

The Human Future in Space with Robert Zubrin



[Opening theme music with voiceover.]

Dr. Robert Zubrin

"So, yeah, I don't think Mars is going to be utopia at all. I think it's going to be a lab. I think it's going to be a place where there's going to be lots of noble experiments, some of which will succeed, some of which will fail, but the ones that succeed will show the way forward for everyone. If we discover new physics, all sorts of things are going to become possible that are currently thought to be impossible. And I think the place we're going to discover the new physics is in space, because there's no better lab than the universe."

[[Theme music plays out.]

Joel McKinnon

Welcome back, friends, to Seldon Crisis. Today's guest is a truly amazing person I've had the pleasure of meeting several times over the last couple of decades. Dr. Robert Zubrin is the president of the Mars Society, an international organization advocating for the grand goal of sending humans to Mars to explore and settle the red planet as a second home for humanity. Dr. Zubrin holds degrees in math, aeronautics, and astronautics, a PhD in nuclear engineering, and in 1990, frustrated by NASA's lack of progress in sending people into deep space following the Apollo program, Zubrin, along with colleague David Baker at Martin Marietta, wrote a research paper on a new mission framework called Mars Direct.

Joel

Dr. Zubrin later wrote a classic treatise called *The Case for Mars* based on Mars Direct, and in 1996, founded the Mars Society. Since then, he's been crisscrossing the globe, inspiring humans from all over the world about the value of exploring Mars and beyond. I'm very happy to have him on the podcast today. Welcome, Robert.

Robert

Thanks for inviting me.

Joel

Cool. So, as you know, I assume, this podcast is generally about a science fiction author, Isaac Asimov, and his most famous work, *Foundation*. So my typical listeners are into that kind of stuff, but we also veer off into related things like the science of *Foundation* and philosophy in *Foundation*, and things that don't have anything to do with *Foundation* or Asimov on occasion. So I'm kind of curious, though, if you've read any Asimov or how familiar you are with him.

Robert

Of course, I read his robot stories. I read the Foundation trilogy and a variety of other things.

Joel

Cool. So, yeah, you have something in common with most of our listeners then.

Robert

Sure.

Joel

So I first wanted to talk about how I came to know about you and the Mars Society, because this was a little interesting story. Back in 1999, NASA had a mission to the south pole of Mars called the the Mars Polar Lander. And as that was approaching, I got my my latent interest in Mars since I was a kid fired up, and I just had to — I got really excited about it. So I had a three year old son, and I took him down to the tech museum of innovation in San Jose, and we went in anticipating — we were just a little bit late for the arrival time, and we went in expecting to see telemetry or a bunch of people, like watching for telemetry to come in. And when we went into this room in the Mars exhibit area, there were a bunch of people with very glum faces and you probably would know why. It had failed to call home. And later it was determined that it never landed successfully. So the interesting thing is, like, I'm thinking "What do I do now?" And I look at these people and they all looked so sad, but they had this stack of books on a table and it was the Mars Society people there.

And one of them just handed me one of the books and said "Here, just read this." And it was the Case for Mars. And so I read it. And soon after that, I was going to Mars Society meetings in the NorCal chapter. And it wasn't much long after that that I went to my first convention at Stanford.

Actually embarrassed to say it was my last convention, but I'd love to see more. And that's where I met you for the first time, I believe. And we've met a few times after that. So that's how I got involved in it.

And I would love it if you could just give a real general overview of what Mars Direct and the Case for Mars is about.

Robert

Okay, well, let's start with Mars Direct. 1989, I was a senior engineer at Martin Marietta Astronautics, a company that is now known as Lockheed Martin, doing preliminary design of interplanetary missions. And at that time, President Bush the first, in July, got up on the steps of the Air and Space Museum together with Armstrong and Aldrin and Collins, the Apollo Eleven crew. And he said "Look, this is the 20th anniversary of the Apollo moon landing. That's what America is all about. And therefore, I, as President am committing us to go back to the moon and on to Mars, and this time to stay.

So it's great stuff, right? And so what NASA did was they commissioned a very large team to come up with a plan for how to implement this. And this included a lot of NASA people. It also included contractors like us and Boeing and others who were tasked to do various pieces of analysis. So we knew what was going on, we did not agree with the plan. At least we did not. And when it all came out, it took three months, this gigantic plan, which was known therefore as the 90-Day Report. And it was a plan to get to Mars in 30 years at a cost of \$400 billion. And which at that time was considered a lot of money.

A lot of money. And it was very apparent to us, the engineers at Martin who had worked on this, that this plan had no merit. It was not well conceived. And furthermore, the thing that really mattered to management was, if this is where the matter was left, there wouldn't be a program, okay? Because congress just rejected this sticker shock. We're not spending \$400 billion.

And furthermore, Americans can't wait 30 years for anything, okay? So it had to be faster, it had to be quicker or It wasn't going to happen at all. And we the engineers who had worked on this went to management.

We said, look, we can come up with a much better plan than this, something that could conceivably be funded. And the management was receptive. And this, by the way, is unusual. The wisdom in the aerospace company among managers is: Agree with whatever NASA says, no matter how stupid it is, because the customer won't like it if you cross them. You are there to be the chorus that says "Yeah, yeah, yeah" okay? But they thought that the 90-Day Report was so off the wall that we had to diverge. And so they pulled together a team of twelve people drawn from the whole Martin company, which was quite large and, about 100,000, and I was one of the twelve to come up with an alternative plan.

And they were all pretty creative spirits within this group. And in consequence, we couldn't agree with each other. And in fact, we came up with three different plans. There's different subsets of this team, each came up with their own plan, and once again, management rose to the occasion. Rather than try to reconcile these different ideas to come up with a company party line, they just said "Look, well, let's float all three plans and see what happens." Which was smart, because you couldn't reconcile the ideas that were implicit in these three plans. So we floated all three in the spring of 1990, and it rapidly became clear that the Mars Direct Plan, which was the plan that had been developed by myself and another engineer named David Baker, mentioned in the Case for Mars and supported by three other people, that this was the plan that had the greatest chance of overthrowing, breaking the logjam here. It was the most radical break with the thinking of the 90-Day Report, but not because it involved some super jazzy advanced technology. On the contrary, in many ways it was the most conservative plan. Far more conservative than the 90-Day Report, which involved constructing giant spaceships in Earth

orbit fully loaded with all the propellant to go to Mars and back using advanced ion drive spaceships and all sorts of other unobtainium. Rather

Joel

Lots of stuff that hadn't been developed yet.

Robert

Right. Our plan was radical in its conservatism, in that it was basically Apollo times two. It was two direct launches to Mars. Now, I mean, Apollo times two in terms of, of how it would be done. It would be done with two launches of a Saturn five class booster, the first to throw the Mars to Earth return vehicle with no one in it but the equipment to make its return propellant out of the Martian atmosphere. And then the second launch to send the people into habitat spacecraft. And because the return ride is waiting for them on Mars, they don't have to fly to Mars in a Battlestar Galactica spaceship.

They fly to Mars in a tuna can habitat. Land it on Mars, it's their house on Mars. And then they leave that on Mars when they fly back in the Earth return vehicle. And so each time you do this, you add another habitat in the base. So I can still remember. It was March 1990. Baker and I were sent down to Marshall Spaceflight Center to brief them on Mars Direct. And I was not expecting a positive reception at all because we were such a dramatic break from the whole party line, but instead, it was overwhelmingly positive, precisely because Marshall was the most conservative center.

They had heard all this stuff of the giant solar electric spaceships and the giant nuclear electric spaceships. All the aerospace companies had been there with their own Battlestar Galactica plans, and they just regarded that all as science fiction. And we come in with something that looked basically like twice as hard as Apollo. And they could relate, because, by the way, this

is 1989 — excuse me 1990, is 21 years after the first moon landing. There were a lot of people in that room who had participated in Apollo.

Joel

Right.

Okay. And that generation, at least the middle and younger half of it, had not yet retired.

Robert

So they went for it. And one of the managers took Baker and I into his office and coached us "Look, you're going to go to Johnson Space Center next week. This is how you got to present it. This is how you got to tell them." We got a lot of support from all over NASA and even from some of our competitors for the same reason why our own management liked it, because basically everybody wanted there to actually be a program. And a lot of people realized that the Battlestar Galactica thing wasn't going to work.

Joel

You were describing something actually possible.

Robert

Right. And technically possible, and at least in principle, politically possible. Now, in fact, we were too late. The 90-Day Report did sink the Bush Space Exploration Initiative. But a couple of years later, 1992, Mike Griffin became Associate Administrator for Exploration. And I briefed him, and he liked Mars Direct a lot. He had me go back to Johnson Space Center and he said "I want you to brief them again, and I'm going to make sure they listen." So he did, and they did. And so NASA then embraced these ideas. Direct flight to Mars, no on orbit assembly, no advanced propulsion, use of Martian resources starting on the very first mission, long duration stays on Mars starting on the very first mission, and other principal features of Mars Direct.

And they embraced it. And then they designed their own version, which I called Mars Semidirect because it embraced these principles. But it was three ships instead of two ships. And it was a crew of six instead of a crew of four. And they had more people, more equipment, heavier equipment. But nevertheless, the basic principles were there. And they costed out this expanded version of Mars Direct at \$55 billion. These were the same people that had costed out the 90-Day Report at 400. And I tried to argue with them. I said look, you don't need this, you don't need that.

And Carl Sagan actually said "Look, Bob, look, it doesn't matter whether it's 50 billion instead of 30 billion. It matters that it's ten civilians, not 100 civilians." And he was right. So there it was. And then what happened was now we're getting to 1994, the 25th anniversary of the moon landing. Newsweek magazine finds out about this that Johnson Space Center had come up with a plan that was 55 billion not 400 billion, et cetera. And they made it their cover story. And I got extensive play. They gave me credit as the source of the ideas. So a couple of weeks later I'm sitting at my desk at Martin and my phone rings and it's a woman's voice.

And she says "Hi, I'm a literary agent. You know you have a book here." And I said "Really?" And she said, "Have you ever written a book?" I said "Yeah, I wrote a book once. I couldn't get it published." And she said "What kind of book was it?" I said "It was a spy novel." She says "Were you ever a spy?" I said "No." "Did you have a literary agent?" "No." "Okay, well, you are an aeronautical engineer and I am a literary agent. And if you write this book, I will get it published."

Joel

Cool.

Robert

And so I wrote The Case for Mars and she sold it to the Free Press which is part of Simon and Schuster. And the whole first run sold out in two weeks. 18,000 copies in two weeks. The thing was a runaway seller. And by the way, here's a funny thing about that. Before the Free Press accepted the proposal for the book it was rejected by 40 other publishers. And I wish I had saved the rejection letters because they were also arrogant. "Who would possibly be interested in a plan for how to get to Mars?"

Joel

Wow.

Robert

So at Simon and Schuster there was an editor there named Mitch Horowitz who was into sort of exploration, adventure kind of books like climbing Mount Everest kind of books. And he saw this as something in that vein and he said "I want to edit this. I want to be the guy for this book." And so they did it and it was a runaway success. And it sold about 150,000 copies in the United States. It sold in about eight foreign languages. And I got 4000 letters from people all over the world. Some emails but at that point mostly actual stamped letters, if you can imagine what 4000 envelopes with stamps on them and things inside of them look like.

And they came from all kinds of people. They came from engineers at JPL and astronauts at JSC. They came from, you know, twelve year old kids in Poland, did firemen in Saskatoon, and the widow of a guy who won the Congressional Medal of Honor in World War Two for sinking a Japanese aircraft carrier and the director of a major opera, and bankers in Paris, in Singapore. And I looked at this. It was an incredible array of people. And I got together with Chris McKay, Carol Stoker, the people that were part of this informal network that I was also a part of called the Mars Underground.

And they had been holding these Case for Mars conferences. And I said "Look at this. If we could pull these people together, we have a force that could maybe make something happen." Because you see, the people, all these letters, they said all kinds of stuff you could imagine. But underneath whatever they were saying, there was one thing they were really saying, which was "How do we make this happen?" Okay? And so we called the founding convention of the Mars Society, which was in August 1998 in Boulder, and 700 people showed up. We sent an invitation to everybody who sent me a letter, 700 of them showed up.

And also the New York Times showed up, and the Washington Post and the BBC and several other major media. And we came out of that with that organization. And we decided we would do three things. One, general outreach, spread the vision. Second, political work to try to expand the existing Mars programs being done by the various governments. And the third being projects of our own, of which the first was the building of the Mars Arctic Research Station.

Joel

Yes. I didn't realize when I first discovered the Mars Society that it was that young. It was only two or three years old at that point, because that was 2000. Well, 99 when I first

Robert

It was one year old.

Joel

Yeah. Well, thank you so much for all the details on that because I hadn't heard how that all started and must have been really exciting to make that kind of breakthrough?

Robert

Certainly it was something. And we raised the money, we built the Arctic Station, and that was an adventure because we had to paradrop the materials on Devon Island, and the paradrops failed.

Joel

Yeah, I remember

Robert

The crater, and some of them were destroyed, and the paid construction crew deserted, and we were left to build it ourselves with the help of the Inuit.

Joel

I think Frank Schubert was involved in that.

Robert

Frank schubert. Absolutely. Frank Schubert was up there on sort of a lark. But when the paid workers all deserted, Frank knew construction and he helped rally the team, which was a mixture, if you can imagine Mars Society members who were up there like astrobiologists and Inuits, okay, Eskimos, if you will, and most of them teenagers. And to give an idea of the gap between the two parts of the construction team, okay, here you have all these astrobiologists and Mars exploration, astro, nautical engineers up there. And then here's an Inuit. And I remember I was walking back to the tent camp from the construction site one night, and I had this horrible hacking cough because it had been freezing rain early in the season.

And so this Inuit kid is walking next to me and he says, there's a good faith healer in Resolute Bay. And I said, "Well, I prefer regular doctors." And he said "You don't believe in faith healers?" And I said "No." And he said, "You can go to hell for not believing in faith healers." All right? So you can imagine, okay, that statement from him was a mixture of Christianity and pre-Christian shamanic beliefs.

Joel

Yeah, okay, that's true, because hell isn't usually a part of shamanic beliefs. And I think

Robert

Right, so there was some Christian ideas mixed there with the pre-Christian ideas. But together we built the Hab. And when the paratroopers failed, this reporter for Space.com or one of these places, he contacted me and he said "So, Dr. Zubrin, how would you compare the failure of your program with that of the Mars Polar Lander?" Okay? And I said "well, there's a similarity in that we both had a crash landing. But there's a difference is that we have a human crew on the scene here, and we are going to pull this off." Okay? And that was the point I made, is, look, you know, on the Mars mission, the human crew is not going to be the weak link in the chain.

It's going to be the strongest link in the chain.

Joel

Right, well, and then when did the Mars Desert Research Station get built?

Robert

Well, after we succeeded in building the Arctic station, we decided we would build a second station in the American desert. And we searched all over the place, and actually we got a hint that led us to the current site from James Cameron, the movie maker, who was sympathetic to the Mars Society and who had scouted that place as a possible site scouted that area as a possible site for a Mars movie he was considering. And we went there and we scouted out. Actually, Frank Schubert and I found the place where we could put our station. Now we had to raise money.

Now we got some of the money. The money came from some unusual places. Half of it came from trade unions, the sheet metal workers and the pipe fitters unions. And the deal was we set this place up. We set up the MDRS at Kennedy Space Center Visitor Complex during the summer of 2001, and we had it as an exhibit there. And we had a bunch of art depicting

humans settling Mars. But it showed a prominent role for construction workers in creating cities on Mars. The building trades were trying to reach out to young men to make their case that the trades were not part of the past, but part of the future.

Okay, so that was the idea, and that's why they gave us some money. And the other part of the money came from Elon Musk, and I believe you were there for part of that process.

Joel

Yeah. So that came after the fundraiser in Palo Alto.

Robert

Right.

Joel

Yeah.

Robert

What happened was we were raising money for the Desert Station, and we had a fundraiser in Silicon Valley. We had it at the house of Bill Clancy. He was a relatively well off, Mars Society member, had a nice house there, and so we had it at his house, and it was going to be \$500 a plate dinner. And I was a speaker, and Cameron was actually there as a speaker.

Joel

The main draw we thought.

Robert

Yeah. Okay, so we get this check in the mail for \$5,000. Wow. Why would someone sell \$5,000 for a \$500 plate dinner? Who's it from? Elon Musk. Never heard of him. Well, we did a little research, found out he was one of the top guys at PayPal, which we had heard of because there were these people who were trying to pay their dues with PayPal instead of with checks or credit cards like normal people and the — so very irritating. But under the circumstances, I decided to put that grievance aside. And I had, like, a two hour cup of coffee with Musk before the event, and then I made sure the right people were sitting next to him at the event.

Like, I think it was Cameron and maybe Carol Stoker.

Joel

Yeah, I think you're right.

Robert

And anyway, so they brought him along, and after the event, he came over to my place here in Colorado and he donated 100,000 and also became the member of the board of the Mars Society for a while.

Got it. That explains a huge discrepancy in what I've been researching myself, because right after the event, I don't know if it was the next day or very soon after, I got an email from Bill Clancy saying "Grand slam" was the subject, and it was about the \$100,000. When I looked at the account of it in that first bio, I can't remember who wrote it for the Musk bio.

Ashley Vance, perhaps?

Joel

Yes, Ashley Vance. And there was a line in there about how Musk had donated \$5,000. So I was thinking, wait, what is this? Those don't match up. But then when I was getting ready for appearing on that BBC doc last spring, I looked into my my notes on it, and I found that I didn't find the email itself, but I found out that I had written it down in my summary that we've gotten 100,000 from Musk. So now I understand how that

Robert

Actually a 105.

He's on our board for a while, but then at a certain point, he contacts me and he says "Look, I'm not the kind of person that wants to be part of somebody else's deal. I got to have my own deal." Okay? "And right now I've already made all the money I could possibly want." And it's interesting, at that point he was worth \$180 million. Now he's worth 1000 times that, but still 180 million was all the money he could imagine wanting. "So this isn't about money for me anymore. I want to do something really important." And he had decided based on, well, his contact with the Mars Society and also the, the book *The Case for Mars*, which he had read, that that was one possible thing and the other was solar energy.

That is, these were the two most important things that could possibly happen in our time period make humanity multiplanetary or defeat global warming with solar energy. And I argued forcefully he should make Mars his thing because solar energy, the business plan for solar energy is obvious. If someone can make it cheap enough so that if anybody's got a way that they can make solar energy cheaper than fossil fuels, it will take off and the world will go solar. And if they cannot, it won't. And anybody who can go to Wall Street with a business plan, with a new technology or a new business model or something that offers promise along these lines, can find an investor.

Okay? On the other hand, humans to Mars, you go to Goldman Sachs or Salomon Brothers or one of these places, and you say "Here's my business plan. Humans to Mars." They say "Get lost." The business plan is not at all obvious, and it will take somebody who could see past, how do we get our money back in triple in five years to, to support that? Well, in the end, he decided to do both.

Joel

Yeah.

Robert

And then he did the car company as well, the electric car company. And it's quite interesting, you see, that of those three ventures, the two that were least credible from a business point of view, that is SpaceX and Tesla were the ones that were most successful. Whereas the solar energy, Solar City, he hardly figures as a factor in that industry at all. That's what he did. And I certainly have a variety of disagreements with Musk, including most recently concerning Ukraine. But to give credit where it's due, okay, he's not in it for the money. He really isn't.

Joel

Right.

Robert

He's in it to make history. And in a way that's both his strongest and weakest. It's both his greatest strength and his greatest weakness is he's passionately driven to want eternal glory for doing great deeds. That's why he's doing SpaceX, that's why he's doing Tesla, okay? And that's also, in my view, how Putin manipulated him by telling him "You can be the guy that stops nuclear war by proposing this peace plan where Ukraine gives up." Okay? But he appeals to his desire for grandeur, but it's also his strength. Someone who was just interested in making money wouldn't have done either SpaceX or Tesla.

Joel

Right. And just as an aside, I did some research into my part back in that year when we did the fundraiser. And it was interesting because I actually met him after the fundraiser. I never even met him at the event, but he came to a chapter meeting and introduced himself, and we all introduced ourselves, and he asked me what I did, and I said I was a web developer. I had just started being a web developer, and he asked me if I could turn a PowerPoint presentation into a website. And the presentation was pretty out there. It was a description of how he wanted to send rockets to Mars using Russian ICBM rockets, and he wanted to land a little greenhouse there.

He had it all worked out. And I did it for him. I did the little presentation, and that was the last I ever heard from him. But I remember the main thing I remember about him at the time jibes completely with what you're saying because he was obviously really determined to make it work, to get to Mars. And what he conveyed to me was that what was driving him was the realization that it wasn't happening otherwise, that nothing was —That great things don't happen unless people make a serious push to make it happen. And he saw that as his role, to make that push.

So anyway, we could talk about Musk for a while, but getting sick of talking about Musk.

Robert

Not to talk about Musk per se, but this is an example. Musk is doing what he's doing with respect to SpaceX because he's motivated by an idea. He's motivated by a vision. Okay? And this is why Victor Hugo said "Nothing can stop an idea whose time has come." And that is true, provided the idea has messengers that can recruit to its banner the forces necessary for its realization. And so I mentioned the Mars Society does three things spread the vision, political work, and projects. The last two are quantifiable. The first is not. But it's probably our most effective role because by spreading the vision, you get people with all kinds of talents in all walks of life decide that they are going to do what they can to make it happen.

And so Musk's accomplishments are his own entirely. Okay? And that of his team, obviously, that he recruits, many of whom also, by the way, have been recruited to this vision by us. But nevertheless, they're the ones who are actually doing it. But nevertheless, by spreading the vision, we recruit to the vision the people who can make it happen. And there'll be people who are businessmen like Musk or engineers like some of his team at SpaceX who work their tails off because they're committed to this vision. And there'll be other people in various places in the political structure who will need to do their part when the paperwork comes across their desk.

And hopefully we'll find enough of these people in enough places that it will happen.

Joel

Yeah, well, a lot has happened in the last 20 years and a lot of it with what's been happening with SpaceX and we're starting to see some progress towards making it possible to do a lot of things out there. Actually, I would love to go on and talk about well, first I want to talk a little more about Mars, if you don't mind. There's been some really exciting space missions to Mars for the rovers like soon after the events we were talking about with the Spirit and Opportunity landings. And then now we had Curiosity and now Perseverance and we actually have a little helicopter flying around on Mars which is totally trippy and we've discovered a lot since then.

And I'm just kind of curious how you see the discoveries that have been made, the scientific discoveries, how that impacts the ideas you have for how a habitat could be built and sustained. Has anything surprised you or is it all going according to plan?

Robert

I've been surprised by the discoveries on the upside and by the accomplishments of the human spaceflight program on the downside. Now, first of all, when I wrote *The Case for Mars* in the mid-nineties I embraced a position that had the support of a substantial faction within the scientific community. People like Chris McKay had come to the conclusion that Mars was both was once warm and wet, that it was once a habitable place, so is great interest for astrobiology and that it could potentially have the resources still to support life and civilization. Now, that was a respectable position within the scientific community at that time but it had not yet been proven.

The discoveries that were made starting with Pathfinder in 1997 and Mars Global Surveyor in that year and then especially with Spirit and Opportunity and the Mars Reconnaissance Orbiter and Mars Odyssey confirmed that point of view. McKay and the rest of them were right. Mars

once certainly was warm and wet. We have found conglomerate rocks. We found salt deposits on the shores of ancient seas and lakes. We have found massive evidence for large amounts of past water on Mars for geologic time periods more than long enough for life to originate three times as long as it took life to appear on Earth after there was liquid water here.

But not only that, we've discovered extant amounts of water that exceeded any that this sort of pro water faction had postulated. We've now discovered, using ground penetrating radar glacier formations on Mars containing more water than in the American Great Lakes made of pure water ice as far south as 38 degrees north which is the latitude of San Francisco or Athens on earth. So in other words, before we had thought "Oh, well, there's water at the poles." And actually that wasn't even established completely until 2007 with the Phoenix mission led by Peter Smith. But now we know it's not just at the pole, but down at mid-latitudes.

There's massive amounts of water in pure form. It could be accessed by ice melting techniques like Rodriguez wells they use in Antarctica. The discoveries that have been made about Mars have confirmed and in fact improved upon the view we had of its suitability, both as a home for life and as a site for future settlement. What has lagged, however, has been the human spaceflight program. Which, well, it appeared to start moving, I mean, the second George Bush started his own vision for space exploration and didn't really go anywhere except to start building the Orion and the SLS, which have now finally flown some 17 years later.

I have to say it's actually worse than that because the SLS is actually based on the booster that Baker and I designed for Mars Direct back in 1988-89. And so I actually don't agree with those that say SLS is a flawed design. It's a design that that was appropriate for its historic period, which was the 1990s. It's a shuttle-derived heavy lift launch vehicle. We, when we designed it in like 89, we didn't think it was the best possible launch

vehicle. We thought it was the easiest launch vehicle to create because it was basically the shuttle launch stack without the orbiter.

It's a simplified version of the space shuttle and they managed to take over 30 years to get it into the field. Unbelievable. NASA has been unable to come up with a consistent vision, the political class has been able to come up with a consistent vision and implement it, at least within the context of the manned spaceflight program. The science program, the planetary exploration missions, and also the space telescopes have done very well. They've had a clear purpose. But the human spaceflight program has operated not as a purpose-driven program, but as a vendor driven program.

Joel

Right.

Robert

But this is one of the reasons why this development of entrepreneurial space has been so welcome and actually caused by the failure of government space. There's nobody in the 1960s well, not really, was looking for an entrepreneurial savior for NASA. NASA was doing great. Space program was doing great. But in the 70s it started to falter and continue to wander. In the 80s and 90s, especially in the 90s, people started saying NASA is not going to open the space frontier. It's got to be done by private enterprise. There were a number of attempts in the 90s to get stuff like that going.

They were all under capitalized and failed. Finally, though, once again the vision recruited to its banners people with the resources to address it seriously. So you had SpaceX, you have Blue Origin, you had the Virgin Galactic, you had some other entities. And then the success of SpaceX in particular has made it possible for people who are not billionaires to

get into the game like Rocket Lab. Working engineers finding investors because they concluded that it's possible for entrepreneurial space to succeed, in fact, brilliantly. To be able to do things that previously thought you needed the governments of superpowers to do.

And not only that, do it in one third of the time, at one tenth the cost and even do things that they had basically deemed impossible, like reusable launch vehicles. And that by the way, has had repercussions outside of the spacefield. It's caused fusion startups to get funded. Not because Musk wasn't— Musk has no involvement in fusion, but his example convinced venture capitalists and other people with money that maybe the problem with fusion power is the same as the problem with usable launch vehicles. That it's not technical but institutional, the wrong people are doing it.

Joel

Right.

Robert

So now we have, the race is on for fusion power and I think we're going to see it this decade but by entrepreneurial fusion companies.

Joel

So your bet wouldn't be with the international effort that's — What is it?

Robert

I actually was involved in the fusion program in the mid 80s when ITER came along and we were doing pretty fast progress in the 80s based on international competition between the American, Soviet, European and Japanese programs. As soon as they all decided to collaborate, all the competitive pressure went out and ITER took 30 years to decide where it was going to put itself. And no new major machines have been built anywhere except in China since the 80s because the previous four dominant programs all collapsed their efforts into ITER. Now of course, earlier this month we had a significant advance from a government fusion program, which was the ignition by lasers of a pellet of fusion fuel at the National Ignition Facility at Livermore Lab.

This is an alternative approach and this is an area where we are not engaged in international collaboration. So once again, the national programs, because they're competitive, can make a certain amount of progress. But I think that the real breakthroughs are going to come from the entrepreneurial fusion groups.

Joel

Yeah, interesting. Yeah. I haven't even read up on those much. I'll have to look into that. Do you have any favorites that you think are making progress?

Robert

Well, there are several. The one I understand the best is the British one, Tokamak Energy because they're actually working on the very concept that I worked on at Los Alamos in 1985 known as the Spherical Tokamak. So I understand how that's supposed to work. And it's interesting that, okay, Tokamak is the mainstream magnetic fusion approach. The Spherical Tokamak was an avant-garde approach to it. Come up — the inventor was an engineer, I believe, named Martin Peng from Oak Ridge and we worked on it at Los Alamos. It was very promising, but it was too avant-garde for ITER, though ITER was just in the early design phase at that time, but it was already too much for them anyway.

So the Brits, with their Tokamak energy, are trying to make a spherical tokamak the Commonwealth Fusion people in Boston are doing something close to that. But then there are some other approaches that people are doing Tri-Alpha Energy, Helion Energy, that are doing things that involve more novel physics than the Tokamak. They're using things where they get the magnetic field lines to curl around on themselves kind of like smoke rings instead of using external magnets. It's complicated. But in any case, there's a whole bunch of these startups. And some of them have gotten, several of them have gotten more than half a billion dollars of investment each, which is serious money in the private world.

Joel

Do you think we're within decades of getting something?

Robert

I think we'll see an ignited magnetic fusion machine this decade. And once again, when I was at Los Alamos, we had a group lunch on one occasion. And the leader of the group got philosophical and he turned to everybody and he said "You know, when fusion power is finally developed, it won't be at a place like Los Alamos or Livermore. It'll be a couple of crackpots working in the garage." And everybody laughed because, you know, these machines are big and they're beyond the means of back garage inventors. But I think he was fundamentally right. If not a couple of crackpots in a garage, a startup working in a warehouse, yeah.

Joel

Yeah.

Robert

That's who's going to do it.

Joel

Well, let's get back to Mars for a moment. What do you think of the ideas on human habitats? I know that there's a ton of them out there. Do you have any that you're excited by that you think might be the most promising?

Robert

Well, okay. You know, the Mars Society had two contests over the past several years. One to design a 1000 person Mars colony and the other to design a 1 million person Mars city-state. And these included the technical side, the engineering, the economy, the architecture, the political and social systems, the aesthetics. So there were all sorts of ideas proposed. Some that I found very interesting involved using water for overhead shielding and actually putting the colonies fish farm, as you were, in the water tank above the colony. So you look up, there's actually light coming in from the sky through the water tank.

But nevertheless, it's more than adequate shielding against cosmic rays and it's serving the function of growing a significant fraction of the colony's food. There's so many different ideas that have been out there. A significant fraction of a Mars colony will be underground, kind of like an underground subway system, if you will. But another fraction of it will be above ground because you do want to use natural light to grow plants. Otherwise power consumption is much too much. How much of your time do you actually spend outdoors? 10%? You spend two and a half hours a day outdoors, that would be a lot for most people. Okay, so if the Mars colonists live 90% of their time indoors, that is, underground where they're totally shielded and only 10% of their time in domed parks up on the surface, the radiation dose is low enough that it really doesn't matter from a health point of view.

Joel

Yes, that's a good way of looking at it. Yes. There's been so many, like "Mars as a hellhole, why would we want to go there?!" kind of things.

Robert

But now, that's an interesting point there. Okay. Because why would we want to go there? People will go there if it offers a way of life that is better than what they find on Earth. If there is better opportunity to exercise your talents, if there is more political freedom, these are our draws. So, for instance, I disagree forcefully with the idea that a Mars colony could be a tyranny because no one would want to go there. That is, I'm actually working on a book right now called "New World what will we create on Mars?" Which looks at this question of what kind of societies are we going to create on Mars?

Well, those two contests between them, it was almost 300 entries and they had all sorts of ideas on, for instance, the political system ranging from social democratic to libertarian and many things that didn't don't fit in with that spectrum. Which are the Martians going to choose? I don't know. I think the Martians will make lots of choices, there will be lots of different Mars city states. The ones that choose the best will be the ones that outgrow the others. Okay. And I believe that yes, there's some aspects of that, I believe that political liberty and intellectual liberty will be a very important part of that because it will be necessary both to draw people to Mars and for the Mars colony to come up with the innovations necessary for it to prosper.

But as for certain other features of it, that will be decided by natural selection.

Joel

Yeah, let me get philosophical just for a moment and connect this back to Asimov. There's a book he wrote called The End of Eternity, if you've heard of it.

Robert

Yeah, but I can't remember whether I read that one or not.

Joel

I can sketch it out really quickly. Basically, it's a time travel story and the Eternals are a group of people who are, they inhabit this kind of realm that's parallel to normal time and space and they're called the Eternals. And their job is basically to groom the timeline and look for problems and smooth things out so that humanity doesn't get in trouble and ruin their future. Right. And what's really fascinating to me about it is that the final take he comes away with on it, is this is a really bad idea because humans need to get into trouble and do things that are really a stretch and really risky or else they become very monotone.

There's just not anything they'll lose the spark to develop and become something new. They stop evolving. And to me, this is one of the great reasons to go to other planets is just because of all the different forces impacting on humans in a different world, how it will change humans in multiple ways and some of those ways will be bad and some of those ways will be good. And the natural selection, as you say, will pick and choose which ones will work best. And that's how we will evolve as a species into a new form.

Robert

We got to be able to try things out. So, yeah, I don't think Mars is going to be utopia at all. I think it's going to be a lab. I think it's going to be a place where there's going to be lots of noble experiments, some of which will succeed, some of which will fail, but the ones that succeed will show the way forward for everyone.

Joel

And it can only provide more opportunities for ways that life on Earth can develop, based on those ideas.

Robert

Sure.

Joel

I hate the idea of this binary approach of planet A and planet B and there is no planet B kind of thing where obviously if we're going to Mars, we're not leaving Earth behind.

Robert

No we're creating new creative branches of human civilization that will make their contribution alongside those that remain on Earth. Just like America, the New World, contributed alongside of Europe and also Eastern civilizations even in advancing human civilization overall.

Joel

Yeah, man, I'm looking at this list of topics and it would take us four or five hours to get through it.

Robert

I don't think you can.

Let me see if I could pick out any that I really wanted to talk to you about. One of the things that I learned from you actually. I met you one of the times I ran into you was at Contact, a conference with science fiction writers and NASA Ames, early 2000s, not too long after that, you know, that fundraiser and you gave a talk on panspermia.

Right.

Joel

And I was so struck by that, that it basically became the core of an idea I had for a rock opera and I ended up writing it. It's called Planet and Sky and it's kind of a mythological science fiction kind of thing where the planet and the atmosphere fall in love. But the panspermia part is how life came to the planet. It came from outside of that star system and populated the planet. Have you developed those ideas of panspermia further from when you talked in the early 2000s?

Robert

Well, somewhat. Look, I think that life can travel between solar systems. I actually wrote a peer reviewed paper on this that got published in the International Journal of Astrobiology. But it's basically this. Okay, back in the 80s, there were some people who observed that there was a rough periodicity of 26 million years to mass extinctions on Earth. Not exactly, but roughly. And they postulated that there could be a star in a highly elliptical orbit around our star that every 26 million years passes through the Oort cloud, destabilizes a bunch of objects, and they come and they bombard the Earth and cause mass extinctions.

So they went looking for this so called Nemesis star. They could not find it. Well, I did a rough calculation, and I looked at, if you consider the Sun's random motion, there's the Sun's orbiting the center of the galaxy, and so are all the other stars, but they also are not exactly orbiting the center. They, superimposed on that orbital motion there's a random motion of around 10 kilometers a second every which way of all the stars. And if you consider the stars as a bunch of objects spaced out at the way they are moving at those velocities, how often do you get a close approach?

Well, it's between 20 and 30 million years. So you don't need a Nemesis star. You just need random motions of stars passing through our Oort cloud, and presumably we're passing through theirs. So guess what? These

close encounters occurring every 20 or 30 million years, it's not a periodic phenomenon. It's a phenomenon with a characteristic frequency. Like, how often do you see a collie? You see a collie a certain number of times a year. It's not because the collie is orbiting your house. It's because there's a certain number of collies out there and a certain probability you're going to see one on any given day.

Okay, so this is happening every so often. Now, when it happens, we get bombarded either by our own Oort cloud or by objects in the other stars or a cloud, and then debris is scattered off the Earth precisely when the other solar system is nearby. So people do calculations of "Gee, how long would it take for a piece of debris to travel four light years, which is the distance to Alpha Centauri?" Well, that's the distance to Alpha Centauri now, but during a mass extinction event, probably the star is less than a 10th of a light year away, possibly much closer than that.

So it's like the analogy I use if you think of warships in the age of fighting sail, which had guns that could fire a few hundred yards, but they had global range. How did they ever manage to hit each other if they're sailing all over the ocean and they only have cannons, could only shoot a couple hundred yards? Well, they would only shoot their cannons when they were within a couple of hundred yards of another ship. Okay, so the stars only let loose their bombardments when they are a close by.

Joel

Right. That makes sense.

Robert

This is happening. And look, there's no evidence that there was ever a time when the Earth was both habitable and lifeless. Okay? That is, as soon as there's liquid water on Earth, virtually, we find evidence of life on Earth. So that means one of two things. Either the processes that are involved in chemistry evolving to life are either very straightforward and occur with high probability. And so the Earth developed life as soon as it could, or life is floating around in the galaxy in the form of spores from panspermia. Or my version, if they're on rocks that have been knocked off of planets and are floating around, but in any case and they land and take hold as soon as the planet can support them.

In other words, if you put some food on the table and leave it there, it will become colonized by bacteria extremely quickly because they're in the air. Well, so either you get spontaneous generation very easily or you get insemination very quickly. But either way, what that says to me is life is common in the universe. Has to be in order to either evolve quickly, or it's there ready to pounce as soon as it finds the place. We know from the Kepler telescope that one in five stars has an Earth sized planet and its habitable zone.

One in five? Not one in a million. One in five. Which means there's like 100 billion habitable planets in our galaxy alone. And these things are constantly moving around, having close encounters with each other that would cause life to be transferred from one to the next. If these things happen every 20 million years and there's been life on Earth for 4 billion years, what's that? That's 200 times this has happened since there's been life on Earth. So life is all over the place in the galaxy from no other source than the Earth spreading it around.

Joel

Yeah. But complex life could be quite rare, right?

Robert

It could be, but look, there's a process, evolution that tends to lead... okay, It leads in all directions, all right? People make a whole fuss about "Gee, evolution doesn't only go towards intelligence. It goes to all these other directions, too." True, it goes in all directions, including intelligence. Okay, so if life is everywhere, I think intelligence is quite common too, because life evolves in all directions, and one, intelligence is one useful adaptation.

Joel

Yeah.

Robert

So life is going to find it.

Joel

So what's your answer to Fermi's paradox? Where are they? Where are the aliens?

Robert

We're here.

Joel

Yeah.

Robert

Okay, once again, if we then come to the conclusion that life is probably everywhere, then in other words, life either evolves spontaneously with ease or it gets transferred with ease. Well, the Earth is 4 billion years old, but the universe is 14 billion years old. And so what's the chance that we were the first? Okay, very small. So therefore we've met the aliens and they are us.

Joel

Yeah, sounds pretty reasonable, but a lot of things had to — we had to dodge a lot of possible disasters that could have wiped us out along the way.

Robert

True. On the other hand, we probably missed a lot of good opportunities.

Joel

Yeah, that's probably true too. So, let's see, what haven't we talked about? I wanted to talk about the Case for Space a little bit. I loved the book, and you talked about a lot of really interesting things like space mining and lunar observatories and things like that. What are you really excited about coming up in the next 20-30 years in space?

Robert

Well, two things. First of all, with the mainstream space program, I'm actually extremely excited about the Webb telescope and other great observatories because I think we will figure out how to detect oxygen in the atmospheres of exoplanets. And there was no oxygen in the Earth's atmosphere until there was life. Oxygen is an artifact of life because oxygen is very reactive and the things it can react with, like hydrogen, carbon, and iron, vastly outnumber the oxygens. So to have free oxygen, somebody's got to be making it. So I'm not talking about trivial amounts of oxygen like exists in the atmosphere, so called, of Europa.

I'm talking about serious oxygen like the Earth's atmosphere. It can only exist if there's life making it. And I think we'll find it and we will discover that we are living in a life filled universe. Then the other thing I'm excited about is the impact of the entrepreneurial space on the main space program. Now, I was a bit more optimistic about this until a few months ago, but still, the scenario is there. Let me tell you the optimistic scenario, okay? The optimistic scenario is SpaceX gets starship flying next year, and it's flying regularly to orbit by 2024. And we're going to have somebody elected in 2024.

And they're going to look at this thing and they say "Here's this cat, wants to send humans to Mars. He's got the ships. If we got together with him, could we get people to Mars by the end of my second term?" And the advisor will say "Yeah" and "Well, is it going to cost a trillion dollars or something?" "No, we already have the transportation system. There's a bunch of other stuff that's needed that he doesn't have." "Well, if we got together with him, could we do it by the end of my second term?" "Yes." "Is it going to cost a trillion dollars?"

"No. It probably could be done within the existing NASA budget, more or less, because he needs a nuclear reactor to produce the power to make the

return propellant and needs Mars spacesuits and Mars rovers and stuff. But this is not a trillion dollar kind of thing. This is billions of dollars kind of thing, and we can do it." "Well, then, let's do it." Okay. Now, I thought that scenario was extremely probable earlier this year. Now, since then, Musk has gotten diverted and I'm hoping this is just a phase, but there was always a chance that Musk could skate off the edge of the ice because he is a risk taker.

But if SpaceX doesn't make it, I believe at this point, the forces that have been set in motion will accomplish the same thing. Maybe there'll be Rocket Lab. Maybe it'll be Blue. Okay. These people are not moving as fast as SpaceX. They got a ways to go to catch up. But basically what Musk has done is proven the point that entrepreneurial space can do the job. So other people are going to get funded. And by the way, if the Starship is successful, there will be Chinese knock offs. This is going to happen one way or the other at this point, and it may take a bit longer if SpaceX loses its way.

But at this point, SpaceX has pointed out the way, and if SpaceX gets lost, others will find the way.

Joel

Yeah, I hope you're right. That's a good way of thinking about it, because I've been pretty morose about what's happening, mostly about Musk just alienating so many people that his vision gets tainted in the process. And people associate the idea of space moving off to other planets as like "Oh, that Musk thing." I'm really hoping that he drops this Twitter craziness as soon as possible.

Robert

Right.

Joel

One other guy I wanted to ask you about is, that we both know from the old days, is Kim Stanley Robinson, and I'm kind of curious if you're still in touch with him?

Have you read any of his recent books? And what do you think?

Robert

I haven't. While I like some of his writing, I think he's a very capable writer. I disagree fundamentally with Kim Stanley Robinson because Kim Stanley Robinson is a believer in The Limits to Growth, and I am not. And I think he does not realize, not only how wrong the Limits to Growth viewpoint is, but how dangerous it is because it sets everyone against each other. Okay. And it is surprising to me that so many people of the left, and Stan considers himself to be a person of the left I don't think he would disagree with that characterization at all, have embraced an idea that in the old days, the left recognized as their enemy. That is if you read Marx or Engels or Henry George or other people, they say this Malthusian idea is just an alibi for poverty and oppression. It's saying "Well, sorry, everyone can't have a decent life. There's not enough to go around." Okay.

And it also leads to fascism. Hitler said this idea of perpetual plenty through science. He said it's a Jewish plot to dissuade the people from believing in the necessity for war. Well, it's not a Jewish plot, but it does dissuade people from believing in the necessity for war.

Joel

Right.

Robert

Okay. And that's why it should be promoted. I just think that Stan has accepted certain ideas which for various reasons, which once upon a time were understood to be ultra right wing ideas. They were embraced by the left in the 70s, in direct opposition to... You know what it's like?

It's amazing to me. Like, you have the Republicans who used to be against the Kremlin. Now they're for it. Okay. And the Democrats at one time were for nuclear power, and then they went against it. You have political factions adopt ideas that are the exact opposite of what they once had. And it's strange how it happens, but it happens.

Joel

Yes. The thing that I have a hard time with, Stan's latest work ever since, I think the book Aurora, which was about an ark ship going to the near, to try to reach Alpha Centauri. I haven't read it yet, but I intend to, and things go badly. And he kind of decided around then that interstellar space travel is never going to happen and that he kind of pivoted to believing in making things work here on Earth. But to me, it seems like you got to keep doing everything. We can multitask and focus on the problems that we have on Earth, as well as continue to reach out and expand our presence, at least in the solar system.

And that's another question I was going to ask you. Do you think there's any possibility of eventually moving to other stars?

Robert

Yes.

Joel

I think my biggest concern about it is something that I hadn't really been aware of until fairly recently, which is the dangers of hitting objects at very high speed, even very tiny objects, and how much shielding you need.

Robert

You need some shielding.

But look, there's two ways I could answer this question fundamentally. First of all, as an engineer at which point I can show you that there are things that I know could be engineered by people with sufficient resources and a little bit more technological skills than we have now. But within currently understood physics, for sure that could get us to 10% speed of light which will get you to Alpha Centauri in 40 years. So fusion, propulsion, this sort of stuff. Okay. But also then, going beyond my remit as an engineer, I have to say I believe, I have faith that there's more science out there to be discovered, that we haven't read the full book of nature yet, that there are more forces of nature ready to be discovered and exploited than those we know about today.

And the reason why I believe that is because there's a lot of things within the current physics canon that absolutely do not make sense, and you just have to look the other way and say, well, that's how it is. For example, our current physics says that matter, energy cannot be created or destroyed, yet here it is all around us. So obviously we've missed something here. When people discovered new forces of nature, things that previously we discovered electricity and instantaneous communication across long distances became possible. We discovered nuclear forces and all sorts of other things became possible.

We discovered quantum mechanics and other things became possible. If we discover new physics, all sorts of things are going to become possible that are currently thought to be impossible.

Joel

Right.

Robert

And I think the place we're going to discover the new physics is in space because there's no better lab than the universe.

Joel

I like that. Well, I think we probably should wrap up.

Robert

Okay.

Joel

In well over an hour. So I'm really happy that you came on. So glad to have you here.

Robert

Okay, so send me a link when it comes out.

Joel

And also, I wanted to ask you, you mentioned a book, and I want to read that book that you're working on.

Robert

It's not done yet, the New World book, but hopefully it will come out around the end of this year.

Joel

This year meaning 2022?

Robert

2023.

Joel

Okay, so a year from now, I should be looking for it.

Robert

I'm living in the future. All right. But yeah, but it will come out within about a year from now.

Joel

Any other projects or anything you wanted to talk about before we close?

Robert

I'm also working on a book about nuclear power, and it might come out even sooner than that.

Joel

Cool. All right, well, I hope your current projects work out well. That weather balloon and whatever else, and it's just so happy to have you.

Robert

It was great Joel, and come to our next Mars Society conference. I'm not sure where it'll be. Chances are either the LA area or back at Arizona State University near Phoenix.

Joel

Yeah, I could probably make it to one of those for sure. That was so exciting, the one I went to. I've been wanting to do another one forever. There's always things in the way, but got to get them out of the way. All right, thanks so much. That was a blast. I really can't thank Robert enough for offering his unique insights on the space industry, Mars life in the galaxy, and so much more. Following up on our discussion on panspermia, I can't resist the urge to crowd Robert's glory here by quoting from something I wrote, but since it was partly inspired by his lecture on the topic, it seems to justify it.

The third episode of Planet and Sky: The Deeper Story, itself a variation on the rock opera Planet and Sky: A Cosmic Love Story, tells the panspermia story from the viewpoint of the travelers themselves and lends the song with which I'll close this episode its name. Here is a little bit of context the narrator provides, which should sound a little more familiar after Dr. Zubrin's explanation. Quote "The three travelers were embedded in a tiny astronomical object floating far out in space. It had once been a part of a larger world rich with life. They were representatives of this life in microbial form and encased in an icy rock that had been shot off into the outer regions of its original star system.

It had drifted further and further away from its native sun until it was barely held by a tenuous thread of gravitational force. Another star had intersected the vicinity of the distant sun, and its travels through the depths of space, as it grew closer, its own gravitational well overcame the weak force of the original one. The planetoid was gradually pulled more strongly by the new star and began its long fall toward its new master." End quote. And with that, I will bid you all happy joys of the season and hope the new year treats you well. And then many more into the dazzling future.

We all have to bear witness to the beginnings of humanity's leap from the cradle. See you on the other face of Janus with the next episode of Seldon Crisis.

Planet and Sky

Far from the star of our home world we rest in this ice world we wait for new land. Blown into space by a terrible blast... a horrible fate is awaiting us here in the void. Deep space is quiet and restful and cold... hardened 'gainst radiation we sleep.

Something comes slowly and makes itself known... now we're on track to a new star. This monster is pulling us faster we move- away from our neighbors far far away. A new journey finds us speed fast on our way- the light getting brighter- the cold fades.

Here comes a source of new light and heat- a golden beacon- our deliverance! We rush to this nightmare, our doom to be scorched- blackened- cold- and dead! Maybe a new place to live, eat, and sleep... on a nurturing world?

Only a few must survive. Bringing the secrets of life. One world grows larger...