

BANQUET ADDRESS:

**"AN ALLIANCE TO RESUCE CIVILIZATION:
Long Range Strategy for Using Space to Protect Mankind"**

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In 1964 *The New Scientist* published a series of articles in which ninety-nine of the leading lights of the scientific establishment - here defined to include the social sciences - were given the opportunity to play oracle. Joshua Lederberg, Isidor Rabi, Fred Hoyle, Norbert Wiener, and B. F. Skinner, among others, were asked to predict what life on Earth in its various constituents would be like twenty years later: in 1984 (no doubt chosen because of its tantalizing Orwellian association).

The series was published by Penguin Books in 1965 in two volumes called, simply *The World in 1984*.* I came across both volumes in the autumn of 1999 while cleaning out a dusty bookcase in a corner of the room at NYU where the science writing classes are held.

After scanning the table of contents, I went straight to a contribution by Dr. Wernher von Braun, then the director of NASA's George C. Marshall Space Flight Center at Huntsville. His contribution was an essay called "Exploration to the Farthest Planets".*

Remember the time. Only seven years earlier, the Soviet Union, widely thought to be a scientific and technological backwash, has startled the world by sending Sputnik to orbit, followed by two more sophisticated successors. The United States had answered with Explorer 1, and the race was on. Space enthusiasts everywhere, young and old, amateur and professional, watched in near-delirium as the two superpowers finally began turning the ancient dream into reality. The political rivalry, no less than the great leviathan rockets themselves, at last broke gravity's grip and carried human beings off Earth and into Space.

President Kennedy pointed the new knights, which they called astronauts, to the Moon. And to his credit, he did so publicly, knowing that success would be irrefutable proof of American technological and managerial prowess, while catastrophic failure would show that a free political system was resilient enough to take a horrible loss. It also should be noted here that, contrary to myth, Kennedy did not in effect wake up one morning and decide on impulse to aim for the Moon. NASA had by then studied the feasibility of landing men on the lunar surface in detail and planned to fly the mission at some point. The president was so briefed. By 1964, Gagarin and Titov had led the way to space, Project Mercury was over and Gemini was about to begin. It was a moment, as one Russian said tearfully, when anything seemed possible.

So von Braun, the charismatic savant who had become famous for conceiving the world's first operational ballistic missile, let his imagination soar in *The New Scientist*. He was already almost messianic when, in October 1951, he ran the First Annual Symposium on Space Travel in the Hayden Planetarium in New York and as you all know or most of you know, that milestone event turned into an eight-part series in *Collier's* magazine that ran from 1952-1954. The successive installments were in effect the blueprint for the space age. The series predicted the space shuttle, a huge station that spun like a roulette wheel, landings on the Moon and Mars, and even the physiological challenges that the new realm would bring to human beings. Some believed eyeballs would turn into soft-boiled eggs under heavy gravitational force and cosmic rays would poison any cell that ventured beyond the protection of the atmosphere.

But von Braun would have none of it, and neither would true believers who carried the dream, most notably Isaac Asimov, Arthur C. Clarke, Gerard K. O'Neill (whose ghost is here tonight) and Carl Sagan.

In his short essay, von Braun predicted that by 1984, mankind would either already have landed on Mars or would have at least made a close approach for reconnaissance. The same for Venus. The Moon, he went on, would by then have been turned into a manned colony. "Lunar landings will have long since passed from the fantastic achievement to routine occurrence," he wrote. "Astronauts will be shuttling back and forth on regular schedules from the earth to a small permanent base of operations on the moon. Von Braun surmised that the base would be the site of an astronomical observatory that would do nothing less than discover the nature, extent, and origin of the universe. Accurate long-range weather forecasts by satellite would be available all over the planet, von Braun continued, and so would navigation by satellite. He called for nuclear power to replace chemical propulsion by 1984, asserted that robotic explorers would range throughout the solar system, and foresaw manned orbiting laboratories with closed ecological systems that supported "pioneering crews" for uninterrupted stretches of two years.

The considerable social benefits of exploring and colonizing space also were obvious to von Braun. As the Crusades prevented a great deal of bloodshed in Europe by directing the energy of its soldiers to faraway places, so, too, would space exploration. It would prevent nuclear war. I quote now, "More citizens of the world than ever before are taking part in the affairs of government," he concluded. "Well-informed, thinking men will continue to support this intriguing and profitable endeavour of space exploration. How far we go in space - and how fast - will continue to be affected by the measure of public support."

Clarke, whose most enduring work is *2001: A Space Odyssey*, was so affected by the Apollo 11 landing on the Moon that he wrote in the epilogue to a book, *First on the Moon*, that "...well before the end of the century, the first human child will be born there. It would be interesting to know the nationality of its parents; but such fading symbols of the old world will not be long remembered, in the fierce and brilliant light of the lunar dawn."*

Gerard O'Neill as you all know had the dream. Following von Braun and Clarke, O'Neill published his own ground-breaking call for the migration to space, *The High Frontier*, in 1976 and founded this institute the following year. It is important to note that O'Neill's doctorate in physics came from Cornell, which also incubated Philip Morrison, Hans Bethe, Richard Feynman, Sagan, and other notables, so he had impeccable scientific credentials. O'Neill wrote pointedly that the technological wherewithal to establish large human communities in space not only existed at the time he wrote his book, but the move to space was turning from a luxurious dream to necessary reality in the face of growing environmental pressure on the home planet.* I will return to that.

Apollo 11's voyage to the Moon and back was arguably the greatest feat of human exploration. It was the longest, fastest, and most meticulously planned journey people have ever undertaken. It was nothing less than Odyssean, both in terms of its goal and in the bravery of the three men who made that potentially perilous trip. The dragons that awaited Armstrong, Aldrin and Collins were the navigational and mechanical problems that would have been almost inconsequential at home, but that could have left two of them to suffer excruciating deaths stranded on the lunar surface, or all three to expire in a derelict command module that was off course, perhaps for eternity. The epic plight of Apollo 13 showed how close the margin was.

Apollo 11's voyage was a tribute to humanity's infinite capacity to overcome enormous obstacles to achieve goals that are both important and clearly articulated. The mission's importance lay in the two-fold charge given by the president: to hand the commies a stinging political defeat while simultaneously demonstrating the nation's matchless technological competence and the heroism of the young men in its armed forces. The articulation came not only from consecrating the mission before the world, but from managing its thousands of intricate components to near perfection.

History records, and many of us remember, that Apollo 11's mission to the Moon engaged the world and caused jubilation and patriotic fervor in the United States.

Then, inexorably, the level of public interest dropped as one succeeding Apollo mission followed another, and as John indicated, most of us were there. By the end, when Gene Cernan left the last footprint on the lunar surface on December 14, 1972 and headed home, the people of Earth were looking elsewhere. The flight of Apollo 17 was every bit as difficult and dangerous as its six predecessors. Its science return was no less important than the others had been, especially since it carried the only scientist in the series, Harrison Schmitt, to fly on an Apollo mission. Yet the grand entertainment, the unparalleled spectacle, the proudest adventure in human history, came to an abrupt end. A fickle world was now preoccupied with more mundane stuff, or at least mundane compared to the overarching requirements of international relations and solar system exploration.

And having accomplished what it was ordered to do, necessarily including the procurement of all the hardware that was required to get to the Moon and back several times, the space agency's budget had gone into a long decline years before the Apollo 17 astronauts came home.

By 1992 - the 500th anniversary of Columbus's own epic journey to a new world - the voyages of Apollo had been relegated to an important, but remote historical artifact. Both of the old antagonists had decided in the wake of the landings on the Moon that such stunts, however ennobling, had to be replaced by a progressive exploration of the solar system with robots and with a real human presence. America's *Skylab*, which used Apollo technology and equipment, was a real, but short-lived, station in space. The Russians, who had been thwarted in the race to the Moon, directed their prodigious engineering capability and limited resources to the broader goal of establishing permanent stations in low Earth orbit. They created a series of Salyut stations that could be re-supplied by Soyuz spacecraft, which also would bring fresh crews and return veterans. And as you know, *Salyut* was followed by *Mir*, a larger, modular station, whose core was launched on a Proton rocket on February 20, 1986. As you also know from quite recent history, it met its fiery end on March 23rd after fifteen extraordinarily productive years in orbit.

The United States, following von Braun's script, came up with a Space Transportation System in the early 1970s whose heart was a reusable rocket plane called an orbiter. Instead of trying to stage more spectaculars, NASA adopted an intensely conservative strategy that called for extending its reach into space in gradual, interlocking, steps. Having won the shuttle from President Nixon on the utterly sophistic arguments that it would fly as many as fifty-five missions a year and be cheaper than expendables because it was reusable, the space agency then argued that the huge investment in the shuttle made little or no sense unless it could be used in the "next logical step." That was a permanently orbiting station. President Reagan approved the station in the summer of 1982 and christened it *Freedom* as an in-your-face gesture to the Commies.

The station was plagued for more than a decade by rancorous arguments within the space community over whether it was really needed, some sabotage by the Department of Defense, which initially wanted its own station, plus partisan conflict in Congress. You all remember that vividly. As the battle of the station budget went on, year after wearying year, von Braun's grandiose but expensive wheel evolved into a progressively smaller and cheaper trussed Tinker Toy. Its industrial backers - chiefly Boeing - argued lamely that the station would allow perfect crystals to be manufactured in micro-gravity and produce other breakthroughs, including astounding advances in science. The science community, which was overwhelming in favor of robotic science missions in the vicinity of Earth, such as the Hubble Space Telescope, and solar system exploration, reacted with unconcealed scorn. Even the job argument was used, pretty much without effect, as *Freedom* slowly petered out. It was eventually resurrected as the *International Space Station*.

On July 18, 1999 - two days before the 30th anniversary of the landing of Apollo 11 - John Noble Wilford, undoubtedly the smartest and most graceful space writer on this planet, had a story on page one of *The New York Times* that is worth quoting in part here tonight:

"Over dinner a few weeks ago, a former astronaut who walked on the Moon and one of the Apollo flight directors got to skylarking about the good old days, something people do when they think of the past receding and a big anniversary approaching, in this case the 30th anniversary of the Apollo 11 lunar landing on July 20, 1969.

"They laughed almost to tears telling cherished stories, one trying to top the other, about the time men flew to the Moon.

"Then a cloud seemed to pass over their faces. Without prompting, they wondered in sadness and perplexity what had happened to the good old days.

"Where were the astronauts on Mars? The permanent lunar bases or the giant space stations wheeling through orbit. This was the future that should have arrived by now, as prophesied in the heady atmosphere of the Apollo 11 triumph. Both men - the astronaut Charles (Pete) Conrad Jr., who was soon to die after a motorcycle accident on July 8, and the flight director Gerald Griffin - worried that the United States had lost the old can-do spirit and the will to carry out ambitious, expensive space endeavors.

"Such bittersweet thoughts among some of those of the Apollo generation as they began celebrating the time when human beings first (and last) set foot on another world."*

The absence of widespread support for the successors to Apollo 11, including the station in its several versions, has plagued NASA, the rest of the space community, and the enthusiasts for the ensuing thirty-two years. There has been incessant hand-wringing over the nature of the problem, with the space agency itself caught in an apparently hopeless conundrum:

Public interest in space has peaked at times of unique high drama - the landing on the Moon - or gross tragedy such as the deaths of the three astronauts in the Apollo 1 fire or, of course, the obliteration of *Challenger*. But unique drama is not only immensely difficult to come by repeatedly, it is ultimately counterproductive for an agency that portrays itself as methodical, logical, orderly, predictable, and in control: all the qualities of good engineering. That is why NASA has tried so hard to make shuttle and space station operations seem as safe and dependable as airline service (or at any rate, as dependable as airline service once was). It is no longer a good analogy. Here is the conundrum: large numbers of people have not gone to airports to watch planes take off for eighty years. The price of dependability is acceptance and complacency, and that means a low level of interest.

Where the overall population is concerned -and to some extent this is reflected in Congress and in what the sociologist C. Wright Mills called the power elite of movers and shakers - reaction to the space program is shaped like the ubiquitous bell curve. On one end there are the staunch zealots and visionaries who are convinced that humanity's migration to space is manifest destiny. Virtually everyone in this room is in that group. A much larger number of people are generally interested in space activities and will tune in, for example when Voyager 2 encounters Neptune, Sojourner roams around Mars, knocking its little head into rocks and *Mir* suffers a potentially deadly fire and collision.

At the other end of the curve are those who are deeply scornful of the program and who believe it is a frivolous waste of funds that could otherwise benefit the homeless, prevent or alleviate disease, and accomplish other socially useful functions. I live in a department at NYU, chocked full, they think it is a joke, it is a waste of money and time. (The same argument was made to me by the historian Arnold Toynbee, the theologian Reinhold Niebuhr, and others before we went to the Moon.)* I covered that for Apollo and both of them thought that it was an affront to humanity to do something as dumb and wasteful as that clearly was. Those on this end of the curve are contemptuous of astronauts and cosmonauts frolicking upside down in orbit and are convinced that sending people to space is an expensive lark that fattens the aerospace industry but that is socially irrelevant. They see no purpose to it except entertainment, preserving a macho image at the space agency, and corporate profit.

The large center of the curve represents ordinary people, educated and not, who are fundamentally indifferent to the space program and who concentrate almost exclusively on the daily challenges and occasional rewards of life on terra firma, foremost among them being work, and their immediate families. (The guy I mentioned last night if you were around. The guy who is driving a load of mattresses someplace is exactly the person I have in mind. What he cares about is 3 squares a day, a roof over his head and bowling. That is what he cares about and he speaks for lots of people). They do not think about space. But the space agency wants them to think about it. This is the group NASA's public relations operation - in common with other federal agencies' public relations operations - has always tried hardest to attract.

But the possibility of fundamentally interesting those in the middle of the curve enough to make a significant portion of them support the space program is virtually hopeless. This is because they don't believe there is anything about space that can benefit them economically or socially, and certainly not intellectually. These are the people who would look at the towering gaseous pillars, the great star incubators, in images of the Eagle Nebula that were sent home by the Hubble Space Telescope, and see nothing more than dirt and crud. They don't care about water on Europa and Ganymede or ancient oceans on Mars and what they may portend. They will never be moved by exploration. They never have been. Exploration has always been undertaken by the intellectual elite, including the abidingly curious, and by those whose environment has been threatened. I'll get back to that too.

Not everybody in the port of Palos turned out on August 3, 1492 to cheer Columbus on as his three pathetically tiny ships started westward. They didn't identify with leaving the comfort and security of their town; with leaving the familiar to strike out for unknown and very likely dangerous places. But some of them, I think, undoubtedly would have felt quite differently if they knew Palos was almost certainly going to be destroyed.

The history of the space age is littered with pieces of broken crystal balls. von Braun's manned expeditions to Mars and Venus and his orbiting colonies have not materialized because there does not seem to be compelling reason for them. No infant has a birth certificate from the Moon colony because the necessity to construct such a place is not evident to most of the people who would have to pay for it, let alone to the government and the power elite. For them, establishing a colony on the Moon is about as relevant as playing polo.

Everyone on the curve except the committed enthusiasts will ignore the notion of migration to space unless there is a reason that is a great deal more compelling than the abstract notion - however correct - that mankind's soul requires the nourishment that comes with asking great questions, searching for answers, and exploring for the sake of sheer adventure. But there is such a reason.

The haunting pictures of a green and blue sphere swept by wisps of white, coursing through an immense black void, were first taken by the crew of Apollo 8 at Christmas 1968. They are perhaps the best-known photographs in the world and have been used in innumerable advertisements and commercials. But more to the point, they have become the icons of the environmental movement because they show explicitly what until then had been known only intellectually: that this planet is itself a small, fragile, spaceship, a solitary vessel filled with precious life, sailing through a vast sea.

And that sea, no less than the one on Earth from which its metaphorical image derives, can be supremely dangerous as well as life-giving. We were through that yesterday and you know it very well. Nature is not more intrinsically benign than are its children of all species. There is danger everywhere. The natural world poses one series of dangers and our civilization, in turn, poses others.

One of the less glamorous but extremely important by-products of solar system exploration has been the discovery that many bodies, planets and satellites, are covered with craters that testify to their having been pummeled repeatedly by projectiles from space. As you know, Mercury and Mars carry the scars from the impacts, which continue, and so do three of Jupiter's Galilean moons - Callisto, Europa, and Ganymede - plus, of course, our own moon. All of them, as well as Earth itself, testify to the fact that rock and metallic asteroids, comets and extinct comet nuclei, and other cosmic wanderers, large and small, moving at terrific speed alone or in groups,

have 15 repeatedly slammed into their targets with punishing effect. We were all through it yesterday, so you know it very, very well.

Earth is bombarded almost continuously by foreign objects, most of them small enough to burn up in the atmosphere before they reach the surface. But many have survived the fiery plunge. Some, like about 100 small iron meteoroids that struck Siberia in 1947, left harmless meter-wide holes. Another Siberian hit was a far different matter, though. One the morning of June 30, 1908, a colossal mid-air explosion occurred right over the Podkamennaya Tunguska River Basin. Although only some reindeer were killed by the midair explosion, people were knocked to the ground forty miles away. They reported seeing an intense bluish-white streak in the sky just before the blast and hearing tremendous noise. An expedition that reached the site nineteen years later found that large stands of trees had been knocked down and charred in a twenty-mile-wide area. Explanations for the explosion have run the gamut from a jettisoned nuclear reactor from a UFO, that is my favorite, to a fragment from the periodic comet Encke, which was in the neighborhood at the time.*

There have been any number of other serious hits caused by Earth crossing asteroids or comets, including one 200 million years ago in Quebec, and the one that blasted the famous Meteor Crater near Flagstaff, only 25,000 years ago. But by all accounts the mother of them all was the ten-kilometer-wide asteroid or comet (or several of them) that slammed into what is now the Yucatan Peninsula. The Cretaceous-Tertiary Collision, or KT boundary, as it is called, is widely credited with finishing off the dinosaurs and wiping out more than half of all other species roughly sixty-five million years ago. But as Carl Sagan explained in his last book, *Pale Blue Dot*, it did a great more than that:

I'm quoting now, "In sequence, a world-immolating fire burned vegetation to a crisp all over the planet; a stratospheric dust cloud so darkened the sky that surviving plants had trouble making a living from photosynthesis; there were worldwide freezing temperatures, torrential rains of caustic acids, massive depletion of the ozone layer and, to top it off, after the Earth healed itself from these assaults, a prolonged greenhouse warming... It was not a single catastrophe, but a parade of them, a concatenation of terrors. Organisms weakened by one disaster were finished by the next. It is quite uncertain whether our civilization would survive even a considerably less energetic collision. "*

In 1989, an asteroid that could have been a half-mile in diameter crossed the Earth's path and came within six hours of plowing into the home planet.

The Chicken Little crowd, which was derided for years for warning about a killer rock causing doomsday, finally got some respect in July 1994 when the late Eugene Shoemaker, a geologist, his wife Carolyn, and David H. Levy, both amateur astronomers, spotted a comet that had been broken into 21 pieces by Jupiter's gravitational pull. The succession of rocks, strung out like a

string of pearls, plowed into the Jovian atmosphere and created terrifying Earth-sized fireballs. That finally got the attention of the government and a sizeable number of astronomers and planetary scientists.

Astronomers and other scientists who are concerned about the impact of projectiles on Earth note that the larger the object, the less likely there will be a hit. That's good news. The bad news, however, is that statistically a two-kilometer or larger rock with our name on it is out there somewhere.

Clark Chapman of the Planetary Science Institute and David Morrison of NASA's Ames Research Center have warned that there is a 1-in-10,000 chance that a big one will hit Earth during the next century, disrupting the ecosphere and killing a large fraction of the world's population.* An impact like the KT Collision, they have said, would cause virtually the entire population of this planet to perish.* Gone. Extinct.

Dave Morrison, who has closely studied the Near-Earth Object (NEO) situation for years, has connected "Students of NEOs", as he called them, around the world on the internet and, with other scientists, has insisted that the first imperative of a so-called Spaceguard system is to inventory ninety percent or more of Earth-Crossing objects of consequential size so an accurate assessment of the danger can be calculated. That too we have gone over. Only then can effective countermeasures, perhaps including spacecraft armed with nuclear explosives to deflect them, be developed.

NEOs are perhaps the most dramatic natural threats to humanity but, as you know, they are far from the only ones. If NEOs constitute the leading external threat, tectonics and volcanism are the leading candidates internally. This is a real doom and gloom evening isn't it? It'll get better.

The worst mass extinction of all time came 250 million years ago, when an estimated 85 percent of species in the sea and 70 percent of those on land were annihilated. So were forests. The catastrophe happened over the course of half a million years - a relative instant in geological time - and no one seems to know why. Another impact is one possibility. But the most discussed possible earthbound cause for the mass killings were million-year-long lava eruption called Siberian Traps. Four other extinctions, major and minor, have been linked by paleontologists to huge lava eruptions.* And a run-of-the-mill volcanic eruption in Iceland in 1783 disgorged three cubic miles of lava and killed an estimated 9,000 people.

To these horrendous threats, add the increasing likelihood of a pandemic as infectious bacteria continue to grow ever more resistant to antibiotics. Writing in the *New England Journal of Medicine* in December, Dr. Cynthia G. Whitney, an epidemiologist, attributed a clear increase in resistance to penicillin to "survival of the fittest" in the bacteriological world. Bacteria with natural resistance to a given antibiotic manage to survive it and multiply. And if the same antibiotic is given again, she reported, the process repeats itself until, gradually, the resistant

bacteria predominate.* Tuberculosis, a notoriously deadly disease that was called "consumption" when it ravaged much of the world in the 18th and 19th centuries, was almost wiped out after World War II by antibiotics. Now a drug-resistant strain is back, not only in poor countries, but in the better off ones as well. In some cases, there is resistance to only one of the five major antibiotics that are used against TB, but in other cases, there is resistance to four of them. "Watch out, guys, this is serious," the lead author of a report on the new epidemic that came out a year ago was quoted as saying. "It's a potential major crisis of the future."*

There are several other ways to either end it all or suffer severe planetary devastation, singly or in combination, that include biotech disasters, a nuclear war, and global warming. You do not need to hear more about global warming. Suffice it to say, Stephen Hawking is on record as claiming that the greenhouse effect will in all probability turn this place into another Venus. And long before that happens, he adds, it would be a good idea to migrate. I'm quoting, "It takes too many resources to send each person into space," he told Britain's Press Association last September. "But unless the human race spreads into space, I doubt it will survive the next thousand years."*

While Hawking's time frame is sobering, the concept of striking out for other worlds to save humanity is far older than the great British theoretician. It is a foundation of science fiction. And science fiction has been the blueprint for science. It goes back to H.G. Wells, Edgar Rice Burroughs, Isaac Asimov and others. Perhaps most recently, Buzz Aldrin and John Barnes called for a migration in *Encounter with Tiber*, which came out in 1996. I'm quoting again, "There's not a place in the universe that's safe forever," one character warns. "The universe is telling us, 'Spread out, or wait around and die.'"

The warning list includes one or more multiple forms of technological collapse and what Bill Joy, the co-founder and chief scientist at Sun Microsystems, has called a dystopian society. Technological chaos might come in the form of a massive breakdown in the global computational system, either accidental or by terrorists, causing widespread disruption of communication, transportation, manufacturing, and other vital services that could cause severe damage on a planet-wide scale.

Joy, in a now famous article called "Why the Future Doesn't Need Us," warned that as machines with human attributes begin to evolve, the human race might allow itself to drift into a position so dependent on the machines that it would have no practical choice but to accept their decisions. He envisioned a system so complex that human beings would no longer be capable of making intelligent decisions. Conversely, Joy added, human control over large systems of machines would be a tiny elite that considered the masses a superfluous, useless burden on society and therefore had to be eliminated.* If you're interested in the engrossing amalgamation of people and ultra smart machines, you might want to read the book that got Bill Joy thinking, that of

course is: Ray Kurzweil's *The Age of Spiritual Machines*.^{*} Kurzweil contends that by the end of this century, there will no longer be a clear distinction between humans and computers.

Asimov, who had a doctorate in biochemistry, once classified potential disasters in descending order of severity. At the top were the ones that would make the whole universe uninhabitable. Next came events that would render the entire solar system unfit for human life. In roughly five billion years, as you know, the Sun will explode into a red giant and charbroil much of the solar system, including this planet, before imploding into a white dwarf. One astrophysicist was quoted in *The New York Times* as saying that when it happens, and this is a direct quote, "it would be a very good idea to be out of town."

But our discomfort will start earlier, as the Sun's luminosity steadily increases, leading to rapid water loss and overheating.

Lower on Asimov's list are disasters which, while disturbing Earth only temporarily, would completely kill off our species. These are the events, already noted, that could spell not only our extinction, but all record that we ever existed.

Personally, I am optimistic about the long-term relationship between humans and machines, and I think we will ultimately be able to hold our own against the computers. But as much cannot be said about the dangerous vagaries of nature. That's not especially trenchant, either, since, as Aldrin and Barnes warn, all planets, like other objects in the cosmos, are born, live, and die.

Even Jerry Siegel knew it. That's why Siegel, who conceived of the cartoon character Superman during a sleepless summer night in Cleveland in 1934, had him born on a distant, old, doomed planet called Krypton. As you may recall, Superman's father was Jor-L, Krypton's foremost scientist. After Krypton had a frightening "earthquake" (really a kryptonquake), Jor-L put his infant son in a "model space flier" - a very small rocket-propelled spaceship - and sent him to safety on Earth. Just as the baby blasted off, Krypton's end came when the whole planet exploded into a "million fragments," killing everyone as it disintegrated. Krypton, of course, had an apocalyptic tectonic problem that obliterated it, in the process destroying all traces of its civilization except for the one individual who escaped.

The fable of Superman is instructive. Certainly no one, including the people in my department, would accuse Jor-L of being frivolous because he made the model space flier to save his son. I take that back. Some would say even that was frivolous and I know who they are.

Similarly, there is more purpose to the space program, however obscure that purpose is, than is apparent to the general public and even to most of its active participants. Successive space agency administrators, going back to Keith Glennan, have understood instinctively that describing their mission as crucial to the safety of civilization was to invite derision and ridicule by an overwhelmingly myopic public and its elected representatives. There is no clear sense of

Earth's many vulnerabilities to most of its inhabitants. Again, that goes back to the mattress guy from last night and he is a metaphor for a lot of things. Nor should there be to people who are preoccupied with more apparent and urgent challenges and dangers. So it is up to the space community itself, and that includes the wider scientific establishment, to begin hedging against calamity.

John W. Young needs no convincing. He orbited the Moon on Apollo 10 in May 1969 and spent three days on the lunar highlands during the Apollo 16 mission in April 1972. He is a thoughtful man. And a deeply concerned one. In October 2000, Young circulated an internal memorandum at the Johnson Space Center warning that human exploration of space is "mandatory" because of the many dangers Earth faces. He began by quoting H.G. Wells: "The future is a race between education and catastrophe."

I'm quoting John Young now, "In the last 40 years of exploration of the solar system, the Earth, our Sun, its other planets and their satellites, we have learned that the normal evolution of this solar system can produce very unpleasant events for Earth people," Young continued. "Space exploration by humans will insure the long-term survival of our species and all the other Earth threatened and endangered species that only humans can protect. What is needed is a Planetary Protection System, does that sound familiar, not to protect the planet, which can take major events - but to protect the people on this planet. The human race is at war: our enemy, pure and simple, is ignorance."

Young ended by listing nine very ambitious goals that needed to be accomplished if this civilization is to survive catastrophe. They included the development of reliable power; acres of inflatable structures so people can live anywhere; terra-forming in a 100 percent closed loop environment that would allow breathing and farming on the Moon and Mars; *in situ* processing so explorers can live off any land they encounter; and a heavy lift capability to send equipment and consumables to any outpost in the solar system.*

A colleague of mine at New York University, Professor Robert Shapiro in the Department of Chemistry, and I believe the time has come to begin to shape the space program so it is capable not only of sailing a handful of individuals around Earth on short, loosely-defined orbital missions, but of providing the means to save civilization in the event of a natural or man-made catastrophe. This would most probably be done by resuscitating the planet, (again, that is the definition of rescue here, resuscitating the planet) -helping to repair and overcome terrible damage - or, if absolutely necessary, by being able to abandon a dead or dying ship altogether. We call the the Alliance to Rescue Civilization, or ARC. And we worked harder on the acronym, as they do in the government, than we did on the idea.

The idea is to continuously copy Earth's overall civilization in its many manifestations - all that we are - and send it elsewhere with people for safekeeping. By this we mean the totality of the

art and literature of any nation or society that wants to participate, plus scientific accomplishments, and life forms of plants and animals by preserving their DNA. In computer nomenclature, this amounts to backing up the planetary hard-drive and storing it elsewhere. It in no sense amounts to abandoning Earth. To the contrary, we believe that the rescued record of this civilization, together with a large, continuously manned outpost, could be used to save Earth after a severe asteroid hit or other major disaster.

The most likely scenario in the relatively short term - measured in decades to centuries - is not a Krypton-like, world-ending, catastrophe. It is a more modest means of destruction, on the order of the great Cretaceous-Tertiary Collision, a worldwide rolling blackout for which California has become the unwilling model, a massive global computer crash and its effects, or any number of other disasters that would profoundly damage the planet and its inhabitants short of complete annihilation. The idea would be to use the ARC record to help rebuild and replace the many things, animate and otherwise, that are wiped out. As you well know, if the dinosaurs had had a space program, they'd still be here.

The idea for a comprehensive backup system is not new. Asimov made reference to an *Encyclopedia Galactica* in the Foundation series: a thorough record of that civilization. And in very rudimentary form, the bronze plaques carried by Pioneers 1 and 2 that describe where they come from and the race that made them, and the far more detailed collection of Earth sights and sounds carried by Voyagers 10 and 11, are repositories of information about the home planet. The difference between them and ARC and what they are carrying is that their message is for other civilizations, not ours. All four spacecraft, as you well know, are long out of this solar system.

There is also a precedent for the consequences of not spreading knowledge and that was mentioned the other morning. It is the destruction of the great library and museum at Alexandria and the disintegration of the glorious metropolis itself two millennia ago. As Sagan noted in *Cosmos*, the library was the first true research institute in the history of the world, where humanity "first collected, seriously and systematically, the knowledge of the world." It was there that Herophilus identified the brain rather than the heart as the site of intelligence; the Euclid devised geometry; Archimedes invented his mechanical wonders; Hipparchus mapped the constellations and measured the brightness of the Sun; and where Dionysius of Thrace brought logic and form to the study of language. And among the many hundreds of papyrus scrolls that were lost in the destruction was one or more written by Aristarchus of Samos, who argued that Earth is merely one of the planets, that they all orbit the Sun, and that the stars are enormously far away. Because the scrolls were destroyed, it took almost 2,000 more years before Kepler, Copernicus, and Galileo put it all together again.*

And there is another lesson in the fate of ancient Alexandria, this one having implications for globalization. Where there was diversity of information among many cultures, the loss of one

body of knowledge through a catastrophic event - the destruction of the library, where so much knowledge was concentrated, was infinitely more serious. It will become even more so if the global system that is the cumulative repository for all of our scientific, medical, and other vital information - the greatest explosion of knowledge in history - takes a major hit.

But that potential weakness is also an enormous advantage. Fortunately, we're not dealing with papyrus scrolls, but with digitized information that can be carried or transmitted to an off-Earth outpost. Since this would take decades to start, and then operate continuously, a permanent, standard computation system, or more likely, one that keeps adapting, would be necessary. As someone who owns long-playing records I can no longer play, and has home movies I can no longer watch, I understand that technological advances can quickly make data unusable. Yet the creation of a permanently adaptable storage and retrieval system is not beyond the capability of people who are conceptualizing the mating of humans and computers.

There are three possibilities for storage sites - and maybe more - again - each entailing a sizable self-sufficient colony of people: the Moon, Mars, or a large orbiting outpost no closer to the home planet than geostationary, and probably at one of the libration points. It need not be said that each would be enormously expensive, both in terms of time and resources. But as far as anybody knows, the good news is that there is time, and that means the resources can be marshaled. Earth remains an eminently seaworthy spaceship. But no captain in his right mind goes to sea without a lifeboat.

And there are other, more immediately useful, benefits to ARC and here we get down to the practical. For one thing, it would finally give the space program a clear and eminently worthwhile long-term focus instead of appearing to cobble one self-serving and seemingly irrelevant engineering project on another. There is an inherent logic and nobility to insuring the survival of humans and other species by spreading their collective seed. No reasonable person would call that frivolous. Except some people in my department. Strangelovian lunatics who believe in the cleansing effects of Armageddon and the eternal life that will follow fiery death have a right to think what they want. But that doesn't mean the rest of us have to go quietly to our destruction when there is a rational way to prevent it. The space program can be the vehicle for that survival.

In addition, this is by nature a truly cooperative international undertaking. Obviously, the resources that would be required to begin such a long-term project and keep it going would have to be multinational, since no one country could hope to do it alone. Nor would they want to. And in that regard, the core of the project's financing would necessarily have to come, in large measure, from the private sector, and in particular from philanthropic institutions that could be depended upon not only start the alliance but see it through. No political institution can be expected to maintain a commitment to a project over the course of many decades. As we have often said - most of our leaders have attentions spans that go about 2 years. A possible exception

would be if the United Nations undertook the project as a permanent institutional part of its infrastructure, like the World Health Organization.

Less obviously, ARC would by definition be a highly cooperative political and cultural undertaking that could be expected to promote international stability and the beginning of the planetary civilization that will be required to colonize other worlds. Less subtly, cooperation in an international space venture is ultimately crucial for the spacefarers. If there was one lesson that came out of *Mir's* spate of horrendous accidents, it was that its occupants had to work together or die. There are no equivalent on-going international relationships on the face of this planet.

But ultimately, it comes down to preventing the unspeakable tragedy of this civilization's disappearing without a trace, abandoning nature and ultimately counting for absolutely nothing with no witness that it ever existed.

Like all space junkies, and despite the list of horrible scenarios I have mentioned, I am fervently optimistic about this race's survival because I believe implicitly that it has the capacity to be rational enough to save itself. The glory of the Alliance to Rescue Civilization that it is intensely positive and profoundly transcendental. Its essence is hope based on reason.

Thank you.

Endnotes

- 1 Calder, Nigel, ed., *The World in 1984*, 2 vols., Harmondsworth, Middlesex, England, 1965.
- 2 von Braun, Dr. Wernher, "Exploration to the Farthest Planets," *The World in 1984*, vol. 1, pp. 39-42.
- 3 Shapiro, Robert, *Planetary Dreams*, New York: John Wiley & Sons, 1999.
- 4 O'Neill, Gerard K., *The High Frontier*, Burlington, Canada: Apogee Books, 2000 p. 15.
- 5 "Amid Apollo 11 Nostalgia, Questions on NASA's Fate," *The New York Times*, July 18, 1999.
- 6 "Eminent Thinkers Mull Import of Moon Voyage For Mankind's Future," *The Wall Street Journal*, July 18, 1969.
- 7 Yeomans, Donald K., *Comets*, New York: John Wiley & Sons, 1991 p. 326.
- 8 Sagan, Carl, *Pale Blue Dot*, New York: Random House, 1994, p. 311.
- 9 Chapman, Clark R. and David Morrison, "Impacts on the Earth by asteroids and comets: assessing the hazard," *Nature*, January 6, 1994, p. 33.
- 10 *ibid.*, p. 36
- 11 Kerr, Richard A., "Biggest Extinction Hit Land and Sea," *Science*, September 8, 2000.
- 12 "Drug-Resistant Bacteria Still on the Rise," *The New York Times*, December 28, 2000.
- 13 "Resisting Drugs, TB Spreads Fast In the West," *The New York Times*, March 24, 2000.
- 14 "Stephen Hawking fears the human race may not survive another millennium," AP, September 30, 2000.
- 15 Aldrin, Buzz and John Barnes, *Encounter with Tiber*, New York: Warner Books, 1996 p. 189.
- 16 Joy, Bill, "Why the future doesn't need us," *Wired* April 2000, p. 239.,
- 17 Kurzweil, Ray, *The Age of Spiritual Machines* New York: Viking, 1999.
- 18 Young, John W., "Why Progress in Human Space Exploration is Mandatory," Houston: Lyndon B. Johnson Space Center, October 23, 2000.
- 19 Sagan, Carl, *Cosmos*, New York: Random House, 1980, pp. 19-20.