Expanding the Frontiers of Knowledge—Neil de Grasse Tyson

A spaceborne radar image of the Great Wall of China in a desert region about 400 miles west of Beijing. The wall is easily detected from space by radar because its steep, smooth sides provide a prominent surface for reflection of the radar beam. The image was acquired by the Spaceborne Imaging Radar-C/X-Band Synthetic Aperture Radar (SIR-C/X-SAR) aboard the Shuttle Endeavour *on 10 April 1994. NASA Image 96-HC-228.*

I do not want to preach to the choir today. You are the choir, and we have a panel of preachers here. Instead, I want to try to stir the pot a little and maybe get you angry, but hopefully not with me. I want to offer a point of view that I have not seen discussed in forums such as this. It is a point of view that represents the landscape in which most of this conversation would need to be present if any of our grand plans for space exploration are to come true.

We all know how important it is to fly. We have been doing it since 1903, and it is a point of pride in our species. We finally could do things the birds could do.

By the way, many people before the Wright brothers said that it would be impossible to fly. Even some well-known scientists, Lord Calvin among them, said, "We'll never have heavier than air flight." Well, of course, birds are heavier than air, and they have no problems flying. So there couldn't be a law of physics against heavier than air flight. So we have to be careful about what we say is impossible.

I would like to offer an argument for why I think it is unlikely that humans will ever leave low-Earth orbit for the next hundred years. I am not going to invoke laws of physics to make that point, because, basically, if the laws of physics do not forbid something, then it can happen. This is why, of course, the people who said nothing would ever go faster than the sound barrier were ignorant, because, in fact, we already had rifle bullets traveling faster than sound.

So when I say, no, I do not believe we will send people out of low-Earth orbit, it is not because I do not think it is scientifically possible. That is no longer an issue. I believe we have enough

confidence in our technologies today so that basically anything we say we want to do, we believe we can do it. There is no doubt about it.

I have done a study of the major funded projects in the history of the world. I think we could quibble about what major means, but I can provide a short list of five or six that we would all agree are some of the major funded projects ever conducted. One of them would be the pyramids. Another one might be the Great Wall of China. The Manhattan project and the Apollo project were two other major funded projects where significant resources of a nation were redirected to enable these projects to take place. I would also include great explorations such as the voyages of Columbus and Magellan. We might imagine that going to Mars or going anywhere other than low-Earth orbit might constitute a major funded project in modern times.

In looking at the history of such projects, I found exactly three drivers. Only these three incentives can induce a population to agree to spend that much money on a major project.

One driver is, of course, economics. If there is a promise of economic return, it is an investment. Such were the voyages of Columbus and of Magellan, and of most explorers of that era.

Incidentally, if you went to the explorer himself and said, "Why are you doing this?" He would typically say, "Oh, because I'm an innate explorer. I want to know what's on the other side of that mountain." These are admirable traits, and the leaders of such expeditions have those traits. But in the end, somebody behind the explorer is writing a check. Italy would not write a check for Columbus, but Spain did.

A second driver is the gratification of ego. That ego can include the praise of a leader or a deity. So major funded projects such as the pyramids were basically elaborate tombstones. The Taj Mahal and the Vatican were built to praise something powerful.

There is a third cause. It is perhaps the most obvious driver—military defense. As examples, the Great Wall of China and the Manhattan project were clearly motivated by national security concerns.

A fascinating combination of economics and defense is the interstate highway system. After Eisenhower came back from the European theater of operations where he saw how effectively Germany was able to move goods and services over the Autobahn, he said, "I want some of those back home." So the interstate system was built for economic reasons, as well as national security.

So these are the three drivers that I have found. I have not found one exception to these.

Now let's go back to the Apollo program for a moment. I remember the 1960s. I knew from age nine that I wanted to study the universe. I watched the Apollo astronauts land on the Moon, and it meant something special to me. But when I went home, I encountered other things, such as picketing outside of the apartment building where my family wanted to move into to prevent it from integrating racially. There are other real-world problems such as the next paycheck that affect the general population.

Also, I remember that there was this mood surrounding the space program, "We are Americans. We're explorers. We're going to explore space. Let's go ahead. This is natural for us." The film we saw this morning was honest about this competition

with the Soviet Union. But let's be a little more blunt about it. The most famous, resonant lines ever to come out of President Kennedy's mouth reflect this international competition.

Spoken 25 May 1961: "I believe this Nation should commit itself to achieving the goal before the decade is out of landing a man on the Moon and returning him safely to the Earth. No single space project in this period will be more impressive to mankind or more important for the long-range exploration of space, and none will be so difficult or expensive to accomplish."

If you hear that, you say, "By gosh, America is about exploration. We're about the exploration of space. That's the next frontier—just like the Columbus voyages and all the great explorers of the fifteenth century. Our next new ocean is space." But remember that this speech was given only six weeks after Yuri Gagarin was launched into orbit by the Soviet Union, a second jolt to the American ego after Sputnik in 1957.

The following paragraph of the speech reads, "If we are to win the battle that is now going on around the world between freedom and tyranny, the dramatic achievements in space which occurred in recent weeks should have made it clear to us all, as did Sputnik in 1957, the impact of this adventure on the minds of men everywhere who are attempting to make a determination of which road they should take."[1]

1. Special Message to the Congress on Urgent National Needs, 25 May 1961. *Public Papers of the Presidents of the United States: John F. Kennedy, 1961* (Washington, DC: U.S. Government Printing Office, 1962), pp. 396–406.

Now if that's not a military speech, I don't know what one is. So that's where the check writing happens, because we view this as a threat. It's a military decision. Kennedy was a big dreamer, but, in the end, one of these three causes reared its head. It happened to be defense couched on the premise of exploration.

Now, of course, space travel is expensive. We like to believe that one day it will be cheap. I'm not really all that convinced of it. I have the Space Shuttle operations manual read by Shuttle pilots in 1982. The whole opening section talks about how cheap it will be to run the Space Shuttle, how much cheaper it will be than any previous way we ever went into orbit. Entire Space Shuttle missions would cost $30 million, tops. That's not what it turned out to be, of course. It costs $200 million a day to keep the Space Shuttle in orbit. Now you can say, "Well, it's cost overruns," but my concern here is not even so much how much it costs, but whether a nation can sustain that through the ebbs and flows of political climate and the ebbs and flows of economic cycles.

If we can send people to Mars for $50 billion, let's do it. Evidence shows that if you start out saying it's going to be cheap, it just does not end up that way. So we need a realistic plan here.

When one of these three drivers is in effect, cost doesn't matter. Yes, there were debates in Congress about the cost of the Apollo program, but they were just pro forma. We spent whatever it took to put Buzz Aldrin and Neil Armstrong on the Moon.

Now is space really our frontier the way the oceans were the frontiers of the old explorers? Space, as you know, is supremely hostile to life. You can say, "Well, explorers had it

bad too." In the 1540s, Pizarro led an expedition into South America to look for the fabled land of oriental spices.

He sailed across the Atlantic to come to South America. He had with him 4,000 men, hundreds of cattle, horses, dogs, a virtual moving city-state, in search of this land. He had it hard moving across the mountain ranges and in the valleys and in the rain forest.

I will quote from William Prescott's account of this: "At every step of their [the crew's] way, they were obliged to hew open a passage with their axes, while their garments, rotting from the effects of the drenching rains to which they had been exposed, caught in every bush and bramble, and hung about them in shreds. Their provisions, spoiled by the weather, had long since failed, and the live stock which they had taken with them had either been consumed or made their escape in the woods and mountain passes. They had set out with nearly a thousand dogs, many of them the ferocious breed used in hunting down unfortunate natives. These they now gladly killed, but their miserable carcasses furnished a lean banquet for the famished travelers."[2]

On the brink of abandoning all hope, Pizarro said "I'm going to send half of you guys back. We're not finding the place. It's probably still out there, but we're running low on supplies. I'm going to send half of you back to get more supplies."

So he sent one of his top men back to get more supplies.

2. William H. Prescott, *History of the Conquest of Mexico and History of the Conquest of Peru* (New York, Random House, Inc., undated), p. 1,074.

But how did he do that? How did he sail the river? The forest furnished them with timber. The shoes of the horses, which had died on the road and then had been slaughtered for food, were converted into nails. Gum distilled from the trees took the place of pitch, and the tattered garments of the soldiers supplied a substitute for oakum.

At the end of two months, a brigantine was completed, rudely put together, but it was strong enough to carry half the company. The company got on the boat, went down the river. The river fed into the Amazon. They said, "Hey, the Amazon, we know where this goes. It goes into the Atlantic." They went to the Atlantic and then sailed back to Europe. Pizarro, after waiting for these guys, found out they weren't coming back. So then he hiked his way back to their base camp and went back to Spain.

My point here is they came to South America and bad things happened, so they just went home. Yes, it was costly to life and limb. But I wonder what would happen if we would send people out to space and suppose they crash-landed on a planet.

If we accept that space and the oceans are analogous frontiers, what would such marooned astronauts do? They would have to mine for new materials on the surface of the planet and rebuild their spacecraft. They would need to extract silicon from rocks and make silicon wafers and imbed circuitry; rebuild their computers. Then they would need to relaunch themselves back into space. That is the counterpart to the ocean-going exploration analogy.

Of course, if astronauts crash-landed somewhere unknown, the planet might not have air. At least Pizarro's team had air to breathe. They did not have to worry about whether there was oxygen.

So space is supremely hostile, but we know this. But when we ask what is the cost of human space missions, we need to consider as many contingencies as possible. This is important because we want to do more than send people on one-way trips, we want to be able to bring astronauts back.

So if exploration is what really matters and not just pride of nation, then perhaps we should genetically engineer a version of ourselves that can survive the hostile environments of space. We've got cloning. We're inside the genome. Let's just do it. Well in fact, we've done that already. Yes, we have emissaries of ourselves that survive the hazards of space; they're called robots. You don't have to feed them or bring them back, and they don't complain if you lose them in space.

So my concern is if costs turn out to be what they have historically been and the time to execute programs lasts as long as it historically has, then I am not convinced that economic cycles and political cycles will allow such programs to survive if they do not satisfy one of these three criteria. The record of history tells us this, unless somehow you want to believe that we are different today than 6,000 years of our predecessors.