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#### The US commercial space industry is booming – private space companies are driving innovation

**Lindzon 2/23** [(Jared Lindzon, A FREELANCE JOURNALIST AND PUBLIC SPEAKER BORN, RAISED AND BASED IN TORONTO, CANADA. LINDZON'S WRITING FOCUSES ON THE FUTURE OF WORK AND TALENT AS IT RELATES TO TECHNOLOGICAL INNOVATION) "How Jeff Bezos and Elon Musk are ushering in a new era of space startups," Fast Company, 2/23/21, https://www.fastcompany.com/90606811/jeff-bezos-blue-origin-elon-musk-spaces-space] TDI

In early February, Jeff Bezos, the founder of Amazon and one of the planet’s wealthiest entrepreneurs, dropped the bombshell announcement that he would be stepping down as CEO to free up more time for his other passions. Though Bezos listed a few targets for his creativity and energy—The Washington Post and philanthropy through the Bezos Earth Fund and Bezos Day One Fund—one of the highest-potential areas is his renewed commitment and focus on his suborbital spaceflight project, Blue Origin.

Before space became a frontier for innovation and development for privately held companies, opportunities were limited to nation states and the private defense contractors who supported them. In recent years, however, billionaires such as Bezos, Elon Musk, and Richard Branson have lowered the barrier to entry. Since the launch of its first rocket, Falcon 1, in September of 2008, Musk’s commercial space transportation company SpaceX has gradually but significantly reduced the cost and complexity of innovation beyond the Earth’s atmosphere. With Bezos’s announcement, many in the space sector are excited by the prospect of those barriers being lowered even further, creating a new wave of innovation in its wake.

“What I want to achieve with Blue Origin is to build the heavy-lifting infrastructure that allows for the kind of dynamic, entrepreneurial explosion of thousands of companies in space that I have witnessed over the last 21 years on the internet,” Bezos said during the Vanity Fair New Establishment Summit in 2016.

During the event, Bezos explained how the creation of Amazon was only possible thanks to the billions of dollars spent on critical infrastructure—such as the postal service, electronic payment systems, and the internet itself—in the decades prior.

“On the internet today, two kids in their dorm room can reinvent an industry, because the heavy-lifting infrastructure is in place for that,” he continued. “Two kids in their dorm room can’t do anything interesting in space. . . . I’m using my Amazon winnings to do a new piece of heavy-lifting infrastructure, which is low-cost access to space.”

In the less than 20 years since the launch of SpaceX’s first rocket, space has gone from a domain reserved for nation states and the world’s wealthiest individuals to everyday innovators and entrepreneurs. Today, building a space startup isn’t rocket science.

THE NEXT FRONTIER FOR ENTREPRENEURSHIP

According to the latest Space Investment Quarterly report published by Space Capital, the fourth quarter of 2020 saw a record $5.7 billion invested into 80 space-related companies, bringing the year’s total capital investments in space innovation to more than $25 billion. Overall, more than $177 billion of equity investments have been made in 1,343 individual companies in the space economy over the past 10 years.

“It’s kind of crazy how quickly things have picked up; 10 years ago when SpaceX launched their first customer they removed the barriers to entry, and we’ve seen all this innovation and capital flood in,” says Chad Anderson, the managing partner of Space Capital. “We’re on an exponential curve here. Every week that goes by we’re picking up the pace.”

#### The plan creates a restriction that encourages companies to move their operations to states with lower standards

Albert 14 [(Caley Albert, J.D. Loyola Marymount University) “Liability in International Law and the Ramifications on Commercial Space Launches and Space Tourism,” Loyola of Los Angeles International and Comparative Law Review, 11/1/14, <https://digitalcommons.lmu.edu/cgi/viewcontent.cgi?article=1708&context=ilr>] TDI

A parallel can be drawn here between the commercial space industry and the maritime law concept of the Flag of Convenience. The term has evolved over time, but in this day and age, it is commonly used to mean the owner of a vessel does not want to create an obligation with a country with stricter standards for registry; hence, the owner will register strictly for economic reasons with a country that has a more convenient registry.133 By flying a Flag of Convenience, ship owners are able to avoid taxation on earnings of ships registered under these flags, and in some cases, they can also receive relief from stricter crew standards and corresponding operating costs.134 A Flag of Convenience is flown by a vessel that is registered in one state, which the vessel has little if any connection to, when in reality the vessel is owned and operated from another state.135 This way the vessel avoids any unfavorable economic requirements from its true home state.136 In this sense, “flag shopping” is similar to “launch forum shopping,” similar in that Flags of Convenience are utilized for economic reasons, such as to avoid high taxes and compliance with certain restrictive international conventions, commercial space companies will forum shop when choosing which country to launch from. As of today, there has yet to be a catastrophic commercial launch incident, so for now commercial space companies do not have an incentive to forum shop, but if there is, the indemnification policies described above may lead companies to seek out countries that provide more coverage so they pay less in the event something goes wrong. This comparison to Flags of Convenience brings up two separate yet equally important issues. First, launch companies may try to follow the Flags of Convenience model and soon catch on to the wisdom of their maritime predecessors by “registering” in countries with more favorable conditions. Of course, in this case the concern is not with registration so much as launching. If launch companies follow the Flags of Convenience model, they will seek out the most convenient state for launch, most likely the state that provides the most liability coverage and has the least safety precautions. Launching from states with low safety standards increases the potential for catastrophic launch events. This, in turn, will place states that are potentially incapable of paying for damages from launch disasters in a position they would not normally assume if these commercial companies had not been drawn to their shores with the promise of more favorable regulations. Second, launch customers may also seek out companies located in states with lower cost liability regimes (lower insurance policy limits) since those companies will presumably charge less to launch their payloads. In this scenario, instead of the launch companies seeking out states with lower liability caps and softer regulations, the launch customers themselves will seek companies located in states with lowcost liability regimes. Here, the effect will be the same as above. Under the Liability Convention, the launching state will be liable for any damage caused by a vehicle launched from within its borders; hence, if customers start engaging in “launch forum shopping,” states will be incentivized to put in place low-cost liability regimes, which in turn will increase the states’ potential payout in the event of a catastrophic launch incident. Looking at the indemnification program the United States has in place in comparison to other countries, it is possible to see how either launch companies or launch customers could engage in “launch forum shopping” when a catastrophic launch incident ever occur. It is also important to keep in mind that various factors go into where a company or customer decides to launch from. A state’s indemnification program is just one factor in this decision. With this in mind, it is clear that if a launch incident did occur in the United States, the commercial launch company would be liable for much more than it would in another country. For instance, why would a commercial space company launch in the United States, where it would be liable up to $500 million and the additional costs that the government would not cover? The argument can be made that a catastrophic space incident has yet to occur, and even if it did, it is unlikely to cost above the $2.7 billion covered by the United States government. Other states like Russia or France, which has the two-tier liability system, would simply cover all claims above the initial insurance, which is much lower than the $500 million mark required by the United States. In that case, the commercial company would never have to pay more than the initial liability insurance. If there ever is a catastrophic commercial space incident in the future, it is easy to see why commercial companies or launch customers might be drawn to “launch forum shop” outside the United States.

#### Maintaining US space dominance requires a homegrown commercial space industry – private companies offshoring gives China the advantage they need

**Cahan and Sadat 1/6** [(Bruce Cahan, J.D) (Dr. Mir Sadat, ) "US Space Policies for the New Space Age: Competing on the Final Economic Frontier," based on Proceedings from State of the Space Industrial Base 2020 Sponsored by United States Space Force, Defense Innovation Unit, United States Air Force Research Laboratory, 1/6/21, https://www.politico.com/f/?id=00000177-9349-d713-a777-d7cfce4b0000] TDI

Today, China’s commercial space sector is in its infancy but is set to grow with continued national and provincial support, which have been rapidly increasing over the past three years.64 Since 2004, the United States and China accounted for 74% of the $135.2 billion venture capital (VC) invested in commercial space. 65 The early 2020s are pivotal, as it would be far cheaper for China and Chinese commercial space firms to acquire space technologies from the United States or allied nation companies seeking revenues or facing cashflow constraints, than to build the companies and their teams and technologies from scratch in China. The tight coupling of Chinese military goals and an economy organized to achieve those goals magnifies the economic threats and market disruptions that the United States must immediately address, in order for DoD and national security operations to rely on US commercial space capabilities.

3. ISSUES AND CHALLENGES

Peaceful Uses of Space and Space Exploration Space has been primarily a shared, not a warfighting, domain.67 With each passing second of Planck time,68 space enables a modern way of life, provides instantaneous global imagery, assures telecommunications, and captures humanity’s imagination for civil space exploration. As a result, space is a burgeoning marketplace and territory for commercial ventures and investors. Strengthening the US commercial space industrial base is vital to and beyond US national security. Civil space activities are a source of US “soft power” in global commerce, cooperation, and investment. 69 The civil space sector, led by NASA, is fundamental to America’s national security. 70 NASA is on an ambitious critical path to return to the Moon by 2024,71 along with developing the capabilities and infrastructure for a sustained lunar presence. NASA’s lunar plans provide a lunar staging area for missions to Mars and beyond. They offer a strategic and economic presence for the United States on the Moon. Congress, the White House, DoD, and NASA must recognize that economic and strategic dominance in service of national security requires catalyzing and accelerating growth of a vibrant, private US industrial and cultural expansion into the Solar System. Human visitation and eventual settlement beyond the Earth require sustaining visionary leaders, aided by, and aiding, US national security. A recurring theme in US policy is “maintaining and advancing United States dominance and strategic leadership in space” because US global competitors and adversaries are competent and capable of outpacing American space capabilities. 72 The stakes are high: At this historic moment, there is a real race for dominance over cislunar access and resources.   
Regulations Should Foster US Commercial Space as a National Asset   
Leveraging the reimagination and disruption of terrestrial industries, the US commercial space industry is pushing the frontiers of the United States and global space economics and capabilities. A pre-COVID19 assessment by the US Chamber of Commerce projected that the US space market will increase from approximately $385 billion in 2020, to at least $1.5 trillion by 2040. 73 This projection represents a seven percent (7%) annual compound average growth rate (CAGR), driven largely by expanded business opportunities in Low Earth Orbit (LEO). Total addressable market (TAM) for US commercial space companies could be far larger were they to have federal and financial support for initiating cislunar space operations and opportunities. Recent advancements in commercial space technologies and business models have driven down costs and unlocked new areas of economic growth and space capabilities that outpace and de-risk acquiring capabilities through traditional US government economic development, research and development (R&D), procurement and regulatory policies and processes. US regulations must ensure that US companies lead in commercial space. In specific, technological advances that lower access costs and expand space mission capabilities, content, continuity, and redundancies must be fully supported by or incorporated into US government programs, budgets, requirements, and acquisition processes. Until commercial space offerings are fully incorporated, and federal acquisition policies and personnel commit to innovation, US government fiscal buying power, intelligence and program support will lag and remain inadequate in comparison to US private sector companies and the nation’s global competitors and adversaries in space.

Addressing COVID-19’s Impact on US Commercial Space The COVID-19 pandemic damaged and still challenges the US space industrial base. US domestic investors’ funding of space R&D remains inconsistent across the lifecycle of New Space companies and the spectrum of technologies necessary to grow the space economy. To date, public R&D, government procurements and visionary space entrepreneurs have played a major role in establishing and funding the New Space industrial base. In the last five years, $11 billion of private capital has been invested.74 Traditional private investors may become reluctant to fund space technologies due to perceptions of higher risk over longer time horizons before receiving profitable returns on their capital. Institutional and long-horizon investors who manage patient capital have an appetite for illiquid, but higher yielding, terrestrial alternative asset investments such as commodities, private equity limited partnerships and real estate.75 The COVID-19 pandemic has created economic uncertainties making the New Space’s funding model unreliable. COVID-19 significantly impacted venture capital (VC)-backed companies: the pace of VC space investments fell 85% between April - June, as compared to January – March, in 2020. 76 Pre-COVID-19, the New Space industrial base confronted multiple challenges in raising later stages of venture capital such as (1) the lag between having an early-stage startup with an idea and commercializing a viable revenue-generating product, (2) the lack of market liquidity for founder and private equity space investments to attract and retain talented teams, and (3) the lack of a market to re-sell contracts for space goods and services when customers buy more capacity than needed. Even prior to the COVID-19 pandemic, federal financing of US R&D was at a historically minor level, as compared to businesses and universities.77 US government support for basic research has steadily declined as a percent of GDP. The federal government will experience near- to medium-term budget constraints.78 The vibrant venture community in the United States has taken up a portion of this slack by increasing R&D investment in later-stage and applied research. However, founding teams and VC financing rely on government to fund earlier R&D for basic science and engineering. Therefore, government must resume the sustainable and impactful past levels of support for basic research, an essential role in the space economy’s public-private partnership that ensures US leadership in space.

Space as Existential Terrain for National Security  
  
In this Digital Era, space integrates and drives all elements of US national security. The Cold War may be over, but since the early 2010s, a renewed era of great power competition has emerged across terrestrial land, air, sea, and cyber domains. This competition extends into space, where a great game ensues.79 Space is no longer an uncontested or sanctuary domain. Competent and capable global competitors and peer adversaries are challenging US military, commercial, and civil space interests. The United States, along with its allies and partners, has had to accept and anticipate that space may be a warfighting domain, as suggested primarily by Russian and Chinese counter-space capabilities, military operations, and declarative statements. On December 20, 2019, the bipartisan National Defense Authorization Act (NDAA) for Fiscal Year 202080 authorized the creation of the US Space Force, under the Department of the Air Force, to secure US national interests in an increasingly contested domain.81 Back in October 1775, the Continental Congress established the US Navy to ensure that commercial and government fleets could freely navigate the Atlantic coastline - today, that includes the South China Sea. Likewise, the USSF’s mission is to ensure unfettered access to and the freedom to operate in space. The 2017 National Security Strategy considers space to be a “priority domain.”82 Freedom of navigation is a sovereign right that nations have fought to achieve and defend. 83 The USSF’s main role is to organize, train and equip, as well as to protecting US space interests and supporting terrestrial and joint warfighters (e.g., US Space Command). Thus, USSF must secure US national interests in space, whether military, commercial, scientific, civil, or enhancing US competitiveness for cislunar leadership.

#### US space dominance prevents global war

**Zubrin 15** [(Robert Zubrin, president of Pioneer Energy, a senior fellow with the Center for Security Policy) “US Space Supremacy is Now Critical,” Space News, 1/22/15, <https://spacenews.com/op-ed-u-s-space-supremacy-now-critical/>] TDI

The United States needs a new national security policy. For the first time in more than 60 years, we face the real possibility of a large-scale conventional war, and we are woefully unprepared. Eastern and Central Europe is now so weakly defended as to virtually invite invasion. The United States is not about to go to nuclear war to defend any foreign country. So deterrence is dead, and, with the German army cut from 12 divisions to three, the British gone from the continent, and American forces down to a 30,000-troop tankless remnant, the only serious and committed ground force that stands between Russia and the Rhine is the Polish army. It’s not enough. Meanwhile, in Asia, the powerful growth of the Chinese economy promises that nation eventual overwhelming numerical force superiority in the region. How can we restore the balance, creating a sufficiently powerful conventional force to deter aggression? It won’t be by matching potential adversaries tank for tank, division for division, replacement for replacement. Rather, the United States must seek to totally outgun them by obtaining a radical technological advantage. This can be done by achieving space supremacy.To grasp the importance of space power, some historical perspective is required. Wars are fought for control of territory. Yet for thousands of years, victory on land has frequently been determined by dominance at sea. In the 20th century, victory on both land and sea almost invariably went to the power that controlled the air. In the 21st century, victory on land, sea or in the air will go to the power that controls space. The critical military importance of space has been obscured by the fact that in the period since the United States has had space assets, all of our wars have been fought against minor powers that we could have defeated without them. Desert Storm has been called the first space war, because the allied forces made extensive use of GPS navigation satellites. However, if they had no such technology at their disposal, the end result would have been just the same. This has given some the impression that space forces are just a frill to real military power — a useful and convenient frill perhaps, but a frill nevertheless. But consider how history might have changed had the Axis of World War II possessed reconnaissance satellites — merely one of many of today’s space-based assets — without the Allies having a matching capability. In that case, the Battle of the Atlantic would have gone to the U-boats, as they would have had infallible intelligence on the location of every convoy. Cut off from oil and other supplies, Britain would have fallen. On the Eastern front, every Soviet tank concentration would have been spotted in advance and wiped out by German air power, as would any surviving British ships or tanks in the Mediterranean and North Africa. In the Pacific, the battle of Midway would have gone very much the other way, as the Japanese would not have wasted their first deadly airstrike on the unsinkable island, but sunk the American carriers instead. With these gone, the remaining cruisers and destroyers in Adm. Frank Jack Fletcher’s fleet would have lacked air cover, and every one of them would have been hunted down and sunk by unopposed and omniscient Japanese air power. With the same certain fate awaiting any American ships that dared venture forth from the West Coast, Hawaii, Australia and New Zealand would then have fallen, and eventually China and India as well. With a monopoly of just one element of space power, the Axis would have won the war. But modern space power involves far more than just reconnaissance satellites. The use of space-based GPS can endow munitions with 100 times greater accuracy, while space-based communications provide an unmatched capability of command and control of forces. Knock out the enemy’s reconnaissance satellites and he is effectively blind. Knock out his comsats and he is deaf. Knock out his navsats and he loses his aim. In any serious future conventional conflict, even between opponents as mismatched as Japan was against the United States — or Poland (with 1,000 tanks) is currently against Russia (with 12,000) — it is space power that will prove decisive. Not only Europe, but the defense of the entire free world hangs upon this matter. For the past 70 years, U.S. Navy carrier task forces have controlled the world’s oceans, first making and then keeping the Pax Americana, which has done so much to secure and advance the human condition over the postwar period. But should there ever be another major conflict, an adversary possessing the ability to locate and target those carriers from space would be able to wipe them out with the push of a button. For this reason, it is imperative that the United States possess space capabilities that are so robust as to not only assure our own ability to operate in and through space, but also be able to comprehensively deny it to others. Space superiority means having better space assets than an opponent. Space supremacy means being able to assert a complete monopoly of such capabilities. The latter is what we must have. If the United States can gain space supremacy, then the capability of any American ally can be multiplied by orders of magnitude, and with the support of the similarly multiplied striking power of our own land- and sea-based air and missile forces be made so formidable as to render any conventional attack unthinkable. On the other hand, should we fail to do so, we will remain so vulnerable as to increasingly invite aggression by ever-more-emboldened revanchist powers. This battle for space supremacy is one we can win. Neither Russia nor China, nor any other potential adversary, can match us in this area if we put our minds to it. We can and must develop ever-more-advanced satellite systems, anti-satellite systems and truly robust space launch and logistics capabilities. Then the next time an aggressor commits an act of war against the United States or a country we are pledged to defend, instead of impotently threatening to limit his tourist visas, we can respond by taking out his satellites, effectively informing him in advance the certainty of defeat should he persist. If we desire peace on Earth, we need to prepare for war in space.

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#### CP Text: All private entities must give a substantial proportion of any assets appropriated in outer space toward redistribution efforts

**The ASTEROIDS act has put us on a timer, we need to use private entity’s unique ability to generate wealth to forward a more egalitarian distribution of wealth and power**

Nick **LEVINE** MPhil Candidate Philosophy of Science @ Cambridge **’15** https://www.jacobinmag.com/2015/03/space-industry-extraction-levine

The privatization of the Milky Way has begun.

Last summer, the bipartisan ASTEROIDS Act was introduced in Congress. The legislation’s aim is to grant US corporations property rights over any natural resources — like the platinum-group metals used in electronics — that they extract from asteroids.

The bill took advantage of an ambiguity in the United Nations’ 1967 Outer Space Treaty. That agreement forbade nations and private organizations from claiming territory on celestial bodies, but was unclear about whether the exploitation of their natural resources would be allowed, and if so, on what terms.

The legal framework governing the economic development of outer space will have enormous effects on the distribution of wealth and income in the Milky Way and beyond. We could fight for a galactic democracy, where the proceeds of the space economy are distributed widely. Or we could accept the trickle-down astronomics anticipated by the ASTEROIDS Act, which would allow for the concentration of vast amounts of economic and political power in the hands of a few corporations and the most technologically developed nations.

Given the pressing problems of inequality and climate change on Earth, the US left has been understandably uninterested in or largely dismissive of any space pursuits. For this reason, it remains unprepared to organize around extraterrestrial economic justice. The Left’s rejection of space has effectively ceded the celestial commons to the business interests who would literally universalize laissez-faire.

Organizing around extraterrestrial politics wasn’t always treated as an escapist distraction. In the 1970s, fighting for a celestial commons was a pillar of developing countries’ struggle to create a more equitable economic order.

Starting in the 1960s, a coalition of underdeveloped nations, many recently decolonized, asserted their strength in numbers in the United Nations by forming a caucus known as the Group of 77. In the early 1970s, this bloc announced its intention to establish a “new international economic order,” which found its expression in a series of UN treaties governing international regions, like sea beds and outer space, that they hoped would spread the economic benefits of the commons more equitably, with special attention to less developed nations.

For these countries — as well as for the nervous US business interests that opposed them — their plan to “socialize the moon,” as some put it at the time, was the first step toward a more egalitarian distribution of wealth and power in human society.

It will be years before the industrialization of outer space is economically viable, if it ever is. But the legal framework that would shape that transition is being worked out now. The ASTEROIDS Act was submitted on behalf of those who would benefit most from a laissez-faire extraterrestrial system. If we leave the discussion about celestial property rights to the business interests that monopolize it now, any dream of economic democracy in outer space will go the way of jetpacks, flying cars, and the fifteen-hour workweek.

#### A focus on a usage of space is gives us the opportunity to tackle things like hunger, poverty, and water contamination.

Siegel ’17 Ethan Siegel, theoretical astrophysicist and science writer, who studies Big Bang theory. In the past he has been a professor at Lewis & Clark College, “Why Exploring Space And Investing In Research Is Non-Negotiable” Starts with a Bang Blog, Forbes.com

Around the country and around the world, there is no shortage of human suffering. Poverty, disease, violence, hurricanes, wildfire and more are constantly plaguing humanity, and even our best efforts thus far can't address all of everybody's needs. Many are looking for places to cut funding, ostensibly to divert more to humanitarian needs, and one of the first places that comes up in conversation is "extraneous" spending on unnecessary scientific research. What good is it to conduct microgravity experiments when children are starving? Why smash particles together or pursue the lowest possible temperatures when Puerto Rico is still without power? And why study the esoteric mating habits of endangered species when nuclear war threatens our planet? To put it more succinctly: With all the suffering in the world — starvation, disease, persecution, and natural disasters — why should we spend public money on an enterprise like fundamental scientific research? This is a line of thinking that's come up repeatedly throughout history. Yes, it's short-sighted, in that it fails to recognize that our greatest problems require long-term investment, and that society's greatest advances come about through hard work, research, development, and often are only realized years, decades, or generations after that investment is made. Investing in science is investing in the betterment of humanity. But that's not always an easy path to see, particularly when suffering is right in front of you. Back in early 1970, shortly after the first Apollo landing, a nun working in Zambia, Africa, Sister Mary Jucunda, wrote to NASA. She asked how they could justify spending billions on the Apollo program when children were starving to death. If one pictures these two images side-by-side, it hardly seems fair. The letter somehow made it to the desk of one of the top rocket scientists at NASA: Ernst Stuhlinger. At the time, Stuhlinger, one of the scientists brought to the United States as part of Operation Paperclip at the conclusion of World War II, was serving as the Associate Director of Science at NASA. Facing an accusation of inhumanity must have been particularly painful for someone who was still often accused of being a Nazi for his role in the German rocket program, but Stuhlinger was unshaken. He responded by writing the following letter, reprinted in its entirety, below. (It’s long, and it only contained one picture, but it’s arguably even more relevant today than it was in 1970.) Your letter was one of many which are reaching me every day, but it has touched me more deeply than all the others because it came so much from the depths of a searching mind and a compassionate heart. I will try to answer your question as best as I possibly can. First, however, I would like to express my great admiration for you, and for all your many brave sisters, because you are dedicating your lives to the noblest cause of man: help for his fellowmen who are in need. You asked in your letter how I could suggest the expenditures of billions of dollars for a voyage to Mars, at a time when many children on this earth are starving to death. I know that you do not expect an answer such as “Oh, I did not know that there are children dying from hunger, but from now on I will desist from any kind of space research until mankind has solved that problem!” In fact, I have known of famined children long before I knew that a voyage to the planet Mars is technically feasible. However, I believe, like many of my friends, that travelling to the Moon and eventually to Mars and to other planets is a venture which we should undertake now, and I even believe that this project, in the long run, will contribute more to the solution of these grave problems we are facing here on earth than many other potential projects of help which are debated and discussed year after year, and which are so extremely slow in yielding tangible results. Before trying to describe in more detail how our space program is contributing to the solution of our earthly problems, I would like to relate briefly a supposedly true story, which may help support the argument. About 400 years ago, there lived a count in a small town in Germany. He was one of the benign counts, and he gave a large part of his income to the poor in his town. This was much appreciated, because poverty was abundant during medieval times, and there were epidemics of the plague which ravaged the country frequently. One day, the count met a strange man. He had a workbench and little laboratory in his house, and he labored hard during the daytime so that he could afford a few hours every evening to work in his laboratory. He ground small lenses from pieces of glass; he mounted the lenses in tubes, and he used these gadgets to look at very small objects. The count was particularly fascinated by the tiny creatures that could be observed with the strong magnification, and which he had never seen before. He invited the man to move with his laboratory to the castle, to become a member of the count’s household, and to devote henceforth all his time to the development and perfection of his optical gadgets as a special employee of the count. The townspeople, however, became angry when they realized that the count was wasting his money, as they thought, on a stunt without purpose. “We are suffering from this plague” they said, “while he is paying that man for a useless hobby!” But the count remained firm. “I give you as much as I can afford,” he said, “but I will also support this man and his work, because I know that someday something will come out of it!” Indeed, something very good came out of this work, and also out of similar work done by others at other places: the microscope. It is well known that the microscope has contributed more than any other invention to the progress of medicine, and that the elimination of the plague and many other contagious diseases from most parts of the world is largely a result of studies which the microscope made possible. The count, by retaining some of his spending money for research and discovery, contributed far more to the relief of human suffering than he could have contributed by giving all he could possibly spare to his plague-ridden community. The situation which we are facing today is similar in many respects. The President of the United States is spending about 200 billion dollars in his yearly budget. This money goes to health, education, welfare, urban renewal, highways, transportation, foreign aid, defense, conservation, science, agriculture and many installations inside and outside the country. About 1.6 percent of this national budget was allocated to space exploration this year. The space program includes Project Apollo, and many other smaller projects in space physics, space astronomy, space biology, planetary projects, earth resources projects, and space engineering. To make this expenditure for the space program possible, the average American taxpayer with 10,000 dollars income per year is paying about 30 tax dollars for space. The rest of his income, 9,970 dollars, remains for his subsistence, his recreation, his savings, his other taxes, and all his other expenditures. You will probably ask now: “Why don’t you take 5 or 3 or 1 dollar out of the 30 space dollars which the average American taxpayer is paying, and send these dollars to the hungry children?” To answer this question, I have to explain briefly how the economy of this country works. The situation is very similar in other countries. The government consists of a number of departments (Interior, Justice, Health, Education and Welfare, Transportation, Defense, and others) and the bureaus (National Science Foundation, National Aeronautics and Space Administration, and others). All of them prepare their yearly budgets according to their assigned missions, and each of them must defend its budget against extremely severe screening by congressional committees, and against heavy pressure for economy from the Bureau of the Budget and the President. When the funds are finally appropriated by Congress, they can be spent only for the line items specified and approved in the budget. The budget of the National Aeronautics and Space Administration, naturally, can contain only items directly related to aeronautics and space. If this budget were not approved by Congress, the funds proposed for it would not be available for something else; they would simply not be levied from the taxpayer, unless one of the other budgets had obtained approval for a specific increase which would then absorb the funds not spent for space. You realize from this brief discourse that support for hungry children, or rather a support in addition to what the United States is already contributing to this very worthy cause in the form of foreign aid, can be obtained only if the appropriate department submits a budget line item for this purpose, and if this line item is then approved by Congress. You may ask now whether I personally would be in favor of such a move by our government. My answer is an emphatic yes. Indeed, I would not mind at all if my annual taxes were increased by a number of dollars for the purpose of feeding hungry children, wherever they may live. I know that all of my friends feel the same way. However, we could not bring such a program to life merely by desisting from making plans for voyages to Mars. On the contrary, I even believe that by working for the space program I can make some contribution to the relief and eventual solution of such grave problems as poverty and hunger on earth. Basic to the hunger problem are two functions: the production of food and the distribution of food. Food production by agriculture, cattle ranching, ocean fishing and other large-scale operations is efficient in some parts of the world, but drastically deficient in many others. For example, large areas of land could be utilized far better if efficient methods of watershed control, fertilizer use, weather forecasting, fertility assessment, plantation programming, field selection, planting habits, timing of cultivation, crop survey and harvest planning were applied. The best tool for the improvement of all these functions, undoubtedly, is the artificial earth satellite. Circling the globe at a high altitude, it can screen wide areas of land within a short time; it can observe and measure a large variety of factors indicating the status and condition of crops, soil, droughts, rainfall, snow cover, etc., and it can radio this information to ground stations for appropriate use. It has been estimated that even a modest system of earth satellites equipped with earth resources, sensors, working within a program for worldwide agricultural improvements, will increase the yearly crops by an equivalent of many billions of dollars. The distribution of the food to the needy is a completely different problem. The question is not so much one of shipping volume, it is one of international cooperation. The ruler of a small nation may feel very uneasy about the prospect of having large quantities of food shipped into his country by a large nation, simply because he fears that along with the food there may also be an import of influence and foreign power. Efficient relief from hunger, I am afraid, will not come before the boundaries between nations have become less divisive than they are today. I do not believe that space flight will accomplish this miracle over night. However, the space program is certainly among the most promising and powerful agents working in this direction. Let me only remind you of the recent near-tragedy of Apollo 13. When the time of the crucial reentry of the astronauts approached, the Soviet Union discontinued all Russian radio transmissions in the frequency bands used by the Apollo Project in order to avoid any possible interference, and Russian ships stationed themselves in the Pacific and the Atlantic Oceans in case an emergency rescue would become necessary. Had the astronaut capsule touched down near a Russian ship, the Russians would undoubtedly have expended as much care and effort in their rescue as if Russian cosmonauts had returned from a space trip. If Russian space travelers should ever be in a similar emergency situation, Americans would do the same without any doubt. Higher food production through survey and assessment from orbit, and better food distribution through improved international relations, are only two examples of how profoundly the space program will impact life on earth. I would like to quote two other examples: stimulation of technological development, and generation of scientific knowledge. The requirements for high precision and for extreme reliability which must be imposed upon the components of a moon-travelling spacecraft are entirely unprecedented in the history of engineering. The development of systems which meet these severe requirements has provided us a unique opportunity to find new material and methods, to invent better technical systems, to improve manufacturing procedures, to lengthen the lifetimes of instruments, and even to discover new laws of nature. All this newly acquired technical knowledge is also available for application to earth-bound technologies. Every year, about a thousand technical innovations generated in the space program find their ways into our earthly technology where they lead to better kitchen appliances and farm equipment, better sewing machines and radios, better ships and airplanes, better weather forecasting and storm warning, better communications, better medical instruments, better utensils and tools for everyday life. Presumably, you will ask now why we must develop first a life support system for our moon-travelling astronauts, before we can build a remote-reading sensor system for heart patients. The answer is simple: significant progress in the solutions of technical problems is frequently made not by a direct approach, but by first setting a goal of high challenge which offers a strong motivation for innovative work, which fires the imagination and spurs men to expend their best efforts, and which acts as a catalyst by including chains of other reactions. Spaceflight without any doubt is playing exactly this role. The voyage to Mars will certainly not be a direct source of food for the hungry. However, it will lead to so many new technologies and capabilities that the spin-offs from this project alone will be worth many times the cost of its implementation. Besides the need for new technologies, there is a continuing great need for new basic knowledge in the sciences if we wish to improve the conditions of human life on earth. We need more knowledge in physics and chemistry, in biology and physiology, and very particularly in medicine to cope with all these problems which threaten man’s life: hunger, disease, contamination of food and water, pollution of the environment. We need more young men and women who choose science as a career and we need better support for those scientists who have the talent and the determination to engage in fruitful research work. Challenging research objectives must be available, and sufficient support for research projects must be provided. Again, the space program with its wonderful opportunities to engage in truly magnificent research studies of moons and planets, of physics and astronomy, of biology and medicine is an almost ideal catalyst which induces the reaction between the motivation for scientific work, opportunities to observe exciting phenomena of nature, and material support needed to carry out the research effort. Among all the activities which are directed, controlled, and funded by the American government, the space program is certainly the most visible and probably the most debated activity, although it consumes only 1.6 percent of the total national budget, and 3 per mille [less than one-third of 1 percent] of the gross national product. As a stimulant and catalyst for the development of new technologies, and for research in the basic sciences, it is unparalleled by any other activity. In this respect, we may even say that the space program is taking over a function which for three or four thousand years has been the sad prerogative of wars. How much human suffering can be avoided if nations, instead of competing with their bomb-dropping fleets of airplanes and rockets, compete with their moon-travelling space ships! This competition is full of promise for brilliant victories, but it leaves no room for the bitter fate of the vanquished, which breeds nothing but revenge and new wars. Although our space program seems to lead us away from our earth and out toward the moon, the sun, the planets, and the stars, I believe that none of these celestial objects will find as much attention and study by space scientists as our earth. It will become a better earth, not only because of all the new technological and scientific knowledge which we will apply to the betterment of life, but also because we are developing a far deeper appreciation of our earth, of life, and of man. The photograph which I enclose with this letter shows a view of our earth as seen from Apollo 8 when it orbited the moon at Christmas, 1968. Of all the many wonderful results of the space program so far, this picture may be the most important one. It opened our eyes to the fact that our earth is a beautiful and most precious island in an unlimited void, and that there is no other place for us to live but the thin surface layer of our planet, bordered by the bleak nothingness of space. Never before did so many people recognize how limited our earth really is, and how perilous it would be to tamper with its ecological balance. Ever since this picture was first published, voices have become louder and louder warning of the grave problems that confront man in our times: pollution, hunger, poverty, urban living, food production, water control, overpopulation. It is certainly not by accident that we begin to see the tremendous tasks waiting for us at a time when the young space age has provided us the first good look at our own planet. Very fortunately though, the space age not only holds out a mirror in which we can see ourselves, it also provides us with the technologies, the challenge, the motivation, and even with the optimism to attack these tasks with confidence. What we learn in our space program, I believe, is fully supporting what Albert Schweitzer had in mind when he said: “I am looking at the future with concern, but with good hope.” My very best wishes will always be with you, and with your children. It's a very different story than the kind we normally tell one another. In our modern world, we're often looking for instant gratification, for a near-term reward or return, and for immediate improvement. But science isn't always like that. Nuclear power wasn't harnessed for decades after the idea was first proposed; the Higgs boson was only found after over 40 years had passed and billions of dollars were invested in its search; gravitational waves weren't found until a full century had passed from Einstein's theory to LIGO's discovery. Yet each of these achievements, along with countless others, have helped bring about the modern world, with billions of people enjoying a higher quality of life than ever before.

#### Private corporations are uniquely key to efficiently get us in space.

**Futurism 17,** Private Companies, Not Governments, Are Shaping the Future of Space Exploration, https://futurism.com/private-companies-not-governments-are-shaping-the-future-of-space-exploration, June 12, 2017//ccavl

Sixty years ago, the Soviet Union launched the first artificial satellite into orbit. The event served as the starting pistol in what would come to be known as [the Space Race](http://www.history.com/topics/space-race), a competition between the U.S.S.R. and the United States for spaceflight supremacy.

In the decades that followed, the first human reached space, a man walked on the Moon, and the first space stations were built. The U.S.S.R. and the U.S. were soon joined by other world powers in exploring the final frontier, and by the time the Soviet Union was dissolved in 1991, the contentious Space Race was something of a distant memory.

In recent years, however, a new Space Race has taken shape—[Space Race 2.0](https://futurism.com/spacex-blue-origin-whos-winning-space-race-2-0/). Rather than powerful nations guided by presidents and premiers, however, the competitors in this race are [tech startups](https://www.cbinsights.com/blog/space-tech-startups-market-map/) and private businesses spearheaded by billionaire entrepreneurs. And while the current atmosphere is far less contentious than that of the first Space Race (save the [odd tweet or two](http://money.cnn.com/2015/12/22/news/companies/jeff-bezos-elon-musk-twitter-feud/)), the competition is just as fierce.

SpaceX, Blue Origin, Bigelow Airspace, Virgin Galactic, Boeing, Lockheed Martin… Not only has the number of private companies engaged in space exploration grown remarkably in recent years, these companies are quickly besting their government-sponsored competitors.

“We’re starting to see advances made by private entities that are more significant than any advances in the last three years that were made by the government,” Chris Lewicki, CEO and President of [Planetary Resources](http://www.planetaryresources.com/), tells Futurism.

Amazon CEO Jeff Bezos’s Blue Origin and Tesla CEO Elon Musk’s SpaceX are arguably the two companies that are setting the pace. In November 2015, the former completed the first successful vertical rocket landing after sending their New Shepard 100 kilometers (62 miles) into the air. SpaceX landed its own rocket a month later, only they did so with a craft twice as heavy as Blue Origin’s and traveled all the way into space first.

A month after that, in January 2016, Bezos’s company became the first entity to [re-launch and re-land a previously used rocket](https://futurism.com/21697/). SpaceX followed suit in 2017. “The government was never able to [build reusable rockets], but now, two private companies within the space of the same year have done that,” points out Lewicki.

Not only are private companies already surpassing their government counterparts, several are poised to widen their lead in the coming months and years.

If all goes according to plan, when SpaceX’s Falcon Heavy launches in September, it’ll take the title of the world’s most powerful rocket away from [NASA’s Saturn V](https://www.nasa.gov/centers/johnson/rocketpark/saturn_v.html). Virgin Galactic is [already selling tickets](https://futurism.com/virgin-galactic-will-soon-launching-tourists-space-new-spaceshiptwo/) for what it expects to be the first private spaceflights, which will take place aboard the sleek VSS Unity. SpaceX plans to send space tourists to the Moon in 2018, and then in 2024, the company hopes to launch a system that will [take people all the way to Mars](https://futurism.com/elon-musk-spacex-is-almost-ready-to-update-the-world-on-its-plan-to-get-humans-to-mars/)…roughly 5-15 years before NASA expects to do the same.

Private companies may be in the lead, but the finish line for this Space Race isn’t exactly clear. The first iteration was arguably “won” when Neil Armstrong took his first steps on the Moon, so does this sequel end when we establish the first Moon base? When a human walks on Mars? When we leave the solar system?

Truthfully, the likelihood of humanity ever calling it a day on space exploration is slim to none. The universe is huge, with [galaxy estimates in the trillions](https://www.theatlantic.com/science/archive/2016/10/so-many-galaxies/504185/), so the goalpost will continue moving back (to bring another sport into the analogy). Rather than focusing on competing in what is ultimately an unwinnable race, private and government-backed space agencies can actually benefit from collaboration thanks to their inherent differences.

“The way that SpaceX, Planetary Resources, or Virgin Galactic approaches space exploration is going to be very different from NASA or the Air Force,” explains Lewicki. Private companies aren’t beholden to the same slow processes that often stall government projects, and they can secure or reallocate funding much more swiftly if need be. However, unlike agencies like NASA, they do have shareholders to keep happy and a need to constantly pursue profitability.

The two sectors, therefore, have a tremendous opportunity to help one another. Private companies can generate revenue through government contracts —for example, [NASA has contracted Boeing](https://futurism.com/a-breakthrough-for-boeings-starliner/) to transport astronauts to the International Space Station (ISS), and SpaceX just closed a deal with the U.S. Air Force to [launch its secretive space drone](https://futurism.com/spacex-secures-u-s-air-force-contract-for-the-worlds-most-mysterious-space-drone/). This leaves the government agencies free to pursue the kind of forward-thinking, longer-term research that might not immediately generate revenue, but that can be later streamlined and improved upon in the private sector.

Ultimately, Space Race 2.0 has no losers. The breakthroughs happening in space exploration benefit us all, and truly, a little friendly competition never hurt anyone (unless you count the egos bruised by those tweets).

#### Space mining is one of the biggest sources of wealth in space.

**Elvis 21**, Martin Elvis is a senior astrophysicist at the Center for Astrophysics | Harvard & Smithsonian. He is the author of [Asteroids: How Love, Fear, and Greed Will Determine Our Future in Space](https://yalebooks.yale.edu/book/9780300231922/asteroids) (July 2, 2021)//ccavl

What can we actually do with asteroids? That brings us to my favourite thing about them: their resources. Being an idealistic astrophysicist, my interest is in the money to be made from them. That really is idealistic because, if we can make a profit mining the asteroids, then doing bigger things in space will become a lot cheaper. Capitalism has its faults, but one thing it does well is to make things cheaper. I want to use it as a tool so that we can build far bigger telescopes than we could practically realise today. What do astronomers want? More light! Bigger telescopes! Asteroid mining could make that dream a reality.

The siren call of asteroids for miners is that the Main Belt asteroids contain vast amounts of resources. The iron found in asteroids adds up to some 10 million times the iron that we have in proven reserves on Earth. That’s a lot. It’s enough to build many rings of iron girders all the way around Earth’s orbit, along the lines of the science fiction novel Ringworld (1970) by Larry Niven. Not that a ringworld is a sensible thing to make, but it is a really big ring. More plausibly, with that much iron we could build cities in space, as envisaged by the physicist Gerard K O’Neill in the 1970s. Each of these cities would be big enough for a million people to live in. They would be rotating cylinders, and as a citizen of one you would be walking around inside the cylinder’s surface, feeling a fake gravity from the centrifugal force. That’s the scale of resources we’re talking about.

These vast material supplies could make for an era that people call ‘post-scarcity’, where there’s plenty for everyone, just as there is in the 23rd century of the Star Trek science fiction franchise. The starship crew on Star Trek don’t work to keep themselves fed and housed, that’s taken for granted. They work for adventure and exploration. Asteroid wealth could help all of us take a step towards that happy state.

The problem is how to get started. Iron in space is not going to make for giant profits in the short run. On the ground, it sells for less than $200 a ton. It would be worth more in space, but unfortunately there’s no one to buy huge tonnages of iron in space. To adapt the tagline from the Alien movies – ‘In space, no one can hear you sell.’ It certainly isn’t worth bringing space iron back to Earth since the cost of doing so would far exceed the price it could command. Starting to mine space for resources will have to begin with something so valuable that the cost of obtaining it in space is small by comparison. For now, the best bets are precious metals and – surprise – water.

Precious metals are obvious. Platinum sells for about $33.5 million a ton, and we know from meteorites that some asteroids are richer in platinum than any mine on Earth. That sounds promising. Platinum sales run at about 200 tons, or billions of dollars, per year. The bad news is that ‘richer than any mine on Earth’ is still concentrations of just tens of grams per ton, and extracting those precious grams isn’t easy. We can’t just bring an asteroid near to Earth to start extracting the platinum where we can have heavy machinery to work on it. That would take way too much fuel because, to carry more mass, rockets have to carry exponentially more fuel; unlike airplanes, they don’t get the oxygen for free from their surroundings, they have to pull it along with them. Any refining of platinum will have to be done robotically out in the native orbit of the asteroid. That’s quite a challenge.

Water is a less obvious money-maker. The surprise is that water is also worth millions per ton – if it’s sold in space. Water in space is really useful. It’s good for drinking, and the oxygen in it is good for breathing. You can split the hydrogen from the oxygen in H2O and you’ve got rocket fuel, and water is good at absorbing radiation

to protect people from cancer-causing cosmic rays. So, in principle, water in orbit is pretty valuable. The good news is that up to 10 per cent of a water-rich asteroid can be water. It won’t be simple ice, most likely, but will be bound into clays and other rocks. Even better, water is much easier to extract than precious metals. Simply heating up the rock will release water that can then be captured.

How much is space water worth? Until recently, it cost $20 million to get a ton of water into even a low orbit – say, to the International Space Station (ISS). To get a ton of water to a high orbit, like the 24-hour orbit of TV transmitting satellites, would cost about three times as much. SpaceX has started to cut that cost; for now, it’s charging about $3 million a ton to a low orbit on a Falcon 9 rocket. Water from asteroids might be able to compete with those prices and still return a nice profit. But the bad news is that, right now, there’s no one in space who wants to buy water. At least not yet. That might be about to change.

### Asteroid Strike

#### Asteroid hits are aperiodic, but certain – traditional probability scales drastically under-state risk. Treat our impact as if it could happen tomorrow

**Brownfield 4** (Roger, Gaishiled Project, “A Million Miles a Day”, Presentation at the Planetary Defense Conference: Protecting Earth From Asteroids, February 26th, [http://www.aiaa.org/content.cfm?pageid=406&gTable= Paper&g](http://www.airpower.maxwell.af.mil/airchronicles/cc/france2.html?pageid=406&gTable=%20Paper&g) ID=17092)

Once upon a time there was a Big Bang... Cause/Effect - Cause/Effect -Cause/Effect and fifteen billion years later we have this chunk of cosmos weighing in at a couple trillion tons, screaming around our solar system, somewhere, hair on fire at a million miles a day, on course to the subjective center of the universe. Left to its own fate -- on impact -- this Rock would release the kinetic energy equivalent of one Hiroshima bomb for every man, woman and child on the planet. Game Over... No Joy... Restart Darwin's clock… again. No happy ever after. There is simply no empirical logic or rational argument that this could not be the next asteroid to strike Earth or that the next impact event could not happen *tomorrow*. And as things stand we can only imagine a handful of dubious undeveloped and untested possibilities to defend ourselves with. There is nothing we have actually prepared to do in response to this event. From an empirical analysis of the dynamics and geometry of our solar system we have come to understand that the prospect of an Earth/asteroid collision is a primal and ongoing process: a solar systemic status quo that is unlikely to change in the lifetime of our species. And that the distribution of these impact events is completely aperiodic and random both their occasion and magnitude. From abstracted averaged relative frequency estimates we can project that over the course of the next 500 million years in the life of Earth we will be struck by approximately 100,000 asteroids that will warrant our consideration. Most will be relatively small, 100 to 1,000 meters in diameter, millions of tons: only major city to nation killers. 1,000 or so will be over 1,000 meters, billions of tons and large enough to do catastrophic and potentially irrecoverable damage to the entire planet: call them global civilization killers. Of those, 10 will be over 10,000 meters, trillions of tons and on impact massive enough to bring our species to extinction. All these asteroids are out there, orbiting the sun... now. Nothing more needs to happen for them to go on to eventually strike Earth. As individual and discrete impact events they are all, already, events in progress. By any definition this is an existential threat. Fortunately, our current technological potential has evolved to a point that if we choose to do so we can deflect all these impact events. Given a correspondingly evolved political will, we can effectively manage this threat to the survival of our species. But since these events are aperiodic and random we can not simply trust that any enlightened political consensus will someday develop spontaneously before we are faced with responding to this reality. If we would expect to deflect the next impact event a deliberate, rational punctuated equilibrium of our sociopolitical will is required now. The averaged relative frequency analysis described above or any derived random-chance statistical probabilistic assessment, in itself, would be strategically meaningless and irrelevant (just how many extinction level events can we afford?). However, they can be indirectly constructive in illuminating the existential and perpetual nature of the threat. Given that the most critically relevant strategic increment can be narrowly defined as the next “evergreen” 100 years, it would follow that the strategic expression of the existent risk of asteroid impact in its most likely rational postulate would be for one and only one large asteroid to be on course to strike Earth in the next 100 years... If we do eventually choose to respond to this threat, clearly there is no way we can address the dynamics or geometry of the Solar System so there is no systemic objective we can respond to here. We can not address 'The Threat of Asteroid Impact' as such. We can only respond to this threat as these objects present themselves as discrete impending impactors: one Rock at a time. This leaves us the only aspect of this threat we *can* respond to - a rationally manifest first-order and evergreen tactical definition of this threat Which unfortunately, as a product of random-chance, includes the prospect for our extinction. Asteroid impact is a randomly occurring existential condition. Therefore the next large asteroid impact event is inevitable and expectable, and that inevitable expectability begins... now. The Probability is Low: As a risk assessment: “The probability for large asteroid impact in the next century is low”... is irrelevant. Say the daily random-chance probability for large asteroid impact is one in a billion. And because in any given increment of time the chance that an impact will not happen is far greater than it will, the chance that it will happen can be characterized as low. However, if we look out the window and see a large asteroid 10 seconds away from impact the daily random-chance probability for large asteroid impact will still be one in a billion... and we must therefore still characterize the chance of impact as low... When the characterization of the probability can be seen to be tested to be in contradiction with the manifest empirical fact of the assessed event it then must also then be seen to be empirically false. Worse: true only in the abstract and as such, misleading. If we are going to *respond* to these events, when it counts the most, this method of assessment will not be relevant. If information can be seen to be irrelevant ex post it must also be seen to be irrelevant ex ante. This assessment is meaningless. Consider the current threat of the asteroid Apophis. With its discovery we abandon the average relative frequency derived annual random-chance probability for a rational conditional-empiric probabilistic threat assessment derived from observing its speed, vector and position relative to Earth. The collective result is expressed in probabilistic terms due only to our inability to meter these characteristics accurately enough to be precise to the point of potential impact. As Apophis approaches this point the observations and resulting metrics become increasingly accurate and the conditional-empiric probability will process to resolve into a certainty of either zero or one. Whereas the random-chance probability is unaffected by whether Apophis strikes Earth or not. These two probabilistic perceptions are inherently incompatible and unique, discrete and nonconstructive to each other. The only thing these two methodologies have in common is a nomenclature: probability/likelihood/chance, which has unfortunately served only to obfuscate their semantic value making one seem rational and relevant when it can never be so. However, merely because they are non rational does not make averaged relative frequency derived random-chance probabilities worthless. They do have some psychological merit and enable some intuitive 'old lady' wisdom. When we consider the occasion of some unpredictable event that may cause us harm and there is nothing tangible we can do to deflect or forestall or stop it from happening, we still want to know just how much we should worry about it. We need to quantify chance not only in in case we can prepare or safeguard or insure against potentially recoverable consequences after the fact, but to also meter how much hope we should invest against the occasion of such events. Hope mitigates fear. And when there is nothing else we can do about it only then is it wise to mitigate fear... “The probability for large asteroid impact in the next century is low” does serve that purpose. It is a metric for hope. Fifty years ago, before we began to master space and tangibly responding this threat of asteroid impact became a real course of action, hope was all we could do. Today we can do much more. Today we can hold our hope for when the time comes to successfully deflect. And then, after we have done everything we can possibly do to deflect it, there will still be of room for hope... and good luck. Until then, when anyone says that the probability for large asteroid impact or Extinction by NEO is low they are offering nothing more than a metric for hope -- not rational information constructive to metering a response or making a decision to do so or not. Here, the probability is in service to illusion... slight-of-mind... and is nothing more than comfort-food-for-thought. We still need such probabilistic comfort-food-for-thought for things like Rogue Black Holes and Gamma Bursts where we are still imaginably defenseless. But if we expect to punctuate the political equilibrium and develop the capability to effectively respond to the existential threat of asteroid impact, we must allow a rational and warranted fear of extinction by asteroid impact to drive a rational and warranted response to this threat forward. Forward into the hands and minds of those who have the aptitude and training and experience in *using* fear to handle fearful things. Fear focuses the mind... Fear reminds us that there are dire negative consequences if we fail. If we are going to concern ourselves with mounting a response and deflecting these objects and no longer tolerate and suffer this threat, would it not be far more relevant to know in which century the probability for large asteroid impact was *high* and far more effective to orient our thinking from when it *will not* to when it *will* occur? But this probabilistic perspective can not even pretend to approach providing us with that kind of information. As such, it can never be strategically relevant: contribute to the conduct of implementing a response. The same can be said when such abstract reasoning is used to forward the notion that the next asteroid to strike Earth will likely be small... This leads us to little more than a hope based Planetary Defense. If we are ever to respond to this threat well then we must begin thinking about this threat better. Large Asteroid Impacts Are Random Events. Expect the next one to occur at any time. Strategically speaking, this means being at DefCon 3: lock-cocked and ready to rock, prepared to defend the planet and mankind from the worst case scenario, 24/7/52... forever. Doing anything less by design, would be like planning to bring a knife to a gunfight. If we expect our technological abilities to develop and continue to shape our nascent and still politically tacit will to respond to this threat: if we are to build an effective Planetary Defense, we must abandon the debilitating sophistry of “The probability for large asteroid impact in the next century is low” in favor of rational random inevitable expectation... and its attendant fear.

#### Only asteroids cause extinction. Both small hits and *near misses* cause war

Gold, Chapman, and Durda 1, [Robert E. Gold Space Engineering and Technology Branch Johns Hopkins University Applied Physics Laboratory, Clark R. Chapman and Daniel D. Durda Office of Space Studies Southwest Research Institute, THE COMET/ASTEROID IMPACT HAZARD: A SYSTEMS APPROACH, www.boundarycondition.com/NEOwp\_Chapman-Durda-Gold.pdf]

Impacts that are even smaller and more frequent impacts than those shown in Table 1 – like the 15 Megaton impact in Tunguska, Siberia, in 1908 – may have major consequences near ground zero. But other natural disasters, like earthquakes and floods, having the same damage potential (e.g. human fatalities), happen at least a hundred times more frequently than small impacts. Perhaps the most serious consequences of impacts similar to and smaller than Tunguska, which happen on timescales comparable to or shorter than a human lifetime, are unpredictable reactions by observers. A bolide ten times brighter than the Sun occurred in the Yukon in January 2000, yielding some meteorites. Such an event in an unstable location in the world could be misinterpreted as an enemy attack and precipitate war. Another possibility is that a small impact could generate political ramifications and fallout from the public, knowledgeable to some extent that NEA searches and mitigation efforts are underway, and angered at those who were ‘supposed’ to be on guard for such events (W. J. Cooke 2000, personal communication).

There has been essentially no modelling at all of the possible economic and social consequences of the kinds of environmental damage listed in Table 1. Clearly, in cases of impactors >1 km in diameter, we enter a realm never previously encountered by modern civilization. Even the great World Wars of the twentieth century left many nations relatively undamaged, and they were thus able to serve as nuclei for recovery. An unexpected impact by a 2 km asteroid might well destroy agriculture in both hemispheres and around the world, leading to mass starvation from which no nation would be immune. Impacts may also precipitate catastrophic failures of modern communications and power infrastructures. Possible mass psychological reactions to such a devastating catastrophe, while portrayed in science fiction novels and movies, have also not been researched in an impact hazard context. Even a near-miss by a dusty comet could have serious ramifications, without even impacting: loss of many satellites in the geosynchronous constellation due to dust impacts and associated plasma arcing could severely disrupt global communications and associated economic and security infrastructures (P. Brown 2000, private communication)

#### Small hits go nuclear

Baum 10, [Seth Baum is Executive Director of the Global Catastrophic Risk Institute, Is Humanity Doomed? Insights from Astrobiology]

The earliest scenario is the impact event: collision between an asteroid or comet and Earth. Such collisions are relatively commonplace, but with impactors too small to prevent human civilization from being sustained. It is possible for small impactors to cause outsized damage if they land in the wrong place. For example, a 2002 asteroid exploded over the Mediterranean; had it landed a few hours earlier, it would have exploded over Kashmir. A Kashmir impact plausibly could have initiated a nuclear exchange between India, Pakistan, and possibly others [18]. Larger, less-common asteroids could land anywhere on the planet and still cause major damage. Such asteroids are a major threat to human sustainability [19]. Indeed, a large asteroid is believed to have caused at least one major extinction event, the Cretaceous-Tertiary. Several major space agencies, including those of Russia and the United States, have active programs to monitor the skies for threatening asteroids. Recently the Russian agency has proposed—to some controversy—deflecting an asteroid that has a small but non-zero chance of hitting Earth in 2029 [20]. Regardless of what the merits of this proposal might be, it is clear that an active asteroid deflection program could play an important role in sustaining life and civilization on Earth.

#### Comet diseases cause extinction

**Joseph** and Wickramasinghe **10** (Rhawn Joseph is an American neuropsychologist and writer, Chandra Wickramasinghe, Director of the Buckingham Centre for Astrobiology, University of Buckingham “Comets and Contagion: Evolution, Plague, and Diseases From Space”, Journal of Cosmology 2010, Vol 7, 1750-1770, January, https://www.researchgate.net/publication/326160954\_Comets\_and\_Contagion\_Evolution\_Plague\_and\_Diseases\_From\_Space)

For much of history comets have been associated with death and disease. There is increasing evidence that life on Earth originated in comets and other stellar debris. If passing comets have continued to deposit viruses and microorganisms on this planet, this may explain why ancient astronomers and civilizations attributed the periodic outbreak of plague to these stellar objects. Moreover, the subsequent evolution and extinction of life may have been directly impacted by the continued arrival of bacteria, archae, viruses, and their genes from space. On this picture the evolution of higher plants and animals, including humans, would be impacted by the insertion of genes from space, as well as recurrent episodes of pandemic disease. Near-culling pandemics and extinction episodes have in fact been preceded by or followed by inserts of viral genes into survivors who have transmitted these viral elements to their progeny, thereby impacting future evolution. Although ancient fears and reverence of comets may be coincidental with the outbreaks of pandemics, they may also have a factual basis.

#### Private entities like the B612 Foundation are key to stop asteroids with telescopes such as Sentinel.

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With the dangers of rogue asteroids made clear by the surprise explosion of a meteor over Russia in February, a non-profit organization is ramping up its effort to search for potentially hazardous space rocks near Earth.

The B612 Foundation was started in 2002 by former NASA astronauts Ed Lu and Rusty Schweickart with colleagues. The organization aims to launch a space telescope called Sentinel in 2017 to catalog near-Earth asteroids, including those that may pose a danger to Earth.

To date, about 90 percent of near-Earth asteroids large enough to destroy the entire planet (about 1 kilometer, or 0.6 miles wide) have been discovered, but far fewer of the smaller, city-killing size (roughly 140 meters, or 460 feet, in diameter) have been found. [[Photos: The Sentinel Space Telescope](https://www.space.com/16341-sentinel-space-telescope-asteroid-mission-pictures.html)]

"We are essentially flying blind in a cosmic shooting gallery," Scott Hubbard, B612 program architect, told reporters on Tuesday (April 9) at the 29th annual [National Space Symposium](https://www.space.com/20590-national-space-symposium-2013-photos.html) in Colorado Springs, Colo.

This reality was starkly illustrated on Feb. 15, when a 55-foot-wide (17 meters) meteor exploded over Chelyabinsk, Russia, just hours before an asteroid almost three times its size called 2012 DA14 flew uncomfortably close to Earth.

Sentinel's goal is to detect about 90 percent of this city-killing class of asteroids over a period of 6.5 years.

The $450 million mission is to be privately funded, though the foundation has partnered with NASA to share its data and use the agency's Deep Space Network of satellites to facilitate communications between Sentinel and the ground. NASA and lawmakers have said they enthusiastically support the mission and the B612 Foundation's efforts.

"We must better recognize what the private sector can do to aid our efforts to protect the world," Rep. Lamar Smith, R-Texas, chairman of the House Committee on Science, Space and Technology, said during a Congressional hearing on the asteroid issue Wednesday (April 10).

Illustration of relative size for DA14 and Chelyabinsk Meteor compared to a footbal field. (Image credit: Michael Carroll)

B612 is also looking to partner with other private organizations, such as the solar system exploration non-profit organization The Planetary Society.

"We are hoping in the future to partner with B612, and we will find the asteroid that could have our name on it," said Bill Nye, the CEO of The Planetary Society. "We will — this sounds extraordinary — we will save humankind. It sounds like science fiction, but it's real."

B612's presentation at the National Space Symposium came one day before the group's CEO, former astronaut Ed Lu, spoke before the House Science, Space, and Technology Committee Wednesday (April 10) on the importance of [searching for potentially dangerous asteroids](https://www.space.com/20619-asteroid-threat-earth-congress.html) before they hit Earth.

Sentinel will fly in a Venus-like orbit around the sun, closer in than Earth. The observatory use an infrared telescope to search for space rocks as they near the sun, absorbing some of its light and re-radiating it as heat.

"If we build sophisticated night-vision goggles, we can see it," said John Troeltzsch, program manager for the Sentinel mission at Ball Aerospace, which has been contracted to build the spacecraft.

Ball was the primary contractor for NASA's infrared Spitzer Space Telescope, as well as the agency's planet-hunting Kepler spacecraft, which, like Sentinel, required a large camera and the ability to point precisely at a given spot in the sky.

"We have a lot of experience with very cold things observing very faint signals," Troeltzsch said. "If you take what we learned on Spitzer and what we learned on Kepler, you can derive Sentinel."

So far, B612 has raised about $2 million for the mission over the past eight months. It hopes to continue to raise $30 million to 40 million per year to keep the project on track.

#### Part of B612’s goal is asteroid mining, losing the ability to do that hurts Sentinel’s ability to help humanity.

#### Wall 12, Mike Wall, nbc news, https://www.nbcnews.com/id/wbna48137791//ccavl

The main goal of a newly announced private space telescope may be protecting Earth, but the instrument could also help out prospective asteroid miners, its builders say.

The nonprofit B612 Foundation's Sentinel space telescope should discover 500,000 near-Earth asteroids within 5 1/2 years of its planned 2017 or 2018 launch, B612 officials say. Some of those space rocks may pose a threat to our planet down the road, while others might be good targets for resource extraction.

Sentinel's mapping campaign could make things easier for asteroid-mining firms like the billionaire-backed [Planetary Resources](https://www.space.com/15391-asteroid-mining-space-planetary-resources-infographic.html), allowing them to focus on characterizing — rather than discovering — promising space rocks.

"We will provide the accurate orbit determinations so that you know where to point your other telescopes," former astronaut Ed Lu, B612's chairman and CEO, told reporters at Sentinel's official unveiling on June 28. "We will get a handle on the sizes of the asteroids, which is critical."[[Photos: The Sentinel Space Telescope](https://www.space.com/16341-sentinel-space-telescope-asteroid-mission-pictures.html)]

The Sentinel space telescope, a mission organized by the nonprofit B612 Foundation, will scan for near-Earth asteroids from an orbit near that of Venus. (Image credit: B612 Foundation)

A wealth of asteroids

Scientists have discovered roughly 10,000 near-Earth [asteroids](https://www.space.com/51-asteroids-formation-discovery-and-exploration.html) to date. Sentinel, which will scan Earth's neighborhood from an orbit near that of Venus, should surpass that total in its first few weeks of operation, B612 officials said.

"When Sentinel is done, it will have catalogued roughly half a million asteroids," Lu said. "It will be the definitive map of the inner solar system."

The 3,300-pound (1,500-kilogram) telescope will look in infrared light, in which asteroids show up as warm, moving blobs against the cold backdrop of space.

The B612 Foundation hopes Sentinel flags any potentially dangerous asteroids several decades before they may strike Earth, giving humanity plenty of time to mount a [deflection mission](https://www.space.com/13524-deflecting-killer-asteroids-earth-impact-methods.html) if need be. Such a mission could nudge the asteroid into a benign orbit using a fly-along "gravity tractor" probe, or knock it off course with a kinetic impact or nuclear blast.

Sentinel's makers also hope the instrument's mapping efforts aid scientists interested in studying and exploring near-Earth asteroids, and help entrepreneurs who want to mine them for such resources as platinum-group metals and water.

"You can't do any of that if you don't know where they are," Lu told SPACE.com.

The telescope should provide relatively accurate size estimates for the space rocks it discovers, Lu added. But Sentinel is not equipped to determine the makeup of asteroids that could be mining targets; such work would require follow-up observations by companies such as Planetary Resources (which is not affiliated with B612 or with Sentinel).

"We're primarily an astrometric mission. That is, we're mapping something," said B612 chairman emeritus Rusty Schweickart, who was the lunar module pilot on NASA's Apollo 9 mission. "We're not doing the kind of detailed spectrographic work that would be required for actual resource exploitation."

Asteroid mining and exploration could help humanity finally gain a firm foothold beyond its home planet, and Lu hopes Sentinel plays a part in making that happen.

"These are stepping stones," Lu said of near-Earth asteroids. "Enabling the exploration of the solar system is essentially what we're trying to do."

# Case

#### Space mining not happening rn, cx proves they can’t name any private entities that mine rocks, cause they don’t.

#### Alt cause – broad space privatization and existing debris.

Muelhapt et al 19 [(Theodore J., Center for Orbital and Reentry Debris Studies, Center for Space Policy and Strategy, The Aerospace Corporation, 30 year Space Systems Analyst and Operator, Marlon E. Sorge, Jamie Morin, Robert S. Wilson), “Space traffic management in the new space era,” Journal of Space Safety Engineering, 6/18/19, <https://doi.org/10.1016/j.jsse.2019.05.007>] TDI

The last decade has seen rapid growth and change in the space industry, and an explosion of commercial and private activity. Terms like NewSpace or democratized space are often used to describe this global trend to develop faster and cheaper access to space, distinct from more traditional government-driven activities focused on security, political, or scientific activities. The easier access to space has opened participation to many more participants than was historically possible. This new activity could profoundly worsen the space debris environment, particularly in low Earth orbit (LEO), but there are also signs of progress and the outlook is encouraging. Many NewSpace operators are actively working to mitigate their impact. Nevertheless, NewSpace represents a significant break with past experience and business as usual will not work in this changed environment. New standards, space policy, and licensing approaches are powerful levers that can shape the future of operations and the debris environment.

2. Characterizing NewSpace: a step change in the space environment

In just the last few years, commercial companies have proposed, funded, and in a few cases begun deployment of very large constellations of small to medium-sized satellites. These constellations will add much more complexity to space operations. Table 1 shows some of the constellations that have been announced for launch in the next decade. Two dozen companies, when taken together, have proposed placing well over ~~20,000~~ [twenty thousand] satellites in orbit in the next ~~10~~ [10]years. For perspective, fewer than ~~8100~~[eight thousand one hundred] payloads have been placed in Earth orbit in the entire history of the space age, only 4800 [1] remain in orbit and approximately 1950 [2] of those are still active. And it isn't simply numbers – the mass in orbit will increase substantially, and long-term debris generation is strongly correlated with mass.

[Table 1 Omitted]

This table is in constant flux. It is based largely on U.S. filings with the Federal Communications Commission (FCC) and various press releases, but many of the companies here have already altered or abandoned their original plans, and new systems are no doubt in work. Although many of these large constellations may never be launched as listed, the traffic created if just half are successful would be more than double the number of payloads launched in the last 60 years and more than 6 times the number of currently active satellites.

Current space safety, space surveillance, collision avoidance (COLA) and debris mitigation processes have been designed for and have evolved with the current population profile, launch rates and density of LEO space.

By almost any metric used to measure activity in space, whether it is payloads in orbit, the size of constellations, the rate of launches, the economic stakes, the potential for debris creation, the number of conjunctions, NewSpace represents a fundamental change.

3. Compounding effects of better SSA, more satellites, and new operational concepts

The changes in the space environment can be seen on this figurative map of low Earth orbit. Fig. 1 shows the LEO environment as a function of altitude. The number of objects found in each 10 km “bin” is plotted on the horizontal axis, while the altitude is plotted vertically. Objects in elliptical orbits are distributed between bins as partial objects proportional to the time spent in each bin. Some notable resident systems are indicated in blue text on the right to provide an altitude reference. The (dotted) red line shows the number of objects in the current catalog tracked by the U.S. Space Surveillance Network (SSN). All the COLA alerts and actions that must be taken by the residents are due to their neighbors in the nearby bins, so the currently visible risk is proportional to the red line.



The red line of the current catalog does not represent the complete risk; it indicates the risk we can track and perhaps avoid. A rule of thumb is that the current SSN LEO catalog contains objects about 10 cm or larger. It is generally accepted that an impact in LEO with an object 1 cm or larger will cause damage likely to be fatal to a satellite's mission. Therefore, there is a large latent risk from unobserved debris. While we cannot currently track and catalog much smaller than 10 cm, experiments have been performed to detect and sample much smaller objects and statistically model the population at this size [3]. The (solid) blue line represents the model of the 1 cm and larger debris that is likely mission-ending, usually called lethal but not trackable. If LEO operators avoid collisions with all the objects in the red line, they are nonetheless inherently accepting the risk from the blue line. This risk is already present.

The (dashed) orange line is an estimate of the population at 5 cm and larger and is thus an estimate of what the catalog might conservatively be a few years after the Space Fence, a new radar system being built by the Air Force, comes on line (currently planned for 2019) [4]. Commercial companies offering space surveillance services, such as LeoLabs, ExoAnalytics, Analytic Graphics Inc., Lockheed, and Boeing, might also add to the number of objects currently tracked. Space Policy Directive 3 (SPD-3) [13] specifically seeks to expand the use of commercial SSA services.

Existing operators can expect a sharp increase in the number of warnings and alerts they will receive because of the increase in the cataloged population. Almost all the increase will come from newly detected debris [5].

The pace of safety operations for each satellite on orbit will significantly change because of the increase in the catalog from the Space Fence. This effect is compounded because the NewSpace constellations described in Table 1 will drastically change the profile of satellites in LEO. The green bars in Fig. 1 represent the number of objects that will be added to the catalog (red or orange lines) from only the NewSpace large LEO constellations at their operational altitudes. This does not include the rocket stages that launch them, or satellites in the process of being phased into or removed from the operational orbits. Neighbors of one of these new constellations may face a radically different operations environment than their current practices were designed to address.

Satellites in these large LEO constellations typically have planned operational lifetimes of 5–10 years. Some companies have proposed to dispose of their satellites using low thrust electric propulsion systems, which would spiral satellites down over a period of months or years from operating altitudes as high as 1500 km through lower orbits where the Hubble Space Telescope, the International Space Station, and other critical LEO satellites operate [6]. Similar propulsive techniques would raise replacement satellites from lower launch injection orbits to higher operational orbits. These disposal and replenishment activities will add thousands of satellites each year transiting through lower altitudes and posing a risk to all resident satellites in those lower orbits. More importantly, failures will occur both among transiting satellites and operational constellations, potentially leaving hundreds more stranded along the transit path.

1. **Probability – 0.1% chance of a collision.**

**Salter 16** [(Alexander William, Economics Professor at Texas Tech) “SPACE DEBRIS: A LAW AND ECONOMICS ANALYSIS OF THE ORBITAL COMMONS” 19 STAN. TECH. L. REV. 221 \*numbers replaced with English words] TDI

The probability of a collision is currently low. Bradley and Wein estimate that the maximum probability in LEO of a collision over the lifetime of a spacecraft remains below one in one thousand, conditional on continued compliance with NASA’s deorbiting guidelines.3 However, the possibility of a future “snowballing” effect, whereby debris collides with other objects, further congesting orbit space, remains a significant concern.4 Levin and Carroll estimate the average immediate destruction of wealth created by a collision to be approximately $30 million, with an additional $200 million in damages to all currently existing space assets from the debris created by the initial collision.5 The expected value of destroyed wealth because of collisions, currently small because of the low probability of a collision, can quickly become significant if future collisions result in runaway debris growth.

#### Kessler’s Syndrome wrong and super long timeframe---he’s adjusted it recently

Kurt 15 – JD-William & Mary

Joseph Kurt, JD- William & Mary School of Law, BA-Marquette University, NOTE: TRIUMPH OF THE SPACE COMMONS: ADDRESSING THE IMPENDING SPACE DEBRIS CRISIS WITHOUT AN INTERNATIONAL TREATY, 40 Wm. & Mary Envtl. L. & Pol'y Rev. 305 (2015)

A. Practical Considerations: Feasible Solutions to the Space Debris Problem Are on Their Way

One key question in assessing whether an international treaty is a requisite for solving the space debris problem is just how difficult it will be to fashion a remedy. The more complex and costly are feasible solutions, the more likely it is that a comprehensive regime is necessary to bind the various actors together. 93Link to the text of the note

A good place to begin is to determine just how imminent is the onset of the cascade of exponentially more frequent debris-creating collisions, known as the Kessler Syndrome. 94Link to the text of the note To be certain, no one can be sure--this phenomenon being subject to highly complex probabilities. 95Link to the text of the note Indeed, experts' estimates of when such a cascade will become irreversible vary [\*316] widely. 96Link to the text of the note The National Research Council produced a report in 2011 that suggested that "space might be just 10 or 20 years away from severe problems." 97Link to the text of the note In fact, the cascading effect has already begun, albeit at a modest pace. 98Link to the text of the note However, Donald Kessler, who first described the eponymous effect in 1978, has significantly recalibrated his own outlook over the years. 99Link to the text of the note Originally, Kessler predicted that catastrophe would result by the year 2000. 100Link to the text of the note That date long passed, Kessler now speaks of a century-long process that "we have time to deal with." 101Link to the text of the note

#### No climate impact---bad studies and adaption.

Nils P. Gleditsch 21, Research Professor at the Peace Research Institute Oslo, “This time is different! Or is it? NeoMalthusians and environmental optimists in the age of climate change,” Journal of Peace Research, pg. 5-6, 2021, SAGE. clarification denoted with brackets.

The most extreme contrarian position is, of course, to deny one or both key conclusions of the IPCC: the reality of global warming or the human contribution to it. However, most environmental optimists accept these two key conclusions but raise other problems with the panel’s discussion of the social effects of climate change and even more so with popular interpretations of the panel reports. For instance, Hausfather & Peters (2020), by no means ‘climate deniers’, decry the common use of choosing the high-risk [scenario] RCP8.59 to illustrate ‘business as usual’ as misleading.

The causal chains from climate change to the proposed effects on human beings are long and complex, and the uncertainty increases every step of the way. In the literature on the social effects of climate change, including the IPCC reports, statements abound that something ‘may’ lead to something else, or that a variable ‘is sensitive to’ another, without any guidelines for how to translate this into probabilities (Gleditsch & Nordås, 2014: 87f). Uncritical use of the precautionary principle, where any remotely possible calamity unwittingly becomes a probable event, is not helpful.

Gleditsch & Nordås (2014: 85) note that while AR5 (IPCC, 2014) did not find strong evidence for a direct link between climate change and conflict, it argued that climate change is likely to impact known conflict-inducing factors like poverty and inconsistent political institutions and therefore might have an indirect effect on conflict. But this assumes that correlations are transitive, which is not generally the case. If A correlates with B and B with C, we know nothing about how A relates to C unless both correlations are extremely high. The strongest case for the climate–conflict link is the effect of interaction between climate change and factors like poverty, state failure, or ethnic polarization. It may be more cost-effective to try to deal with these other risk factors than with global warming itself if the goal is to reduce the ‘risk multiplier’ effect of climate change on armed conflict.

The articles in this special issue do not generally see scarcity by itself as necessarily resulting in strongly negative outcomes. Factors like development, state failure, and previous overload on ecosystems continue to play an important role in that they interact with climate change to produce conflict and other social outcomes. For instance, Ide, Kristensen & Bartusevicˆius (2021) conclude that the impact of floods on political conflict are contingent on other factors such as population size and regime type. Moreover, most of the articles do not assume that scarcities are likely to arise at the global level. They may be regional (mostly in Africa), national, or local. Urban and rural areas may be affected by different scarcities. Climate change may also affect particularly strongly groups that are already at an economic or political disadvantage. The effects can be alleviated and adaptations constructed at these levels.

The argument about how climate change may indirectly impact conflict leans heavily on the negative economic consequences of climate change, but with little or no reference to the research that explicitly deals with this topic. In fact, the relevant chapter in AR5 concluded that for most sectors of the economy, the impact of climate change was likely to be dwarfed by other factors. Tol (2018) finds that the long-term global economic effects are likely to be negative, but that a century of climate change will have about the same impact on the economy as the loss of one year of economic growth. Other economists are more cautious, but the dean of climate change economics, William Nordhaus (2018: 345, 359), estimates that ‘damages are 2.1 percent of global income at 3C warming and 8.5 percent of income at 6C’, while also warning that the longer the delay in taking decisive action, the harsher the necessary countermeasures. Stern (2006) is more pessimistic, based mainly on a lower discount rate (the interest rate used to calculate the present value of future cash flows) as are Wagner & Weitzman (2015). Heal (2017) argues that the Integrated Assessment Models generally used in the assessment of the economics of climate change are not accurate enough to provide quantitative insights and should not be taken as serious forecasts. Yet, all these economists take the basically optimistic view that climate change is manageable with appropriate policies for raising the price on the emission of greenhouse gases. With a chapter heading from Wagner & Weitzman (2015: 17): ‘We can do this’.

This more optimistic assessment of climate change does not assume that the challenge will go away by itself or can be left to the market. A plausible approach, favored by most economists,10 is the imposition of a robust and increasing price on carbon emissions (whether as a carbon tax or through a cap and trade scheme) high enough to reduce the use of fossil fuels and encourage the search for their replacement. More than 25 countries had such taxes by early 2018 (Metcalf, 2019), but generally not at a level seen as necessary for limiting global warming to, say, 2C. This approach relies on the use of the market mechanism, but with targets fixed by public policy. Income from a carbon tax can be channeled back to the citizens to avoid increasing overall taxation. To speed up the transition, funds can also be allocated to the research and development of cheaper and more efficient production of various forms of fossil-free energy, including nuclear power (Goldstein & Qvist, 2019).

The response of the environmental optimists continues to emphasize the role of innovations; technological innovations, such as improvements in battery technology, the key element in the 2019 Nobel Prize in chemistry,11 but also social innovations, as exemplified by the experimental approach to the alleviation of poverty, rewarded in the same year by the Nobel Prize in economics.12

While the most important countermeasures will be directed at the mitigation of climate change, there is also a strong case for adaptation. If sea-level rise cannot be totally prevented, dikes and flood barriers will be cost-effective and necessary, at least in high-value urban areas. If parts of Africa suffer from drought, there will be increased use for new crops that are more suitable for a dry climate, possibly developed in part by GMO technology. Industrialization in Africa can decrease the one-sided reliance on rain-fed agriculture, as it has in other parts of the world, which have moved human resources from the primary sector to industry (and then to services). Continuing urbanization will move millions out of the most vulnerable communities (Collier, 2010). While structural change failed to produce economic growth in Latin America and Africa after 1990, Africa has experienced a turnaround in the new millennium (McMillan & Rodrik, 2014) and there are also potentials for increasing productivity by structural change within agriculture in Africa (McCullough, 2017).