for practice colonies on the Moon (which is much nearer). I agree that his modernised space-freighter system will make him more money than God - and he is doing a very good job of advertising Space X using this 'Mars mission to save humanity' But I'm afraid in the end it boils down to profit and share-holders, like everything else.

Reply • Share ›

Steve ➚ Ed Jagger • a year ago

Read more about Musk. This is an easy story to tell about him, but it's not supported by evidence. The evidence is very good that he is actually hell-bent on colonizing Mars.

Also, the radiation concern, while nonzero, is way overblown. Here's some info:
https://www.reddit.com/r/sp...

1 Reply • Share ›

Jonas Friedmann ➚ Steve • a year ago

You are hopefully right. There is a German physicist named Harald Lesch who says it makes no sense to colonize the mars. He says more or less it is not possible to create an atmosphere because the Mars has no magnetic field. We are not able to increase the mass. And solar winds will shave off any atmosphere we could build up. And even if it would be possible to create a stable atmosphere, the two moons Phobos and Deimos will rub at the atmosphere. Following they lose their energy and crash into the Mars. Than everything is destroyed again and for 100 thousand years no living will be possible again. What do you think?

Reply • Share ›

Steve ➚ Jonas Friedmann • a year ago

Well, it's always about the quantitative facts. It took Mars (hundreds of?) millions of years to lose its atmosphere; if we come up with any way to terraform it within

thousands or tens of thousands of years, that method will easily be able to keep up with the solar winds.

As for Phobos and Deimos, I haven't heard of that. They're pretty small as far as moons go -- 6 and 10 km radii -- so their impact wouldn't destroy everything for 100,000 years. Could be a problem, but a civilization able to terraform a planet should have some ideas about that -- e.g. blowing them into smaller chunks to make the impact far less severe.

However, in any case, what matters for whether or not people go colonize Mars isn't what will happen in the end, but what they believe will happen. If people believe that colonizing Mars isn't a doomed venture, and want to do it, then they'll do it, right or wrong.

Reply • Share ›

inservo ➚ Steve • a year ago

you definitely need to work on your perspective. There are much much much more non-US citizens on planet earth and maybe (hard to imagine for the standard US dickhead, I know) some have political systems that are maybe not perfect but at least do soemhow work.

If you want to throw your country in the trashcan, do us all a favour and go on but do not take everyone else with you.

Reply • Share ›

Steve ➚ inservo • a year ago

Was this supposed to be a reply to me? I don't see the connection.

2 Reply • Share ›

Hayley Mac • 2 years ago

Is anybody else up for moving to Mars for four years to escape the Trump presidency? We can clean up the mess when we're back in 2020.

2 Reply • Share ›

guest ➚ Hayley Mac • 2 years ago

Stop bringing politics into this. Your type is exactly the kind of tribalism that's makes the Squeegle alien or whatever his name is root for humanity's imminent demise. All I pointed out above is that there are people who stab each other over sneakers and start world wars over "measuring contests" like the article talked about, and that maybe Musk is trying to back up junk data that belongs in the recycle bin. He should focus on saving polar bears and elephants, instead of "Never Trump" or "Never Hillary" monkeys who fling poo at each other because their guy is better.

1 Reply • Share ›

Hayley Mac ➚ guest • 2 years ago

That comment was meant in light-hearted jest. I assure you I have no intention of moving to Mars.

Ironically I've just watched the latest episode of South Park and it appears Cartman has had the same idea.

1 Reply • Share ›

Yian Huang • 2 years ago

Why aren't they colonising the Moon first or simultaneously, as a proof of concept and/or to get people excited?

Reply • Share ›

Dan Apted ➚ Yian Huang • 2 years ago

Your question is very appropriate. Colonization of LEO is the first step, Colonization of Geosynchronous orbit is the second step. Colonization of L1 and L2 orbit is 3rd step. Lunar colonization is 4th step and industrial mining/colonization of the asteroid belt is 5th step and colonization of LMO (Low Mars Orbit) is the 6th and final step before we invade Mars. Just figuring out where to land on Mars as a first step in the invasion is a decades long study and decision making process that should be left to the people living in LMO. They will be the ones who supply the products and knowledge about living and operating so far from home to the souls who descend to the surface.

Reply • Share ›

Amit Vikram ➚ Dan Apted • a year ago

Because Mars is more hospitable than moon. Mars' gravity is 38% of Eath's gravity while moon's gravity is nearly 16.7% of that of Earth's. So humans can get use to Mars' gravity much easily. Also there is cosmic radiation. Mars has an atmosphere although relatively thinner than that of Earth, it shields off some cosmic ray particles and humans can build their habitats underground for extra protection. While moon has no atmosphere whatsoever. So underground habitats would also not protect from radiation effectively at moon. Also there is

possibility to terraform Mars. The main reason Mars and moon don't have a thick atmosphere like earth is because Earh has it's own magnetic field which protects atmosphere from charged particles of solar wind, while Mars and moon don't. Mars didn't had any protection from solar winds which stripped apart it's atmosphere. Mars has Dry ice (frozen CO2) sheets in it's poles and if we nuke them, it will release that CO2 in atmosphere and hence thickening it's atmosphere in which plants can grow, increased atmospheric pressure will prevent water from boil off at low temperatured and hence liquid water would be able to sustain on it's surface and the green house effect will warm up the mars a bit which is currently very cold. The solar wind will again strip that atmosphere, but it is a very slow process and therefore we would have millions of years to get a solution for that problem.

Reply • Share ›

David Sabo ➚ Dan Apted • 2 years ago

Musk intends to skip all that and go straight to Mars. His reasons are very appropriate - i.e., the intermediary steps aren't really necessary, and the Moon isn't all that well-suited to colonization in the near term. Tim's article lays this all out reasonably well.

To Yian's question more directly, colonizing the Moon has a different set of challenges - but most importantly, for Elon, it's aiming too low (literally and figuratively). The moon also is not as well suited to long-term survival of a self-sustaining colony and cannot be terraformed the way Mars can. So the proof-of-concept idea really would be proving we can build greenhouses on the Moon, but it's not the same.

That all said, if it gets cheap enough under SpaceX's leadership to toss stuff up into space, I am sure people will want to do cool things with the moon, too!

1 • Reply • Share ›

IamGrimalkin ➚ David Sabo • a year ago

What do you mean that the moon can't be terraformed the way mars can? If you mean adding a breathable atmosphere that won't set on fire, the moon has a smaller surface area than mars so will probably need less buffer gas, and if you are launching it as nitrogen from earth you won't need as much delta-v to get it there. So in some sense it might be easier.

Reply • Share ›

Deven Kale ➚ IamGrimalkin • a year ago

The moon is too small. It's gravity isn't strong enough to support an atmosphere thick enough or dense enough to be breathable by humans.

Reply • Share ›

IamGrimalkin ➚ Deven Kale • a year ago

Yes it is. The atmosphere would eventually be lost to space without a magnetosphere, of course, but it isn't that much lighter than Titan, and that has an atmosphere thicker than the Earths.

Reply • Share ›

Deven Kale ➚ IamGrimalkin • a year ago

The mass of the moon is 54.63% of the mass of Titan. That's similar to saying $546,000 isn't that much less than $1,000,000. It's a huge difference.

The atmosphere on Titan is as dense as it is because of what that atmosphere is made of. In fact, Titan's atmosphere is not only thicker than Earth's it's also denser at 1.5 bars even though Titan is far less massive. Although this could partially be explained by being protected by Saturn and having a weaker Solar Wind as well.

Your question was about having an Earth-like atmosphere though, and I'm no physicist so I can't do the calculations myself but I trust the experts I've read/heard who say that you can't get a sustainable Earth-like atmosphere on the moon more than a dozen or so feet thick, and it would be nowhere near dense enough to be breathable.

Reply • Share ›

IamGrimalkin ➚ Deven Kale • a year ago

Just run the numbers and it turns out you're right, the moon can't have an atmosphere even for relatively short periods. You're right, Titan's higher mass can make a difference when you have an edge case like the moon, as can its higher density and lower temperature.

Reply • Share ›

IamGrimalkin ➚ Deven Kale • a year ago

Yes, you can't get a sustainable atmosphere on the moon. You can't get a sustainable atmosphere on Mars, either. The point is, it can take long enough to leak out for you to live there in the meantime, and you can help hold it there with an artificial magnetic field.

Reply • Share ›

Dan Apted ↗ David Sabo • 2 years ago

I understand his desire and share it, but he(read we) need to pay for it and we need people to be prepared for the trip and the stay. By putting up the aforementioned first steps we have the funding for the other steps. A LEO vacation or stunt or lark is far fetched as is a honeymoon on the moon. But I can rationalize how some people might be able to pay for it if the SpaceX re-usability model becomes reality. Furthermore I can envision how Hilton, or Amazon, or Trump might even fund a hotel or at least a bed and breakfast in LEO or even on the Moon. The profits from it and the taxi service to get you there are literally sky high. If they are as big as I can imagine then so is a convention center in LEO or at L1 or L2. With enough demand then we must mine asteroids or other objects to harvest the least expensive building materials if you want to attract the most visitors. That gets us the materials to go to LMO and with that distance orbiting farms and more harvesting of materials from asteroids. Then there is the money, the infrastructure and the people trained to work and live in space to actually invade Mars. You can't go to Mars and sustain a colony without knowledge and money. The first steps get us there. Attempting to skip those steps is attractive folly.

Reply • Share ›

ameba#23234 MdR • 2 years ago

I noticed a mistake or just can't find any source on that venus has any oxygen in upper or lower atmosphere.

" Randomly, at the top of Venus's clouds is a layer where the temperature and pressure are similar to those on Earth, and because oxygen and nitrogen both rise in Venus's dense atmosphere (like helium does on Earth), the air in that layer might actually be close to breathable."

Reply • Share ›

jmac ↗ ameba#23234 MdR • 2 years ago

Try this:
http://onlinelibrary.wiley....

Reply • Share ›

Mario • 2 years ago

"In the last few thousand years, humans invented the concept of being "inside," and now almost all people think of home as somewhere indoors—maybe in the future, a giant, artificial space habitat that has mountains and rivers and trees and millions of people will be the equivalent of the invention of "inside" as it applies to an entire world" That was beautiful! I just started singing "imagine" in my head

Reply • Share ›

Hendu71 • 2 years ago

I wonder which one is technically most difficult: "Fixing" climate change, building a colony on mars, or building a Star-Wars-like floating "Cloud City" on Venus?

Reply • Share ›

Michael Pang ↗ Hendu71 • a year ago

IMO they're easiest to hardest in the order you gave, but the first two mostly depend on peoples' collective will.

Reply • Share ›

Nobody • 2 years ago

Anybody knows what the hell did just happen at Florida? Or more like, what will it cause?

Reply • Share ›

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Nadeem Adnan

The possibility depends is to enable individuals from different lands in the world to be the primary candidates to the another wave of people that will be selected to go to Mars. As reported by http://www.theboringstate.com. Even people from a nation such as Egypt, Pakistan, Saudi Arabia, have heavily shown affair and they really like to go The Red Planet. A very interesting text can be read here :
http://www.theboringstate.com/.../hello-houston-problem...

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Caleb Mayo

thanks for this and for rocking out in general. in case you go around updating things, the radiation shield idea seems real enough now to merit a mention under blue-green mars. many smarties note, given the missing martian magnetosphere, that cosmic and solar radiation will slowly strip away whatever atmosphere we whip up, so it seems there's some place in the convo for a note about making that evap not happen. NASA image here includes fun words magnetosheath, magnetotail and magnetopause:
https://www.popularmechanics.com/.../magnetic-shield.../

as exciting: looks like by blocking radiation we can probably start some of that sweet, sweet melting. seems relevant and likely. apologies if you already heard this stuff and thought about putting it in the piece and i'm now just one more voice telling you to spend time on something other than whatever should be your main project right now kinda like how i'm out here posting on a comment section instead of generating content oh dear god--

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Michelle Oblack Smith

great news say no to small penis i introduce you to DR SANTY JATTO herbal mixture cream …DR SANTY JATTO penis enlargement herbal cream and herbal remedies in Africa.This is the only Male Penis Enlargement Cream has been used by men around the world supplement that has been PROVEN to-enlarge your penis – safely, quickly, and importantly – PERMANENTLY.Full SANTY JATTO Penis Enlargement Cream when used will Increase in penis length by 1-10 inches Increase in penis width by 20%helps in preventing Premature Ejaculation.Achieved longer, rock hard erections All gains in penis length and width are 1... See More

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Mohammed Saud

How small is your penis exactly? I need to know... for research purposes only

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