A GOAL FOR THE HUMAN SPACEFLIGHT PROGRAM

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The goal of the human spaceflight program should be to increase the survival prospects of the human race by colonizing space. Self-sustaining colonies in space, which could later plant still other colonies, would provide us with a life insurance policy against any catastrophes which might occur on Earth.

Fossils of extinct species offer ample testimony that such catastrophes do occur. Our species is 200,000 years old; the Neanderthals went extinct after 300,000 years. Of our genus (*Homo*) and the entire *Hominidae* family, we are the only species left. Most species leave no descendant species. Improving our survival prospects is something we should be willing to spend large sums of money on—governments make large expenditures on defense for the survival of their citizens.

The Greeks put all their books in the great Alexandrian library. I'm sure they guarded it very well. But eventually it burnt down taking all the books with it. It's fortunate that some copies of Sophocles' plays were stored elsewhere, for these are the only ones that we have now (7 out of 120 plays). We should be planting colonies off the Earth now as a life insurance policy against whatever unexpected catastrophes may await us on the Earth. Of course, we should still be doing everything possible to protect our environment and safeguard our prospects on the Earth. But chaos theory tells us that we may well be unable to predict the specific cause of our demise as a species. By definition, whatever causes us to go extinct will be something the likes of which we have not experienced so far. We simply may not be smart enough to know how best to spend our money on Earth to insure the greatest chance of survival here. Spending money planting colonies in space simply gives us more chances--like storing some of Sophocles' plays away from the Alexandrian library.

If we made colonization our goal, we might formulate a strategy designed to increase the likelihood of achieving it. Having such a goal makes us ask the right questions. Where is the easiest place in space to plant a colony—the place to start? Overall, Mars offers the most habitable location for *Homo sapiens* in the solar system outside of Earth, as Bruce Murray has noted. Mars has water, reasonable gravity (1/3rd that of the Earth), an atmosphere, and all the chemicals necessary for life. Living underground (like some of our cave dwelling ancestors) would lower radiation risks to acceptable levels. The Moon has no atmosphere, less protection against solar flares and galactic cosmic rays, harsher temperature ranges, lower gravity (1/6th that of the Earth), and no appreciable water. Asteroids are similar. The icy moons of Jupiter and Saturn offer water but are much colder and more distant. Mercury and Venus are too hot, and Jupiter, Saturn, Uranus, and Neptune are inhospitable gas giants. Free floating colonies in space, as proposed by Gerard O'Neill, would need material brought up from planetary or asteroid surfaces. If we want to plant a first permanent colony in space, Mars would seem the logical place to start.

If colonization is our goal, rather than bringing astronauts back from Mars, we should leave them there to multiply using indigenous materials. Once we have astronauts safely sitting on the surface of Mars, it makes more sense to send them additional supplies rather than to trade them for an equal number of astronauts sitting on Earth. After all, trips from one planet to another pose an additional risk, and it is on Mars that the astronauts help our survival prospects. We just need a few astronauts who would rather be founders of a Martian civilization than return to ticker tape parades on Earth. We can find such intrepid men and women.

The real space race is whether we colonize off the planet before the funds for the human spaceflight program end. Now that the Cold War is over, the driving force that got us to the Moon has ended and the human spaceflight program is in danger of extinction. Expensive technological projects are often abandoned after awhile. The Egyptians built bigger and bigger pyramids for about 50 years and then built smaller and less well made ones before finally quitting entirely. Admiral Cheng Ho sailed a

great Chinese fleet all the way to Africa and brought back giraffes to the Chinese court. But then the Chinese government decided to cancel the program. Once lost, opportunities may not come again. The human spaceflight program is only 48 years old. The Copernican Principle tells us that our location is not likely to be special. If our location within the history of human space travel is not special, there is a 50% chance that we are in the last half now and that its future duration is less than 48 years (cf. Gott, 2007). If the human spaceflight program has a much longer future duration than this, then we would be lucky to be living in the first tiny bit of it. Bayesian statistics warn us against accepting hypotheses that imply our observations are lucky. It would be prudent to take the above Copernican estimate seriously since it assumes that we are not particularly lucky or unlucky in our location in time, and a wise policy should aim to protect us even against some bad luck. With such a short past track record of funding, it would be a mistake to count on much longer and better funding in the future. Instead, assuming funding levels in the next 48 years like those we have had in the past 48 years, we should ask ourselves what project we could undertake in the next 48 years that would be of most benefit to our species. Planting a self-supporting colony on Mars would make us a two-planet species. It would change the course of world history. You couldn't even call it world history any more. It might as much as double our long term survival prospects by giving our species two chances instead of one. Colonies are a great bargain. You just send a few astronauts and they multiply there using indigenous materials. It's the Martian colonists that would do all the work. They would increase their numbers by having children and grandchildren on Mars while increasing their habitable facilities and biosphere using indigenous materials--with no further help needed from us. If couples had four children, on average, the colony, on its own, might multiply its initial population by a factor of as much as a million in 600 years.

And colonies can plant other colonies. The first words spoken on the Moon were in English, not because England sent astronauts to the Moon but because it planted a colony in North America that did. People on Mars might one day plant colonies elsewhere themselves. If people on Earth were extinguished by some catastrophe, Martian colonists might at some later date send an expedition to repopulate it.

Since the funding window for colonization may be short, we should concentrate on establishing the first self-supporting colony in space as soon as possible. That it be self-supporting is important since this would allow it to continue even if funding for space launches from Earth were discontinued.

If establishing a self-supporting colony is our goal, we could skip going back to the Moon, and concentrate on colonizing Mars. According to calculations by Gerard O'Neill, about 50 tons per person are required for a self-supporting colony in space (including biosphere). One of the three colonization waves that populated North and South America with Native Americans began when perhaps a dozen or so people traveled across a land bridge from Asia about 12,000 years ago. The Aboriginal population of Australia may have started with as few as 30 people who voyaged there by raft some 60,000 years ago. (Genetic diversity of our Mars colony could be increased by bringing frozen sperm and egg cells along.) If we just put up into low Earth orbit as much tonnage in the next 48 years as we have in the last 48 years (in Saturn V and Shuttle launches alone) we could deliver 2,304 tons to the surface of Mars. We would need a heavy lift vehicle like the *Ares V*. Four new *Ares V* rockets could be assembled at a time in the vertical assembly building at Cape Canaveral and be ready for launch in sequence during the launch window which opens up once every 26 months. Even if it took 11 years to develop the *Ares V* rocket, we could still deliver 1,808 tons to the surface of Mars in the next 48 years. With no greater commitment in the next 48 years than we have made in the last 48 years we could plant a colony on Mars. The goal would then be to make the colony self-supporting as soon as possible.

If we fail to establish a self-supporting colony on Mars while we have the chance, it would be a tragedy. The dimensions of that tragedy might not become apparent to us until such time, perhaps many thousands of years from now, when we would find ourselves trapped on Earth with no viable space program, a low population, and our extinction as a species looming near. Moreover, we might end up spending as much money in real terms on the human spaceflight program in the future as we have in the past and *still* never get to Mars. If that happens, it would be a double tragedy. But if we just continue as we are now, without a clear or urgent purpose, this may well be our future.

We should worry that we will not succeed at colonizing off the Earth. Why? Because we are having this conversation on Earth right now. If the human species stays limited to Earth, you and I are entirely typical. You should worry that we might fail to colonize.

The United States has a particular stake in this. It put Neil Armstrong on the Moon. But the importance of that event is yet to be determined. As Kenneth Gatland said in *The Illustrated Encyclopedia of Space Technology*, in 1989, "It is still too early to assess the full significance of the Apollo Moon landings. Did they represent a blind alley of technological advance never to be repeated, or were they the beginning of a bold new era in which mankind eventually will colonize the solar system." If we stay on Earth, then Neil Armstrong's flight is just another event in the history of exploration, like Edmund Hillary's ascent of Mount Everest or Roald Amundsen's visit to the South Pole. But if Neil Armstrong's flight is just the first step in our becoming a multiplanet species, then he is an important historical figure like Christopher Columbus—someone who was part of changing the course of human history. Indeed, as Representative Robert Torricelli of New Jersey, speaking in favor of the continuation of the manned spaceflight program, once said, if we quit, then "Neil Armstrong's giant leap for mankind will turn out to have been a small step after all."

I do not say establishing a colony on Mars would be easy. Small colonies often fail. In North America, the Jamestown colony failed before the Plymouth colony eventually succeeded. Persistence is valuable. Colonizing Mars is a dangerous enterprise for the astronauts who go, but it is what we should be doing. Astronauts are risking their lives every time they take off; we should give them something to do that is worth risking their lives for.

Because the human spaceflight program is not very old we should be colonizing off the Earth as soon as possible, while we still can. In 1961 President Kennedy said: "We choose to go to the Moon in this decade and do the other things not because they are easy but because they are hard." Many people remember that line. But then he added another less well remembered coda: "Because that challenge is one we are willing to accept and unwilling to postpone." Space colonization is a challenge we should be willing to accept and unwilling to postpone.

With a great recession upon us it is easy to imagine human settlement of Mars being postponed or taken off the table entirely. On the other hand, President Obama now has an opportunity to set forth a new and inspirational objective for the human spaceflight program, one that could change the course of human history.

Reference:

Gott, J. R., "Longevity of the Human Spaceflight Program," *American Institute of Physics Conference Series*, *886*, 113-122 (2007).