The Future of Space

In his book *The Case for Space: How the Revolution in Spaceflight Opens Up a Future of Limitless Possibility*, **Robert Zubrin**, founder and president of the Mars Society, tells the amazing true story of a new generation of entrepreneurial endeavors in space, such as SpaceX and Blue Origin. He also lays out some bold predictions for the future. At a Cato book forum in October, Zubrin outlined that vision. **Berin Szóka**, president of TechFreedom, shares the enthusiasm for spaceflight but offered a dose of Hayekian humility about our ability to predict economic outcomes.

ROBERT ZUBRIN: This photo is something that many of you may have seen online. This is February 2018, the launch and landing of the Falcon Heavy by Elon Musk's SpaceX. Now, anyone who saw this no doubt thought it was cool, but if you don't know the background to this, you don't know how cool this really was. Because in 2010, President Obama put together a blue-ribbon committee headed up by my old boss Norm Augustine, the CEO of Lockheed Martin, to evaluate whether George W. Bush's moon initiative was possible within acceptable cost limits. They concluded that it was not. According to them, development of a heavy lift vehicle would take at least 12 years and cost at least, wait for it, $36 billion. Now Musk has done it in six years at a cost of less than $1 billion, and to cap it all, the thing is three-quarters reusable. So this launch was a shot heard round the world.

What Musk did has was not merely introduced a very desirable aerospace system but also proven a principle: that it is possible for a well-led entrepreneurial team to do things in a third the time of the federal government at less than a tenth the cost—things that previously it was thought only the governments of major powers could do. And not only that, but the private sector can do things that governments could not do at all despite 60 years of trying. And with that, SpaceX has set off an international space race. You have Jeff Bezos's Blue Origin, Richard Branson's Virgin Galactic, and even companies not led by billionaires using their discretionary cash in order to become immortal through historic achievement. Companies started by working engineers, people with no more means than most middle-class people but who managed to get investment.

One incredible example is Rocket Lab, a New Zealand company founded by a working engineer, that mobilized $300 million in investment. They have reached orbit with a launch from New Zealand. This is not science fiction, folks. This is real stuff, and it's really happening. New Zealand has no space program, but they've achieved this through the initiative of private citizens and investors. And since this race has been unleashed, it has shown that it is going to be self-driving. First of all, Musk himself, with his breakthroughs in reusability, has reduced the cost of space launch by a factor of five. The cost of space launch went down a lot from Sputnik through the Apollo landing as we became competent in the various space-flight technology and pretty much developed the whole bag of tricks during that 12 years of the initial space race.

That was done by governments in the early era. They got the job done, and they reduced the price of space launch from millions of dollars a kilogram to $10,000 a kilogram. But there it stayed for 40 years until 2009. Between 2009 and 2019, as SpaceX has entered the field, it's fallen from $10,000 a kilogram to $2,000 a kilogram. And Musk is trying to make even that price point obsolete. He's working on a new propulsion system, a launch system called Starship, which will be fully reusable and will knock down the cost of space launch by another factor of three. So, we're headed toward $700 a kilogram or even $500 a kilogram. And the cheaper launch is, the more launches there are going to be. That's elementary economics. It's cheaper, more people will do it.

Last year, there were about a hundred satellite launches in the whole world. SpaceX got 24 of them. They got a quarter of the lot. This is one relatively small launch company compared to its competitors like United Launch Alliance, the joint operation of Boeing and Lockheed Martin. They did a quarter of the total number of launches worldwide in 2018 and, really, the majority of the world market that was open for bids. Most of the rest of those were China or Russia or other governments, so you couldn't compete for it at all. Now, because of the lowering of launch costs, I think very quickly we're going to see 200 or 300 satellite launches a year. That in turn will contribute to further lowering of launch costs, as the cost of launch is spread out over more launches. But also, it will contribute to the lowering of spacecraft costs, because they

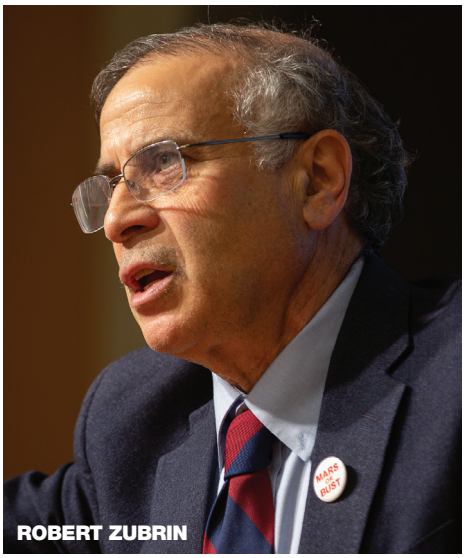
will be being produced in more numbers. Furthermore, the designers of spacecraft will be less conservative.

For the past half century, the prevailing wisdom among spacecraft designers is don't use anything that hasn't been used before; because the launch is so expensive, you don't want to risk your whole spacecraft for a 20 percent improvement in some system. So it became like the person who won't see any movies he hasn't seen before. That's not the way to get a broad education, is it? That's where spacecraft development has been stuck since the moon landings.

But now there is another revolution that has been going on, really driven by technological developments outside the space community. That's spacecraft miniaturization. We're now seeing micro-spacecraft, 10-kilogram spacecraft, that can do things that previously it took a 1,000-kilogram spacecraft to do. They're much smaller and lighter and therefore much cheaper to launch. They're also cheaper to build. These are million-dollar spacecraft instead of hundreds of millions of dollars. And that's another innovation which will facilitate the opening of space.

That's just what we've seen so far, in the past 10 years or so. I do believe, though, that if we're going to make space travel comparable to air travel, it will still have to get much cheaper. Air travel from here to Los Angeles is maybe $5 a kilogram, not $500 a kilogram. How do we get there? You can't do it with 300 satellite launches a year or something like that. But reusable launch vehicles open up a new market altogether, which is surface-to-surface flight on Earth. For the past 3,000 years, people have made money on the ocean. Some have made money actually taking wealth from the ocean, for instance, by fishing or mining. But far more wealth has been developed on the ocean by using the ocean as a global low-drag medium for commerce.

The ocean connects ports across the world with less drag than is available on land. And that's where the serious money in maritime activity has been. Well, space is a zero-drag medium connecting every point on Earth to every point. You can travel from anywhere on Earth to every other place on Earth in less than an hour if you go through space. Of course, this is unthinkable with expendable vehicles, but it


ROBERT ZUBRIN

> "One kilogram has fallen from $10,000 to $2,000."

becomes rational, or at least conceivable, with reusable vehicles. I've run the numbers.

Now, we won't see this everywhere to everywhere. It probably is going to have to be from ports, so you can launch offshore and land offshore and not have all the noise and rockets in the city. But the Starship, if it was used as a transport of this kind, could probably be feasible with a ticket price Los Angeles to Sydney of around $20,000.

To be sure, that is more than I've ever paid for an airplane ticket! But that is the price of a first-class ticket from Los Angeles to Sydney right now. And all those people get is a tablecloth, a free drink, and a reclining bed. Whereas with this, you're getting there in less than an hour instead of 15 hours, and you're getting half an hour of zero gravity and the stars of space out your window. And now instead of hundreds of flights per year, we're talking about the possibility of hundreds of flights every day.

If you get a bigger market like this, then you can start making spacecraft components at costs comparable to other things. A rocket engine is less complex than your car, but your car costs $20,000 or something like that. A rocket engine, you're not going to get one for less than millions. Why? Because one is a mass production item and the other isn't. But if you start producing rocket engines, not in ones or twos, but in thousands, tens of thousands, then they become cheaper. Same thing for all the other flight systems, and this will open up the way for orbital commerce—things like orbital research labs, even orbital manufacturing. These were demonstrated in principle on the International Space Station but could not even remotely be commercial because of the tremendous costs of the space shuttle and also the bureaucracy of the space station. But now, if you're talking about cutting the cost of access to orbit by an order of magnitude, and furthermore that means that there'll be private space stations, which won't put up four years of red tape before you can fly to your experiment on it and so forth, you're going to start seeing that kind of stuff. That's the future we have to look forward to because we've finally unleashed markets and entrepreneurism in space.

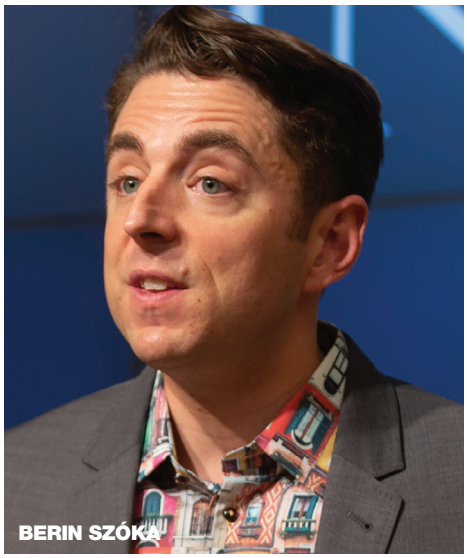
BERIN SZÓKA: It's really an honor to be here. Dr. Zubrin's book *The Case for Mars* inspired me in a very profound way when I read it in 2004. If you can remember that moment, Burt Rutan had just won the X Prize for becoming the first person to send a reusable vehicle with a person in it into space twice in two weeks. And that was a real moment—it felt like a second Sputnik.

I was a young law clerk at that point. I had just graduated law school, and I read a lot of books, but the one that moved me most was *The Case for Mars*. It inspired me. A lot of that book is really about the power of ideas to inspire people. I think you'll get that when you read this new book, *The Case for Space*, which I would highly recommend that you do. But what I would tell you from that experience, from getting so inspired by Dr. Zubrin's previous book, is that what was happening at that point back in 2004 is really two distinct things.

Prophecy is one thing, but timing's quite another. So, my advice to all of you who are interested in this field is probably you shouldn't quit your day jobs. You probably shouldn't try to do what I tried to do, which was that I decided to build my legal career in space law and start an institute for space law and policy. ISLAP is the cleverest think tank name you've never heard of because, well, it didn't get off the ground. It turned out there really wasn't a market for that. I have done some space law work over the last 15 years, but it's been very, very slow going. And that's really the nature of this field. Dr. Zubrin may be right about everything he says, but I don't think anybody in this room, including him, can predict how long any of these things will take.

When he says, for instance, in one of the most inspiring passages of the book, that, "All of this can soon become attainable. A new force is broken loose, a new tree is growing. We have only to water it, foster it, clear its way upward and make sure that no one does anything to kill it"—in some sense, I think that's true and I find that vision very compelling. I do consider him a prophet, but I quibble with the word "soon." We really have no idea how long that's going to take, and more importantly, we really don't know what it's going to look like. He describes a number of things that could be plausible scenarios, that could be plausible business models, and those things could happen. But if I have learned one thing about technology policy over the last 15 years of working in the field, it's the point that—appropriately enough here in the F. A. Hayek Auditorium—the most fundamental thing for us to understand is just how little we can imagine about the future.

The future really is an unknowable place, and there will be an infinite number of challenges to overcome. We don't know how long it will take people to do those things, and most critically, we don't which things will actually make money. Because at the end of the day, there are grand institutional forces at work here. Governments will do what they're going to do. There are real national security issues at stake, and the national security of the United States is going to drive this country to invest in certain things, and that's going to play an important role in what the settlement of the space frontier looks like. But at the end of the day, the promise that he describes, you can think of that as macroeconomics. Yes, there's a new world that you can see from Spain in 1492, and there are all sorts of prophecies you could make about how that new world will be colonized or opened up or what that will look like, but nobody could possibly have imagined what it actually looked like because there really wasn't any one master plan.


BERIN SZÓKA

> "Future viability is fundamentally unknowable."

It was a countless endless array of plans and endless iterations. And Dr. Zubrin knows that, to be sure. I'm not saying that he's trying to design a single top-down technocratic future. But he is an engineer, and that mentality is hard to break, and it pops up throughout the book. He's got particular plans that he's particularly excited about, and I hope that they come true, but I don't think that we're going to get to space in any sort of clear path. I don't think there is any bridge from here to there. There's not a single there. The settlement of the space frontier—fundamentally at its best, it really ought to be about excitement, yes, and about what the future could look like, but at the same time, we need a kind of humility. We have to recognize that Julian Simon was right: the ultimate resource really is human ingenuity, and the resources of space are really only there for what we make of them.

We'll see what happens with them. I just caution everyone in reading the book and thinking about this not to fall prey to the particular obsession that people have with one way of doing something—the idea that Mars is our future and it's the terraforming of Mars that's going to happen. Because it creates a kind of confirmation bias. If you start from that premise, you end up reasoning backwards, and this comes across pretty clearly in certain parts of the book.

But the question of what is the business model, what are the economics that will actually make that sustainable, is fundamentally impossible to answer from our perspective today. You can't simply say, well, people will figure things out and that will drive innovation and that will support the business model. That may be true over the course of hundreds of years. But what will

actually sustain development step by step, quarter by quarter, as companies have to justify the decisions they're making, is marginal cost and marginal revenue. It's the same economics that has driven our economy today and will always drive our economy. People have to make their businesses viable, and the challenges in doing that are really quite considerable.

I'm a lawyer. I'm not an engineer. I don't have a degree in nuclear physics. I suspect no one else here does besides Dr. Zubrin, so I'm not going to get into the kinds of debates with him that you would hear at a space conference where people who are actually engineers or actually physicists would say, "Well, you might underestimate how serious the proper radiation is to deal with, or the effects of microgravity." I'll just talk about a few things that I know something about. I've talked a little bit about economics. It's a big part of what I do. The internet revolution is, I think, an important contrast to this, right? The internet revolution is in many ways very similar. It is about settling the electronic frontier. That's why we have the Electronic Frontier Foundation. That's why people think about cyberspace as a vast uncharted territory. But the single most important lesson to draw from that is that nobody could have imagined what the internet of today looks like from back in 1995 or 2000 or 2005, or even 2010 or 2015. It is constantly changing, and if I got up here today and told you the future is X, Y, and Z and artificial intelligence is going to do the following, I would of course be proven wrong, right?

Now, there are some constants Dr. Zubrin can describe, and he does that very usefully. There are some important factors that really are just matters of physics, and they do lend themselves to certain kinds of launch architecture. For those reasons, this book is incredibly worth reading. It's important to understand those things about the future, what it takes to get outside the Earth's gravity, why the moon is an easier base of operations than the Earth is, and the like. All those things are essentially based on constants of physics. Those are things that an engineer is eminently qualified to talk about. But when it comes to making predictions about what will actually close business cases, I'm not qualified to do that. He's not qualified to do that. We can do it notionally. It's useful to think about those things, but don't confuse those for predictions of what the future's really going to look like step by step. It's inherently going to be messier than that.

> "People are being inspired today."

And, so, then we come to my area of expertise. I'm a policy wonk; I'm a lawyer. I deal with what Congress does and how law works every day. And when I read a book like this, I inevitably see that when an author attempts to bring things down to today and to what this audience can do, the audience is encouraged. The readers are encouraged to do things like supporting private space companies. Because they are going to face a lot of obstacles, and he's absolutely right. It's really important and valuable for someone to tell a story as compelling as his. Where prophecy plays an important role is in inspiring people—inspiring people to go into careers. As the book points out, the number of people who got degrees in hard sciences went through the roof after the Apollo project.

People like me were inspired by the success of Burt Rutan in 2004. People are being inspired today, and it's similarly important to inspire people to make their voices heard in our democratic process to defend companies that are facing regulatory obstacles. That's all very useful. But then it comes to the actual policy issues, and what exactly is it that we can do as policy matter? Now, once again, I agree with Dr. Zubrin about his suggestions for the most part. He's absolutely right that the way that the government buys services today, on a cost-plus basis, completely skews the way that procurement works. It skews the nature of the space economy. Changing that would make a big difference. It's not the silver bullet that's somehow going to radically instantly change the market, but it will make a difference—an important difference on the margin. But that alone is not going to make private-sector businesses viable.

NASA was designed to create jobs spread across as many congressional districts as possible. This is just a political reality. We could want it to change, but that's not going to make it change overnight. So, while government can play a role here in being helpful, I think it's a mistake to expect too much from government. Similarly, NASA having a better plan for how to get to the moon would make a difference. But fundamentally, my concern is what we might get is a repeat of the Apollo program, where we ultimately go and have what we in the space world call "flags and footprints." We get excitement out of that and that has some value. But what really matters is jump-starting a sustainable private-sector presence where people can make money on a regular basis. And he does describe some scenarios where that could happen, but some of those scenarios really involve some pretty significant assumptions about what might happen in the future. I think there are significantly more difficult problems than the problems that SpaceX faced in trying to lower launch costs. So to say that this is all going to happen once certain technology is developed on Earth and it's somehow going to just spark a revolution that settles the space frontier, I think that underestimates how difficult these problems are and how long it is going to take to solve them. ■