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## 1AC

### 1AC

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#### Violation:

#### Quals make cards credible, not publications, and determining credibility is easiest when quals are in citations, so in-cite inclusion increases the probability unqualified evidence is treated as such, trains debaters to internalize backgrounds and research motivations, sharpens ev comparison, and raises the bar for ev quality. All of these warrants link robustly to EDUCATION, the only portable skill and reason schools fund debate, as qualified input forms the backbone of debate, doubly true given quals are *UBIQUITOUS in LD and CX*. Also, we included quals, which makes debate easier for our opponents, linking to FAIRNESS, which is key to participation in competitive activities and objective evaluation.

#### DTD—wins and losses determine the direction of the activity, proven by paraphrasing and disclosure norms. DTA doesn’t solve norm-setting because theory is not what you do but what you justify nor in-round abuse because it has already occurred and we can’t sift through every article.

#### CI first—reasonability is arbitrary, inviting judge intervention. A race to the top for better norms improves debates. If you think this is frivolous, ask yourself the following questions: Why do we read evidence in the first place? Why do the NSDA rules say author qualifications are a requirement for written citations? And what norms would have been considered “frivolous” when you debated that are the norm now—if judges, biased towards their own disclosure and evidence practices, simply decided stuff was just frivolous or unreasonable on arbitrary grounds, debate would stagnate. Make them beat us technically to disprove our arguments, the same way you would evaluate a debate about the resolution.

#### No RVIs—you shouldn’t win for meeting expectations; the alternative chills theory and encourages baiting.

#### Spirit over text, or debate devolves into BS one-line we-meets.

### 1AC

#### Mars is in sight.

**Greenfieldboyce 25** [Nell Greenfieldboyce, NPR science correspondent & Masters of Arts degree in science writing, 2-12-2025, Is Trump the president who will truly set a course for Mars?, NPR, https://www.npr.org/2025/02/13/nx-s1-5294575/president-trump-elon-musk-mars-moon, Willie T.]

Back in 1969, Robert Zubrin remembers watching the first moon landing when he was a teenager. He says if someone back then had asked him to predict when astronauts would walk on Mars, "my guess would have been the early 1980's."

"And, in fact, NASA had plans to do that at that time, which were aborted by the Nixon administration," says Zubrin, an aerospace engineer who is president of the Mars Society and author of The Case for Mars.

Over the decades, as administrations have come and gone, presidents have repeatedly promised future missions to Mars, holding this up as a **key goal** for human space exploration.

Never before, though, has a **president** had such a **close relationship** with a would-be Mars colonizer, one who has transformed the world of rocketry.

Elon Musk, President Trump's ally who is **shaking up government agencies**, founded the company SpaceX with the goal of making humans a **multiplanetary species**. In addition to ferrying astronauts to orbit for NASA, this company is currently building and test flying a new space vehicle, **Starship**, that's designed to **transport massive amounts of cargo—including people**—and land on Mars.

"This is **quite a singular moment** for the prospects of getting to Mars," says Zubrin, who sees this as a time filled with both opportunity and peril.

"I think it actually is pretty clear right now that we're going to get a **humans-to-Mars program** started," he says.

But to succeed, any such plan would need broad political support, and he worries about Mars suddenly becoming a divisive, partisan issue.

"This is not going to work," says Zubrin, "if this is understood to be an Elon Musk hobbyhorse."

The presidents and Mars

In his inaugural address in January, President Trump got the attention of the space community when he said the United States would "pursue our **manifest destiny into the stars**, launching American astronauts to plant the Stars and Stripes on the planet Mars."

In some ways, a president inspirationally referring to Mars is nothing new.

Back in 1989, for example, President George H. W. Bush called for a return to the moon, to be followed by "a journey into tomorrow, a journey to another planet: a manned mission to Mars." He envisioned footprints in the Martian dirt by 2019, the 50th anniversary of the moon landing.

"Within a few short years after President Bush's Kennedy-esque announcement, however, the initiative had faded into history," one policy analyst wrote.

A decade and a half later, President George W. Bush refocused NASA on a return to the moon by 2020, adding that "with the experience and knowledge gained on the moon, we will then be ready to take the next steps of space exploration: human missions to Mars and to worlds beyond."

President Obama told NASA to forgo the moon, but did maintain Mars as a goal: "By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth," he said in a speech at NASA's Kennedy Space Center. "And a landing on Mars will follow."

First, the moon?

During President Trump's first administration, he issued a space policy directive that refocused NASA on a human moon landing, with missions to Mars added as a future goal.

That program, called Artemis, is what NASA has pursued ever since. It continued under President Biden, although it's been criticized as relying on a super-expensive rocket that rarely flies.

Despite delays and cost overruns, NASA says it is poised to send humans to **orbit the moon next year**. A landing is planned for the year after that.

Trump's reference to Mars, but not the moon, in his inaugural speech had some in the space community wondering if this was a result of Musk's influence.

The new Trump administration could **kill Artemis and its lunar plans**, but Casey Dreier, chief of space policy for the Planetary Society, says that would be "strange in the historical sweep of things" given that the first Trump administration basically created this program

"There's a lot of good reasons to still go to the moon, one of which is that the U.S. has made a commitment to not just its allies, but to the broader commercial space and business community here in the country," notes Dreier.

Still, he thinks that the current administration might challenge NASA to really nail down how the space agency will move from **lunar exploration to a Mars** mission.

More difficult than the moon

NASA has a "Moon to Mars Program Office," notes Dreier. He thinks, however, "there's no 'to Mars' part of it. It's all 'to moon.' "

He says NASA has constrained budgets, and there's always been concerns that the agency hasn't had enough resources to pursue both the moon and Mars.

"It's hard to express verbally, I think, how much harder Mars is than the moon and how different it is," says Dreier.

A trip to the moon takes just three days. Going to Mars, in contrast, takes months—one way.

Recently, a NASA program aimed at retrieving pristine rocks from the surface of Mars and bringing them back to Earth ran into real trouble, as costs ballooned by billions and the mission timeline slipped. One decision the Trump administration will have to make is whether, and how, to pursue this science mission.

Dreier says in terms of human exploration, NASA needs to lay out how its lunar activities will actually help get the agency **closer to going to Mars.**

"That is the key reframing that could help the long-term exploration program be more **efficient and effective**," he says.

President Trump's pick to lead NASA is Jared Isaacman, a private astronaut who flew to orbit twice in SpaceX vehicles and completed the first commercial extravehicular activity, or spacewalk. He has yet to be confirmed.

A NASA spokesperson told NPR in an email that the agency is "looking forward to hearing more about the Trump Administration's plans for our agency and expanding exploration for the benefit of all, including sending American astronauts on the first human mission to the Red Planet."

A non-partisan planet

Because of the **way the planets align**, potential launch **windows** to Mars open up in **2026 and 2028.**

Musk has publicly stated that he's aiming to send Starship to Mars as soon as **next year.**

Starship has yet to reach orbit, but Zubrin thinks it's possible that an uncrewed Starship might land on Mars by **2028**.

#### Reliable energy sustains human settlement.

**Pombo 21** [Daviel Vazquez Pombo, MSc in High Voltage Engineering from Aalborg University & PhD in Planning and Operation of Isolated Hybrid Power Systems from Technical University of Denmark, 4-7-2021, A Hybrid Power System for a Permanent Colony on Mars, Space: Science & Technology A Science Partner Journal, https://spj.science.org/doi/10.34133/2021/9820546, Willie T.]

Many are the reasons behind establishing a colony in Mars such as the possibility of discovering extraterrestrial life, ensuring the survival of our species after a massive extinction event, and improving quality of life, etc. However, there are only a **few scientific publications** regarding Mars colonisation. The few existing **focus mostly on spacecraft concepts** and design, at the expense of hardly mentioning or even **neglecting basic day-to-day** critical infrastructures like the power system. In fact, the relevant previous work starts mostly on the 70s, later in the 90s and 2000s; a couple of very high-level publications appear that mainly update some of the base assumptions due to the discoveries obtained by different unmanned missions sent to the red planet. In any case, establishing a permanent outpost in Mars **requires** a flexible, scalable, **reliable, and safe power system**. Therefore, this paper is aimed at analysing power sources, transmission/coupling possibilities, topology, etc. for a near-future Mars colony. This is addressed by reviewing all the excellent work developed since the 50s until the early 2000s and then updating it with present methods and technologies. Culminating with a proposal of a power system suitable for the task at hand, serious dialogues must start among the scientific community as it is its duty to serve humankind’s development [1–5].

There has not been much development specifically about the power system. Early documents like [6] proposed either a purely nuclear system or a combination with solar photovoltaic (PV) [7]; some others [8] suggested radioisotope but with a back-up role. However, most of the available **work is superficial and undetailed**. Recent development in energy technology obtained as a result of the energy transition demands a revision of the sources and storage system that might be used in the power systems of surface space missions. In addition, no document has proposed a balance of plant, a proper topology, or addressed the transmission system for the colony to name a few, not to mention how to address the particular effects of the Martian environment on electrical equipment [9]. Thus, studies focusing solely on the **Martian environment and requirements** are needed. Thus, this paper is aimed at reviewing the available technologies that will conform the power system of a near-future Martian colony and propose a suitable topology. This is done by reviewing the different proposed mission designs, concluding in a reasonable evolutionary scenario for the colony and its balance of plant suitable to satisfy its power and energy needs.

Then, the structure of the paper is as follows: Section 2 reviews the history of the most important documents published targeting manned missions to Mars, the interest behind establishing a permanent outpost, and it subsequently defines a dynamic architecture for the outpost. Thereafter, different power sources are analysed on Section 3 in order to choose a suitable combination conforming the Martian hybrid power system (HyPS). Then, whether the coupling should be in AC, DC, or mixed is discussed in Section 4. Afterwards, the resulting topology of the HyPS is presented and evaluated in Sections 5 and 6, respectively. Finally, the conclusions of this work are presented in Section 7, while also pointing out research paths that might continue this work.

2. Background, Motivation, and Mission Requirements

This section reviews the most important studies targeting Mars exploration in chronological order. This is aimed at illustrating the evolving concepts in certain areas while the stagnation in others such as power systems, while also helping to define the targeted mission. Despite the intention of providing an overview of all the developed science, there is a strong focus on NASA achievements until the 2000s, since Roscosmos public documents are written in Russian, a language sadly falling out of the knowledge base of the author.

The first formal approach to reach Mars was published in 1953 [10], where the flight systems and spacecraft are envisioned. A crew of 70 would be the first humans seeing the planet up-close as the arrival date was 1965 and precursor robotic missions were not considered. However, it was not until 1988 where a space agency such as NASA published a study with a similar aim [2], followed shortly by series of studies of human and robotic exploration beyond Low Earth Orbit and the Moon, Mars, Phobos, etc. [11, 12]. Then, [13] concludes that enough technological readiness would be achieved by 2000, starting the operations shortly afterwards; envisioning crews of 4 people, doubling two years after the first arrival and, also, suggesting several schedules ranging from 2011 to 2018 for the first mission and 2014 to 2027 to inaugurate the first permanent settlement.

In any case, [13] satisfies the power needs of the missions by means of SP-100, a nuclear fission reactor designed in 1989 for lunar missions easily adaptable for Mars [6]. It is worth mentioning that all the previous publications dismiss the possibility of using any locally available resources since there was no data available until the discoveries obtained by both Viking landers. Subsequently, in 1991, [14] further elaborates about a surface operating reactor, while [15] takes an extra step by coupling it with an in situ resource utilisation (ISRU) unit. A device capable of using local water, ice, and atmospheric CO2 as raw materials for fuel, air, water, plastics food, and other supplies. However, this concept will fall into oblivion for more than 10 years [16–18]. Afterwards, [19] points out the need for further research about the Martian environment before they could design landers, space suits, and other surface systems. After 1997, the approach taken by the studies changes trying to acquire a more holistic perspective, since previous attempts like [20] ended up focusing mostly or solely into flight and trajectory designs. Then, [9, 21] represent the most complete analyses until then, aiming to be used to drive R&D plans, understand mission requirements, open discussions, establish a baseline for future proposals, and stimulate further thought by also demanding improvement in certain aspects like the power system. A crew of 6 is envisioned in [9], no attention to surface power system is paid, and no ISRU is considered despite [15] being published 6 years prior.

After entering the new millennia, a high-level review of the Mars mission is published [3] stating that human arrival to Mars is so certain that a second revision will be necessary between 2015 and 2020 to account for the actual arrival. The book reviews concepts such as [10, 19] which never envisioned the role of robotic exploration. These unmanned missions helped discover unknown phenomena that would have ruined any manned mission developed with that time’s technology. It also points to the arrival delay caused by these discoveries as the reason for funding reduction in benefit of robotic exploration. The more was discovered, the least money available for a manned mission was available. Then, [16, 17] present concepts for self-sustaining Mars colonies by means of implementing ISRU. In [16], the 500 people colony site is selected in the North polar cap due to the water/ice available, while [17] focuses on obtaining water from the atmosphere, to avoid site dependency, envisioning a modular architecture capable of either 100, 1000, or 10000 crew scenarios. Following this trend, [18] is aimed at implementing an ISRU system to support propulsion and power systems for ground and flight vehicles in two scenarios, an Antarctica-inspired 100 people scenario and another terraforming scenario with a crew of 10000.

The first document from the European Space Agency (ESA) about a Mars mission is published in 2006 [22], which presents plans to study the Martian environment by using rovers. Then, [23] revives the interest of manned missions in three different sites, discussing mobility possibilities both on the surface and underground; the arrival is estimated between 2030 and 2040. Subsequently, in 2009, [7] suggests a framework aiming to facilitate reaching Mars as a multiagency effort. The document describes the systems and operations of a robotic precursor and the first three manned missions of 6 people each in different locations. This document stands out as the first time that the power system and energy management are highlighted as a key improvement needed. Subsequently, [24], a more completed version of [7], builds upon some of the aforementioned documents like [11–14, 21, 22] and others like [25, 26]. Among the conclusions of [24], the higher importance of robot-human partnership should be mentioned. Additionally, the selected crew of 6 must land prior to 2030; otherwise, a technology reassessment will be needed. Lastly, [24] contains the first proper section about the power system, which is envisioned as a combination of nuclear and PV for the main power while radioisotope power systems (RPSs) for backup needs. Thereafter, in 2014, [27] updates [7] with the latest developments, increasing again the role of robots and identifying solar power generation, nuclear fission, and active thermal control among the critical technologies. On the other hand, ESA and Roscosmos have a shared exploration agenda; however, no manned missions are foreseen [28, 29]. India and Japan have expressed that their targets do not include Martian exploration whatsoever, while China do it independently, targeting manned missions to the Moon in 2030 in collaboration with Russia as a prior step [30, 31]. Then, the Evolvable Mars Campaign is the current NASA mission seeking to enable crewed Mars missions in the mid-2030s timeframe [32]. Lastly, SpaceX is targeting the first manned mission to Mars in 2024 as preparation for a permanent settlement to be started shortly afterwards [5]. Nevertheless, why should we keep pursuing the dream of reaching Mars?

Many publications like [7–9, 33, 34] have reviewed the numerous reasons and objectives behind reaching Mars, which can be divided into 5 categories: planetology, humanistic, scientific, technological, and political. Ultimately, the goal is the integration of all the prior and acquired knowledge, which is referred in this work as holistic. This unification of knowledge will transcend any objectives established for the Mars colonisation and will push humanity forward. A summary of the possible reasons and objectives behind the conquest of Mars is presented in Figure 1Opens in image viewer. Nevertheless, the questions risen due to this endeavour might be even more valuable than the answers we hope to find [23].

Figure 1 Reasons to go to Mars.

Once the reasons behind getting humans into the red planet have been stated, the importance of establishing a permanent settlement instead of a temporary visit should be highlighted. The most important reason backing a sustained human presence in Mars is the increased cost-effectiveness of the mission. Research potential and discoveries escalate during sustained missions, while the cost does not increase significantly [23]. However, even disregarding the difficulty of reaching the planet safely, the particularities of engineering a robust system capable of operating under the Martian conditions will unequivocally translate in technological advancement for the general humanity. Examples of this process can be [35] where cross-disciplinary research is undertaken making use of the ISRU to propel an ascent vehicle in Mars, or [36] where a prototype for a greenhouse suitable for the Martian environment is presented, or [37] which is aimed at expanding the applications of ISRU units. Additionally, since one of the objectives is to avoid a massive extinction event, establishing permanent human settlements in other celestial bodies is a key. Then, **terraformation** of Mars, which consists of warming up the planet, in order to **thicken its atmosphere**, ultimately obtaining **liquid water surface oceans** on Mars [34], would **only be interesting** to achieve if there is a sustained human presence on the planet [38]. Lastly, Mars is **not considered the end** of the space exploration, but rather a **step** in it. Future missions aimed at more distant celestial objects will **require longer stays** before returning or continuing; thus, Mars represents a great training **outpost**.

At the end of the day, there are a variety of different envisioned manned missions, with crews ranging from **4 to 10000** depending on the length of stay and the ultimate exploration objectives. Barely no attention has been paid to the configuration and actual implementation of the power and energy management system (PEMS). Manned missions might still be decades down the road; however, complex robotic missions rather than individual rovers might be closer than ever due to latest developments in the field [39, 40]. Whatever the case, **manned or unmanned**, all the infrastructures depend on having a functional power system. Therefore, a reference architecture for the colony must be defined prior to sizing the necessary PEMS as it is needed in order to estimate the mission’s power and energy needs.

2.1. Architecture of the Colony

Even though there is no certainty as of this moment about the exact outlook of the colony, there are several strong candidates that can provide a rough approximation to be used as a starting point. Additionally, one of the self-imposed conditions of this work is that all systems must use current or near-future technology (technology readiness level of at least 6); no breakthrough technologies are assumed as following the recommendations of [22, 41]. Then, depending on the objective, any Mars surface mission can follow one of the coming strategies [7]:

(i)

Mobile home: all the structures are packed in a mobile, rover-based colony whose objective is long-duration exploration at great distances in a nomadic way

(ii)

Commuter: fixed, stable site for the colony with inclusion of both un- and pressurised rovers for mobility and science. The focus is on human exploration

(iii)

Telecommuter: similar to commuter, although most of the exploration is based on teleoperation of small robotic system from the local habitat

The focus of this work is on the commuter scenario as is the one that has received more attention and, also, it is the one best serving the purpose of a complex, permanent colony. One of the main reasons is the expected cost reduction of future missions by making use of the ISRU units and local manufacturing. While its concrete economic implications are tough to estimate and fall beyond the scope of this work, it is simple to understand how having a base in Mars will greatly reduce future mission costs. This is due basically to two reasons: launching satellites or other robotic missions manufactured directly on site and the possibility of providing support or maintenance [23].

In the commuter architecture, any planetary structure can be divided into 8 categories: habitats, laboratories, bioregenerative life support, ISRU, surface mobility (rovers), extravehicular mobility (eva suits), power system, and launch and landing area. All of them contain similar equipment such as windows, hatches, docking mechanisms, power distribution systems, life support, environmental control, safety features, stowage, waste management, communications, airlocks, and egress routes [9, 13, 17]. It is worth mentioning that rovers in this scenario are assumed to have a range of 100 km before needed resupply [7]; however, there is already available technology to get significantly larger ranges [42]. Disregarding the mobility range and the number of rovers, the habitats are always expected to keep a minimum of occupation due to safety measures [24]. Then, with an increasing population and expected duration of the colony, the number and purpose of the habitats change dramatically; if for a 6 people colony, habitats only include the bare minimum survival needs [7, 9]; a 100 people colony demands the existence of recreation facilities such as shops, open community spaces, parks, and public transportation [17].

2.2. Growing Stages of the Colony

After identifying the colony architecture as a commuter, the most influencing parameter affecting the power and energy demand is the foreseen population as it affects the required resources, habitats, etc. Since the aim of this work is to establish a permanent self-sustaining colony, its deployment is approached in stages.

Given the recent development in the field of robotics, it is reasonable to assume that the settlement will be founded by robots, which will **select and prepare the terrain** for the arrival of the first crew. Later, an initial crew of 6 will arrive, continuing the expansion of the colony and starting the scientific work. The next arrivals are expected shortly afterwards once the **technology and structures have been tested**, thus **ramping** the population in steps to 20, 50, and 100. This chain of arrivals and colony development is consistent with published work as [7, 10, 13, 17, 32, 41]; however, the robotic role has been considered, in general, higher. Then, even though there are already scenarios envisioning colonies **up to 10000** people [16, 17], the author considers that scenario to be far enough in the future to require a technology and method reassessment specially including the lessons learned from the first years of the Martian colony.

#### Nuclear is key but investment is needed.

**Nguyen 20** [Tien Nguyen, Ph.D. in Organic Chemistry & B.S in Chemistry with Minor in Physics, 5-15-2020, Why NASA thinks nuclear reactors could supply power for human colonies in space, Chemical & Engineering News, https://cen.acs.org/energy/nuclear-power/NASA-thinks-nuclear-reactors-supply/98/i19, Willie T.] \*\*brackets in original\*\*

The astronauts pass their **days in darkness**. After several months of living on the moon, they’re still adjusting to the endless night. The crew’s habitat at the lunar south pole sits in a shadowed crater—chosen for its promise of ice—that has not been touched by a single ray of sun for billions of years.

Fortunately, the nearby nuclear reactor is unfazed by the **lack of light**. Connected to the astronauts’ base camp by a kilometer of cables cautiously tracing the lunar surface, the reactor provides an **uninterrupted supply** of electricity for recharging rovers, running scientific instruments, and most importantly, powering the **air and heating systems** that keep the astronauts **alive.**

This is one vision of what human exploration could look like on the moon. In fact, NASA has plans to make some versions of this scene a reality—and soon.

The agency aims to send a human mission to the moon by 2024 in an effort named the Artemis project. Congress has allocated more than $6 billion of NASA’s 2020 fiscal budget for space exploration programs including the Space Launch System rocket, the Orion spacecraft, exploration ground systems, and research and development. The agency estimates that it will cost $35 billion to land a crew on the lunar surface, including the first woman to step foot on the moon. After 2024, NASA hopes to move to launching one human mission each year and reach sustainable operations on the moon by 2028.

The lessons learned in that phase will be crucial in preparing for **future trips to Mars**. One major effort will involve figuring out which power systems—including ones that have never been tested on the lunar surface, such as nuclear power—would best support future settlements. Whether the necessary materials can be brought safely to the moon and whether systems such as nuclear fission can run **reliably under such harsh conditions** are central questions that must be answered as engineers weigh their options.

Going nuclear

Choosing a power source depends on the particular mission’s needs, says Michelle A. Rucker, an engineer at NASA’s Lyndon B. Johnson Space Center who has researched possible architectures for space settlements. Electricity may come from nuclear reactors, solar panels, batteries, fuel cells, or some combination of these technologies connected in a power grid, she says. “I’m a big fan of all the types of power.”

But each power source has distinct pros and cons to consider. Solar arrays have reliably delivered renewable power in space for decades but are useless in places that never get any light, like the potentially resource-rich craters on the moon. And on the windy, dusty surface of Mars, solar panels may **struggle to collect** enough light, making them a risky option for powering life support systems, Rucker says. **Batteries and fuel cells have limited lifetimes** for now, relegating them to **supplementary power sources at best.**

One type of nuclear device that has been used to power spacecraft is a radioisotope thermoelectric generator, which runs on the heat produced by the decay of plutonium-238. These generators have been used since the 1960s in Mars rovers and space probes sent to the outer edges of the solar system, such as the Voyager spacecraft and Cassini. Despite being the workhorses of scientific missions, the generators provide only several hundred watts of power, just enough to send radio signals back to Earth or power a camera.

On Earth, the nuclear technology used by power plants is nuclear fission, which splits uranium-235 atoms via bombardment with neutrons to generate heat that’s captured to produce electricity. Nuclear fission holds the potential to provide a **continuous, reliable source** of power for a small space settlement designed to last **for several years.**

In the 1960s, many scientists thought fission reactors for space would follow on the heels of radioisotope generators. In 1965, the US launched a small nuclear fission–powered satellite named SNAP-10A, but electrical issues caused it to fail a mere 43 days after launch; it’s still in orbit, now just another piece of space junk. The Soviet Union launched 31 nuclear fission–powered satellites over the next 2 decades.

But the development of new nuclear fission reactors for space stalled during that time because of design problems and ballooning budgets. Engineers wanted advanced performance from these systems right away, which led to complicated and expensive designs, says David Poston, a nuclear engineer at Los Alamos National Laboratory. He and Patrick McClure, who specializes in reactor safety at Los Alamos, have worked at the lab for the past 25 years and recall the days when nuclear fission had fallen out of favor.

“Pat and I were sitting around just kind of demoralized,” Poston says, “because we had gotten to the point where NASA wasn’t really interested anymore because the impression was that it was going to be too expensive and too hard to develop a fission reactor.” But the pair were convinced their team could come up with a design to dispel the funk that had settled around fission power for space.

In the early 2010s, they got their chance: researchers at Los Alamos and later the NASA Glenn Research Center and the US Department of Energy began work on a joint project called Kilopower, now renamed the Nuclear Fission Power Project. The goal is to develop a **new nuclear fission** power system for space that would be **capable of producing 10 kW of electrical energy.**

Designing the reactor

Four of these reactors could **easily provide** the 40 kW of power that Rucker estimates a six-member crew would need to live on Mars. The team’s modular, compact design is lightweight **enough for space exploration**, in which every kilogram counts. Previous hypothetical fission-power concepts required a payload of 12–14 metric tons (a 6–7 t reactor plus a backup), whereas a single Kilopower reactor would weigh an estimated 1.5 t, she says.

The team decided to approach the reactor design anew, putting one priority above all: simplicity. This meant not only maintaining a simple mechanical design but also looking for opportunities to simplify safety approvals and project management. As an example, McClure says, the team made a conscious choice to limit the size of the nuclear core to a container already being used to test nuclear materials instead of fabricating a new one.

“I hate to call it an innovation because it’s not that complicated. But it’s an innovation that we said, ‘Why don’t we just do it the simple way that we know is going to work?’ ” Poston says. “We knew it was going to work, but the world didn’t.”

The nuclear core, which is about the size of a paper towel roll and weighs 28 kg, comprises a solid alloy of about 8% molybdenum and 92% highly enriched uranium. The nuclear material is surrounded by a beryllium oxide reflector that bounces neutrons into the core to drive the fission reaction. Lodged inside the core is a rod of pure boron carbide that absorbs neutrons, quenching fission reactions.

When the boron carbide rod is slowly removed, neutrons start to strike uranium atoms, occasionally splitting them, creating more neutrons and releasing energy as heat. Once the number of neutrons lost equals the number of neutrons being produced, the reactor becomes self-sustaining. The fission-generated heat travels through sodium-filled heat pipes to a set of Stirling engines. Designed in the early 1800s, these simple piston-driven engines convert heat to electricity. Finally, the team’s reactor design includes a radiator to remove the excess heat, sloughing it off into space.

“We wanted to show not only the world but ourselves that we can still do something real because we had gotten away from actually testing real fission systems,” Poston says.

In a proof-of-concept test called DUFF, the team showed that the hardware worked to produce electricity. Then, in 2018, the team successfully tested a prototype of the reactor at the Nevada National Security Site. During the months-long KRUSTY experiment, researchers tested each of the reactor’s components and its ability to withstand various failures. (The experiment names were inspired by The Simpsons TV show.) The reactor also **successfully passed** a 28 h test, in which it **ramped up to full power**, peaking at about 5 kW, operated at a steady state, and then **shut down safely.**

The team hopes that with more optimization, such as by increasing the size of the nuclear core, it can meet its goal of producing 10 kW per reactor.

Of course, some people look at highly enriched uranium with skepticism, given its potential to harm humans and its role as a material for nuclear weapons. But McClure says transporting uranium to the moon and working alongside a reactor can be **done safely**. Uranium emits weak α particles, which **can’t penetrate a piece of paper or skin**, so the **shielding** that surrounds the nuclear core would prevent astronauts from any radiation exposure. Burying the reactor a few meters into the ground or putting it behind a big rock feature could also help keep astronauts safe from radiation when the reactor is on. Once the reactor has run its course, the radioactive waste will likely be shielded and left alone.

The worst-case scenario for such a system would involve the entire reactor blowing up midlaunch, aerosolizing and dispersing uranium particles. Even then, a person a kilometer away might receive a dose in the millirem range—less than the dose you get from solar radiation when you take a plane flight, McClure says.

Ultimately, the fission reactor’s future will depend on not only technical success but also **sufficient funding**. Dionne Hernández-Lugo of the NASA Glenn Research Center and deputy project manager of the Nuclear Fission Power Project says the proposed budget puts the team “on the path to build and send a surface power system to the moon.”

“It’ll be really exciting to test [the reactor] on the moon and get some experience under our belts before we go to Mars,” Rucker says. “On the moon, you’re close to home, so if something fails, it’s a fairly close trip to get back home, whereas on Mars, your system better be working.”

#### Either we successfully colonize or save humanity while trying.

**HÉIgeartaigh 16** [Seán Ó HÉIgeartaigh, professor @ Cambridge + PhD in Genomics from Trinity College of Dublin, 10-5-2016, Technological Wild Cards: Existential Risk and a Changing Humanity, Centre for the Study of Existential Risk, https://papers.ssrn.com/sol3/papers.cfm?abstract\_id=3446697]

4. WORKING ON THE (DOOMSDAY) CLOCK

**Technological progress** now **offers us a vision of a remarkable future**. The **advances** that have brought us onto an unsustainable pathway have also **raised the quality of life dramatically for many**, **and** have **unlocked scientific directions that can lead us to a safer, cleaner, more sustainable world**. With the right developments and applications of technology, in concert with advances in social, democratic, and distributional processes globally, progress can be made on all of the challenges discussed here. Advances in renewable energy and related technologies, and more efficient energy use—advances that are likely to be accelerated by progress in technologies such as artificial intelligence—can bring us to a point of zero-carbon emissions. **New manufacturing capabilities provided by synthetic biology may provide cleaner ways of producing products and degrading waste.** A greater scientific understanding of our natural world and the ecosystem services on which we rely will aid us in plotting a trajectory whereby critical environmental systems are maintained while allowing human flourishing. **Even** advances in **education and women’s rights** globally, which will play a role in achieving a stable global population, **can be aided specifically by the information, coordination, and education tools that technology provides, and more generally by growing prosperity in the relevant parts of the world.**

**There are catastrophic and existential risks that we will simply not be able to overcome without advances in science and technology.** **These include** possible **pandemic outbreaks**, **whether natural or engineered**. **The early identification of incoming asteroids**, **and approaches to shift their path, is a topic of active research at NASA and elsewhere**. While currently there are no known **techniques to prevent or mitigate a supervolcanic eruption,** this **may not be the case** with the tools at our disposal **a century from now**. **And in the longer run, a civilization that has spread permanently beyond the earth, enabled by advances in spaceflight, manufacturing, robotics, and terraforming, is one that is much more likely to endure**. However, **the breathtaking power of the tools we are developing is not to be taken lightly**. **We have been very lucky to muddle through the advent of nuclear weapons without a global catastrophe**. And within this century, it is realistic to expect that we will be able to rewrite much of biology to our purposes, intervene deliberately and in a large-scale way in the workings of our global climate, and even develop agents with intelligence that is fundamentally alien to ours, and may vastly surpass our own in some or even most domains—a development that would have uniquely unpredictable consequences.

#### Every second matters.

**Beckstead 14** [Nick Beckstead, research fellow at Oxford University's Future of Humanity Institute, 2014, Will we eventually be able to colonize other stars? Notes from a preliminary review, https://www.fhi.ox.ac.uk/will-we-eventually-be-able-to-colonize-other-stars-notes-from-a-preliminary-review/, Willie T.]

While this estimate is conservative in that it assumes only computational mechanisms whose implementation has been at least outlined in the literature, it is useful to have an even more conservative estimate that does not assume a non-biological instantiation of the potential persons. Suppose that about 10^10 biological humans could be sustained around an average star. Then the Virgo Supercluster could contain 10^23 biological humans. This corresponds to a loss of potential equal to about 10^14 potential human lives per second of delayed colonization.” Bostrom 2003, “Astronomical Waste.”

[2] “The lion’s share of the expected duration of our existence comes from the possibility that our descendants colonize planets outside our solar system. There are **many stars** that we may be able to reach with future technology (about 10^13 in our supercluster). Some of them will probably have planets that are **hospitable to life**, perhaps many of these planets could be made hospitable with appropriate technological developments. Some of these are near stars that will burn for much longer than our sun, some for as much as **100 trillion years** (Adams, 2008, p. 39). If multiple locations were colonized, the risk of total destruction would dramatically decrease, since it would take independent global disasters, or a cosmological catastrophe, to destroy civilization. Because of this, it is possible that our descendants would survive until the very end, and that there could be extraordinarily large numbers of them.” Beckstead 2013, “On the Overwhelming Importance of Shaping the Far Future,” p. 57.

### 1AC

#### Green growth fails AND locks in existential warming. Only a nuclear war catalyzes a transition.

McDonald ’19 [Samuel Miller; January 4; studied energy transition politics at Yale's School of the Environment and is a doctoral researcher at the School of Geography and the Environment at Oxford, regular contributor to Current Affairs, New Republic and the Guardian; The Trouble, “Deathly Salvation,” https://www.the-trouble.com/content/2019/1/4/deathly-salvation]

The global economy is hurtling humanity toward extinction. Greenhouse gas emissions are on track to warm the planet by six degrees Celsius above preindustrial averages. A six-degree increase risks killing most life on earth, as global warming did during the Late Permian when volcanoes burned a bunch of fossilized carbon (e.g., coal, oil, and gas). Called the Great Dying, that event was, according to New York Magazine, “The most notorious [extinction event…]; it began when carbon warmed the planet by five degrees, accelerated when that warming triggered the release of methane in the Arctic, and ended with 97 percent of all life on Earth dead.”

Mainstream science suggests that we’re on our way there. During the winter of 2017, the Arctic grew warmer than Europe, sending snow to the Mediterranean and Sahara. The planet may have already passed irreversible thresholds that could accelerate further feedback loops like permafrost melt and loss of polar ice. Patches of permafrost aren’t freezing even during winter, necessitating a rename (may I suggest ‘nevafrost’?). In the summer of 2018, forests north of the Arctic Circle broke 90 degrees Fahrenheit and burned in vast wildfires. We’re reaching milestones far faster than scientists have even recently predicted. As Guardian columnist George Monbiot noted, “The Arctic meltdown […] is the kind of event scientists warned we could face by 2050. Not by 2018.” Mass marine death that rapidly emits uncontrollable greenhouse gasses is another feedback loop that seems ready to strike. The ocean is now more acidic than any time in the last 14 million years, killing everything from snails to whales. It’s growing rapidly more acidic. Meanwhile, from the global South to wealthier industrialized countries, people are already dying and being displaced from the impacts of extreme climate change via extreme droughts, floods, wildfires, storms, and conflicts like the Syrian civil war. Authoritarianism is on the rise due directly to these climate emergencies and migrations.

The IPCC has recently alerted the world that we have about a decade to dramatically cut emissions before collapse becomes inevitable. We could prevent human extinction if we act immediately. But the world is unanimously ignoring climate change. Nations will almost certainly fail to avert biosphere collapse. That is because doing so will require a rapid decarbonization of the global economy.

But why does decarbonization--an innocuous enough term--seem so implausible? Well, let’s put it this way: a sufficient transition to non-carbon energy would require all the trains, buses, planes, cars, and ships in the world to almost immediately stop and be replaced with newly manufactured vehicles to run on non-carbon fuel, like hydrogen cells, renewable electricity, or some carbon-neutral biofuel. All this new manufacturing will have to be done with low-carbon techniques, many of which don’t exist yet and may be impossible to achieve at scale. This means all the complex supply chains that move most of the world’s food, water, medicine, basically all consumer goods, construction materials, clothing, and everything else billions of people depend on to survive will have to be fundamentally reformed, in virtually every way, immediately.

It also means that all the electric grids and indoor heating and cooling systems in the world must be rapidly transformed from centralized coal and gas power plants to a mixture of solar, wind, and nuclear—both distributed and centralized—dispersed through newly built micro-grids and smart-grids, and stored in new battery infrastructure. These new solar panels, batteries, and nuclear plants will somehow have to be built using little carbon energy, again something that may be impossible to achieve at a global scale.

The cost of this transition is impossible to know, but surely reaches the tens of trillions of dollars. It needs to happen in just about every industrialized nation on the planet and needs to happen now—not in 2050, as the Paris Agreement dictates, or the 2030s, as reflected in many governments’ decarbonization goals. The engineering and administrative obstacles are immense; disentangling century-old, haphazard electric grid systems, for example, poses an almost unimaginable cascade of institutional and logistical hurdles. Imagine the difficulty of persuading millions of municipalities around the world to do anything simultaneously; now, imagine convincing them all to fundamentally shift the resource infrastructure on which their material existence depends immediately.

Perhaps even more daunting are the political obstacles, with diverse financial interests woven together in a tapestry of inertia and self-interest. Virtually all retirement funds, for instance, are invested in fossil fuel companies. Former and current fossil fuel industry managers sit on all manner of institutional committees in which energy and investment decisions are made: trustee boards of universities, regulatory commissions, city councils, congressional committees, philanthropic boards, federal agencies, the Oval Office couch. Lots of people make lots of money from fossil fuels. Will they sacrifice deeply vested interests to prevent collapse? They certainly have not shown signs of doing so yet, when the stakes are as dire as they’ve ever been; most have instead ruthlessly obstructed meaningful action. Will enough people be willing to do what it takes to forcibly remove them from the most powerful institutions in the world? That also seems unlikely, given meager public involvement in this issue so far.

This is the obstacle of collective action: everyone has to sacrifice, but no one wants to start. Who will assent to giving up their steady returns from fossil fuels if everyone else refuses? When people are living so precariously as it is (43% of American can’t afford basic necessities), how can we ask them to undertake energy transition? The US drags its feet on decarbonizing and justifies it by arguing that China has not made strong enough commitments. Which country will voluntarily give up access to strategic fossil fuel reserves? Much of our geopolitical dynamics and wars have revolved around access to mineral resources like oil. Is the US going to put itself in a disadvantaged position for the climate? Shell withdraws research funding for renewables because ExxonMobil goes full steam ahead on oil, and, hey, they must compete. Fossil fuel funded politicians of both parties certainly will not aid transition.

If untangling the webs of influence, interests, and engineering preventing decarbonization weren’t daunting enough, the world will also have to suck billions of tons of greenhouse gases out of the atmosphere that have already been emitted. Keeping the planet to even a deadly 1.5 degrees Celsius increase of warming depends on it.

This sounds simpler than it is, as if a big vacuum cleaner could siphon particulates from the sky. But no one really knows how to extract and sequester carbon at the scale necessary to prevent catastrophic climate change. Engineers have thrown out a lot of ideas—some more plausible than others—but most scientists who have looked at proposals generally agree that it’s wishful thinking. As Huffington Post quotes Clive Hamilton, “In order to capture just a quarter of the emissions from the world's coal-fired power plants we would need a system of pipelines that would transport a volume of fluid twice the size of the global crude-oil industry.” Of course, manufacturing, shipping, and constructing those pipelines would require immense carbon energy inputs and emissions. And that’s just to capture the emissions from coal!

Like energy transition, carbon capture and sequestration requires governments to act collectively to invest trillions of dollars in risky, experimental, and probably mostly ineffectual sequestration technologies. Again, it’s a collective action problem: nobody wants to be the one to sacrifice while no one else is putting themselves on the line. And the miniscule likelihood that energy transition will occur under a Trump-Digs-Coal presidency—and the Trumpian nationalists winning elections across the world—casts further doubt on the possibility of rapid decarbonization. The administration’s energy department has projected that, “The carbon footprint of the United States will barely go down at all for the foreseeable future and will be slightly higher in 2050,” as InsideClimateNews notes. The world, today, is still setting records for carbon emissions and there’s no sign that will change anytime soon.

The only period in US history the nation has undertaken anything near the magnitude of collective action necessary for mitigation was during the Second World War and the rebuilding effort in its aftermath. But even those projects involved a fraction of the capital and coordination that will be necessary for sufficient energy transition and carbon sequestration. More importantly, today’s collective action will have to be politically justified without the motivation of defeating a personified enemy—a Hitler, if you will. Today, with interpersonal alienation running rampant and extremely consolidated wealth and power, industrial economies seem infinitely far from a cultural, political atmosphere in which collective action policies are even close to possible. To the contrary, wealthy countries are all still slashing public goods, passing austerity budgets, and investing heavily in fossil fuel infrastructure. Even most elected Democrats are dragging their feet on passing climate policy. The world is going in the exact opposite direction from one in which humans can live.

We’ve tied ourselves in a perfect Gordian knot.

The global economy is a vast machine, operating beyond the control of even the most powerful individuals, and it has a will of its own to consume and pollute. It’s hard to believe that this massive metal beast will be peacefully undone by the people who survive by it, and we all survive by it in some way, often against our wills; it bribes and entraps us all in ways large and small.

But a wrench could clog the gears, and maybe only a wrench can stop it. One wrench that could slow climate disruption may be a large-scale conflict that halts the global economy, destroys fossil fuel infrastructure, and throws particulates in the air. At this point, with insane people like Trump, Putin, Xi, May, and Macron leading the world’s biggest nuclear powers, large-scale conflagration between them would probably lead to a nuclear exchange. Nobody wants nuclear war. Rather, nobody sane and prosocial wants nuclear war. It is an absolute horror that would burn and maim millions of living beings, despoil millions of hectares, and scar the skin of the earth and dome of the sky for centuries, maybe millennia. With proxy conflict brewing between the US and Russia in the Middle East and the Thucydides trap ready to ensnare us with an ascendant China, nuclear war looks like a more realistic possibility than it has since the 1980s.

A devastating fact of climate collapse is that there may be a silver lining to the mushroom cloud. First, it should be noted that a nuclear exchange does not inevitably result in apocalyptic loss of life. Nuclear winter—the idea that firestorms would make the earth uninhabitable—is based on shaky science. There’s no reliable model that can determine how many megatons would decimate agriculture or make humans extinct. Nations have already detonated 2,476 nuclear devices.

An exchange that shuts down the global economy but stops short of human extinction may be the only blade realistically likely to cut the carbon knot we’re trapped within. It would decimate existing infrastructures, providing an opportunity to build new energy infrastructure and intervene in the current investments and subsidies keeping fossil fuels alive.

In the near term, emissions would almost certainly rise as militaries are some of the world’s largest emitters. Given what we know of human history, though, conflict may be the only way to build the mass social cohesion necessary for undertaking the kind of huge, collective action needed for global sequestration and energy transition. Like the 20th century’s world wars, a nuclear exchange could serve as an economic leveler. It could provide justification for nationalizing energy industries with the interest of shuttering fossil fuel plants and transitioning to renewables and, uh, nuclear energy. It could shock us into reimagining a less suicidal civilization, one that dethrones the death-cult zealots who are currently in power. And it may toss particulates into the atmosphere sufficient to block out some of the solar heat helping to drive global warming. Or it may have the opposite effects. Who knows?

What we do know is that humans can survive and recover from war, probably even a nuclear one. Humans cannot recover from runaway climate change. Nuclear war is not an inevitable extinction event; six degrees of warming is.

Given that mostly violent, psychopathic individuals manage the governments and industries of the world, it may only be possible for anti-social collective action—that is, war—to halt, or at least slow, our inexorable march toward oblivion. A courageous, benevolent ruler might compel vast numbers of people to collective action. But we have too few of those, and the legal, political, and military barriers preventing them from rising are immense. Our current crop of villainous presidents, prime ministers, and CEOs, whether lusting for chaos or pursuing their own petty ends, may inadvertently conspire to break the machine now preventing our future. When so bereft of heroes, we may need to rely on humanity’s antagonists and their petty incompetence to accidentally save the day. It is a stark reflection of how homicidal our economy is—and our collective adherence to its whims—that nuclear war could be a rational course of action.

#### RAINOUT---expert climatic models prove.

Reisner ’18 [Jon, Gennaro D’Angelo, Eunmo Koo, Wesley Even, Matthew Hecht, Elizabeth Hunke, Darin Comeau, Randall Bos, James Cooley; February 13; scientist at Los Alamos National Laboratory; NASA Postdoctoral Fellow at NASA Ames Research Center, former UKAFF Fellow and member of the Astrophysics Group at the School of Physics of the University of Exeter; Scientist at Continuum Models and Numerical Methods Group in X-Computational Physics Division; computational scientist in the Computational Physics and Methods Group at Los Alamos National Laboratory; computer programmer and Deputy Division Leader, Sigma at Los Alamos National Laboratory; scientists and modeler tracking changes in ice melting; Member of the Center for Atmosphere Ocean Science at the Courant Institute of Mathematical Sciences; \*\*\*\*\*\*\*\*Project leader at the Los Alamos National Laboratory, former Weapons Effects program manager at Tech-Source; Ph.D. in applied mathematics from Columbia University; Journal of Geophysical Research: Atmospheres, “Climate Impact of a Regional Nuclear Weapons Exchange: An Improved Assessment Based On Detailed Source Calculations,” vol. 123]

To quantitatively account for natural and forced variability in the climate system, we created two ensembles, one for the natural, unforced system and a second ensemble using a range of realistic vertical profiles for the BC aerosol forcing, consistent with our detailed fire simulation. The control ensemble was generated using small atmospheric temperature perturbations (Kay et al., 2015). Notably, the overall spread of anomalies in both ensembles is very similar. These ensembles were then used to create “super ensembles” using a statistical emulator, which allows a robust statistical comparison of our simulated results with and without the carbon forcing.

Our primary result is the decreased impact on global climate indices, such as global average surface temperature and precipitation, relative to standard scenarios considered in previous work (e.g., Mills et al., 2014; Pausata et al., 2016; Robock, Oman, Stenchikov, et al., 2007; Stenke et al., 2013). With our finding of substantially less BC aerosol being lofted to stratospheric heights (e.g., over a factor of 4 less than in most of the scenarios considered by previous studies), these globally averaged anomalies drop to statistically insignificant levels after the first several years (Figures 14 and 16). Our results are generally comparable to those predicted by other studies that considered exchange scenarios in which only about 1 Tg of soot is emitted in the upper troposphere (Mills et al., 2008; Robock, Oman, Stenchikov, et al., 2007; Stenke et al., 2013). There are more subtle suggestions of regional effects, notably in the extent of the region over which SST differences between ensembles remain significant in the final years of simulation (Figure 17). Further work is required to adequately analyze these and other potential regional effects.

Historical analysis of several large volcanic eruptions and a recent large fire also supports this result. For example, Timmreck et al. (2010) claim that nonlinear aerosol effects of the Toba Tuff eruption 74,000 years ago helped limit significant global cooling impacts to a 2 year time period and that any cooling beyond this time period could be due to other effects. It should be noted that this eruption was estimated to have produced 106 Tg of ash and comparable amounts of other gases, such as sulfur dioxide (SO2), while the estimated amount of soot produced by a regional exchange is on the order of 10 Tg or 5 orders of magnitude smaller than the ash (not including gases) produced by the Toba eruption. Noting that a nuclear exchange is not identical to volcanic events, it has been asserted that BC particles produced by fires should have a greater impact on absorbing solar radiation than even has the significantly larger amounts of ash and various gases produced by large eruptions (e.g., Robock & Toon, 2010). Likewise, recent work in analyzing BC emissions from large fires suggests that in such fires, similar to large volcanic eruptions, coating of soot particles with other particles in convective eddies tends to increase their size and hence increase their subsequent rainout (China et al., 2013) before they can reach the stratosphere. In fact, the recent study of Pausata et al. (2016) found that growth of BC aerosol via coagulation with organic carbon significantly reduces the particles' lifetime in the atmosphere.

#### BIAS---AFF studies are rife with confirmation and politics.

Singer ’18 [Fred; June 27; professor emeritus at the University of Virginia and a founding director and now chairman emeritus of the Science & Environmental Policy Project; American Thinker, “Remember Nuclear Winter?” https://www.americanthinker.com/articles/2018/06/remember\_nuclear\_winter.html]

Nuclear Winter burst on the academic scene in December 1983 with the publication of the hypothesis in the prestigious journal Science.  It was accompanied by a study by Paul Ehrlich, et al. that hinted that it might cause the extinction of human life on the planet.

The five authors of the Nuclear Winter hypothesis were labeled TTAPS, using the initials of their family names (T stands for Owen Toon and P stands for Jim Pollak, both Ph.D. students of Carl Sagan at Cornell University.)  Carl Sagan himself was the main author and driving force.

Actually, Sagan had scooped the Science paper by publishing the gist of the hypothesis in Parade magazine, which claimed a readership of 50 million!  Previously, Sagan had briefed people in public office and elsewhere, so they were all primed for the popular reaction, which was tremendous.

Many of today's readers may not remember Carl Sagan.  He was a brilliant astrophysicist but also highly political.  Imagine Al Gore, but with an excellent science background.

Sagan had developed and narrated a television series called Cosmos that popularized astrophysics and much else, including cosmology, the history of the universe.  He even suggested the possible existence of extraterrestrial intelligence and started a listening project called SETI (Search for Extraterrestrial Intelligence). SETI is still searching today and has not found any evidence so far.  Sagan became a sort of icon; many people in the U.S. and abroad knew his name and face.

Carl Sagan also had another passion: saving humanity from a general nuclear war, a laudable aim.  He had been arguing vigorously and publicly for a "freeze" on the production of more nuclear weapons.  President Ronald Reagan outdid him and negotiated a nuclear weapons reduction with the USSR.

In the meantime, much excitement was stirred up by Nuclear Winter.  Study after study tried to confirm and expand the hypothesis, led by the Defense Department (DOD), which took the hypothesis seriously and spent millions of dollars on various reports that accepted Nuclear Winter rather uncritically.

The National Research Council (NRC) of the National Academy of Sciences published a report that put in more quantitative detail.  It enabled critics of the hypothesis to find flaws – and many did.  The names Russell Seitz, Dick Wilson (both of Cambridge, Mass.), Steve Schneider (Palo Alto, Calif.), and Bob Ehrlich (Fairfax, Va.) (no relation to Paul Ehrlich) come to mind.  The hypothesis was really "politics disguised as science."  The whole TTAPS scheme was contrived to deliver the desired consequence.  It required the smoke layer to be of just the right thickness, covering the whole Earth, and lasting for many months.

The Kuwait oil fires in 1991 produced a lot of smoke, but it rained out after a few days.  I had a mini-debate with Sagan on the TV program Nightline and published a more critical analysis of the whole hypothesis in the journal Meteorology & Atmospheric Physics.  I don't know if Carl ever saw my paper.  But I learned a lot from doing this analysis that was useful in later global warming research.  For example, the initial nuclear bursts inject water vapor into the stratosphere, which turns into contrail-like cirrus clouds.  That actually leads to a strong initial warming and a "nuclear summer."

#### Humanity wouldn’t have the capacity to rebuild OR develop hazardous technology.

Dartnell ’15 [Lewis, April 13; UK Space Agency research fellow at the University of Leichester; Aeon, “Out of the ashes,” https://aeon.co/essays/could-we-reboot-a-modern-civilisation-without-fossil-fuels]

Bad as things sound, that’s not the end for humanity. We bounce back. Sooner or later, peace and order emerge again, just as they have time and again through history. Stable communities take shape. They begin the agonising process of rebuilding their technological base from scratch. But here’s the question: how far could such a society rebuild? Is there any chance, for instance, that a post-apocalyptic society could reboot a technological civilisation?

Let’s make the basis of this thought experiment a little more specific. Today, we have already consumed the most easily drainable crude oil and, particularly in Britain, much of the shallowest, most readily mined deposits of coal. Fossil fuels are central to the organisation of modern industrial society, just as they were central to its development. Those, by the way, are distinct roles: even if we could somehow do without fossil fuels now (which we can’t, quite), it’s a different question whether we could have got to where we are without ever having had them.

So, would a society starting over on a planet stripped of its fossil fuel deposits have the chance to progress through its own Industrial Revolution? Or to phrase it another way, what might have happened if, for whatever reason, the Earth had never acquired its extensive underground deposits of coal and oil in the first place? Would our progress necessarily have halted in the 18th century, in a pre-industrial state?

It’s easy to underestimate our current dependence on fossil fuels. In everyday life, their most visible use is the petrol or diesel pumped into the vehicles that fill our roads, and the coal and natural gas which fire the power stations that electrify our modern lives. But we also rely on a range of different industrial materials, and in most cases, high temperatures are required to transform the stuff we dig out of the ground or harvest from the landscape into something useful. You can’t smelt metal, make glass, roast the ingredients of concrete, or synthesise artificial fertiliser without a lot of heat. It is fossil fuels – coal, gas and oil – that provide most of this thermal energy.

In fact, the problem is even worse than that. Many of the chemicals required in bulk to run the modern world, from pesticides to plastics, derive from the diverse organic compounds in crude oil. Given the dwindling reserves of crude oil left in the world, it could be argued that the most wasteful use for this limited resource is to simply burn it. We should be carefully preserving what’s left for the vital repertoire of valuable organic compounds it offers.

But my topic here is not what we should do now. Presumably everybody knows that we must transition to a low-carbon economy one way or another. No, I want to answer a question whose interest is (let’s hope) more theoretical. Is the emergence of a technologically advanced civilisation necessarily contingent on the easy availability of ancient energy? Is it possible to build an industrialised civilisation without fossil fuels? And the answer to that question is: maybe – but it would be extremely difficult. Let’s

## 2AC

### Quals—2AC

### Space—2AC

### Impact Turn—2AC

#### Green capitalism proliferates destabilizing biotechnology that facilitates bio-war.

**Albert ’20** [Michael; April 2020; lecturer in Global Environment Politics at the University of Edinburgh, Ph.D. from Johns Hopkins University, and former lecturer in International Relations at SOAS University of London; Global Policy, “The Dangers of Decoupling: Earth System Crisis and the ‘Fourth Industrial Revolution’,” vol. 11]

Whatever the actual potential of these technologies, it is clear that a **powerful tech**nological imaginary exists among policy makers, technologists, and **econ**omists that contributes to an **unshakeable faith** in **innovation** and human ingenuity to solve the **decoupling** challenge. Degrowth proponents have so far mainly challenged this optimism by emphasizing the limited potential of renewable energy due to its intermittency and high land and raw material demands (e.g. Kallis, 2018). However, this may downplay the (at least theoretical) potential for convergent breakthroughs in **nano**technology, **synthetic bio**logy, and **AI** to vastly improve **renewable energy** efficiency and storage systems while designing new materials to substitute for depleting minerals (Diamandis and Kotler, 2014). More broadly, while degrowthers have to some extent considered individual FIR technologies (particularly AI and biotechnology) (e.g. Kallis, 2018; Kerschner et al., 2018), they have yet to address their convergent and mutually amplifying character, which leaves them vulnerable to the arguments of techno-optimists.

<<TEXT CONDENSED, NONE OMITTED>>

Of course, the revolutionary promise of these technologies may fail to materialize, and, given the magnitude of the decoupling challenge, degrowth advocates are right to be skeptical. However, due to irreducible uncertainty combined with the ‘exponential’ and ‘revolutionary’ potential of the FIR (Schwab, 2017), even more rigorous critical assessments would always be insufficient in the eyes of the techno-optimists. Therefore, an alternative line of response should also be pursued: what if the FIR does succeed in decoupling economic growth from total environmental impact? What unintended consequences then might this give rise to?3 Dual-use technologies and the democratization of violence First, we must consider that all these are ‘dual-use technologies’, or technologies with potential both for economic productivity and violence. As Blum and Wittes (2015, p. 2) explain, these technologies are driving a trend referred to as the ‘democratization of violence’ in which the ‘destructive power once reserved to states is now the potential province of individuals’. Rather than simply a matter of creating new individual weapons, Blum and Wittes (2015, pp. 39, 7-8) emphasize that convergent FIR technologies are generating ‘whole technological fields – a series of breakthroughs in basic science and engineering’ that ‘generate creativity in their users to build and invent new things, new weapons, and new modes of attack’. And to compound the problem, while FIR technologies empower individuals to kill and provoke systemic chaos unlike any other time in history, they also empower states to monitor the minute details of private and public life and potentially constrict individual and collective freedoms, while the unprecedented threats enabled by these same technologies will likely reinforce governmental efforts to intensify securitization as deeply as is technologically feasible. Blum and Wittes summarize the emerging predicament as follows: How should we think about the relationship between liberty and security when we both rely on governments to protect us from radically empowered fellow citizens around the globe and also fear the power those same technologies give to governments? (Blum and Wittes, 2015, p. 13)

<<PARAGRAPH BREAKS RESUME>>

Blum and Wittes do not consider how the earth system crisis will intersect with these threats, either as a positive or negative feedback. But it should be clear that, in a world of FIR-driven **sustainability** solutions, they would **inevitably intensify**, and it is thus necessary to consider what new problems and governmental responses they would engender.4

Without claiming to exhaustively describe the security risks created by the FIR, I will focus on three emerging areas of concern: biosecurity, cybersecurity, and state securitization, and will then discuss how they may collectively generate a spiral of insecurity and securitization.

Biotechnology and the emerging terrain of biosecurity

To begin with biosecurity, both the promise and peril of biotechnology – particularly the still nascent field of synthetic biology – is its immense creative potential. As a recent report from the National Academies of Sciences (NAS) describes:

**synthetic bio**logy is expected to (1) **expand** the **range** of what could be **produced**, including **making** bacteria and **viruses more harmful**; (2) decrease the amount of time required to engineer such organisms; and (3) expand the range of actors who could undertake such efforts. (NAS, 2018, p. 4)

For example, manipulating DNA structures in microorganisms can make certain agents more **virulent**, improve their **resistance** to **antibiotics** and **vaccines**, make them **less detectable** by already limited **surveillance** systems, transform harmless microorganisms into **deadly** ones, and make pathogens more **resilient** to **diverse atmospheric conditions**, thus increasing their **lifespan** (Charlet, 2018; NAS, 2018). At present these **capabilities** remain **limited** and dependent on highly advanced techniques and laboratory equipment, which is why most experts believe there have to date been no mass casualty bioterror attacks (NAS, 2018). However, the NAS notes that improvements in **synthesis tech**nology have followed a ‘**Moore’s Law**–like’ curve for both reductions in costs and **increases** in the length of **constructs** that are **attainable**’, and that ‘these **trends** are likely to **continue’** (NAS, 2018, pp. 18–19). Moreover, automated DNA synthesis techniques remove much of the time-consuming and technically difficult aspects of manipulating DNA, further reducing barriers to access (Wintle et al., 2017). And in the future, experts warn that ‘**convergent capabilities**’ between **synthetic bio**logy, **info**rmation **tech**nology, **nano**technology, and **3D printing** may enable **‘sudden’ breakthroughs** in bioweaponization (e.g. by improving **bio-agent stability** and **delivery**, providing **advance**[d]s **aerosolization** capability, and accelerating the ‘**Design**-and-**Build**’ cycle) (NAS, 2018, p. 87).

The **possibilities** of bio-weaponization will expand as these techniques **diffuse**, which are already enabling the formation of a ‘DIYbio’ movement in which amateur scientists, inventors, and others are increasingly ‘capable of doing at home what just a few years ago was only possible in the most advanced university, government or industry laboratories’ (Bennett et al., 2009, p. 1109). The new **CRIPSR**/Cas9 gene editing technique further expands the range of **genomic tinkering available** to individuals, which has been **widely embraced** by the DIYbio community as a powerful tool that ‘makes it easy, cheap, and fast to move genes around – any genes, in any living thing’ (Maxmen, 2015). The capacities of DIY **biohackers** remain limited in important ways, though the trends described above suggests they will continue to increase as barriers to advanced bio-weaponization fall (NAS, 2018). And while the risks are evident, the democratization of these techniques may also facilitate the diffusion and customization of local solutions to environmental and health challenges while enhancing popular participation in the direction of biotechnological evolution away from transnational corporate dominance (Bennett et al., 2009).

We can therefore say that these emerging technologies pose a unique kind of ‘security dilemma’: while their **development** and **diffusion** may strengthen local and global capacities to solve **environmental** challenges, they may also **imperil global security** by **unleash**ing **unique**ly **power**ful and **complex** violence capabilities. Synthetic biology is only in its early stages, and governments from the UK to China aim to ‘accelerate [its] industrialization and commercialization’ in order ‘to drive economic growth’ and ‘develop solutions to key challenges across the bioeconomy, spanning health, chemicals, advanced materials, energy, food, security and environmental protection’ (Synthetic Biology Leadership Council, 2016, pp. 13, 4). If calls for emergency action to **exponential**ly **expand** the **green economy** indeed **accelerate** these trends (Falk et al., 2018), then by 2030 (and more so by 2040) we will live in a world where genetically engineered **biofuels** dramatically increase, genetic tinkering with **crop varieties** is **normalized** to enhance agricultural resilience, and gene **drives** are deployed to control old and new **disease vectors** intensified by climate change (among other potential applications), which would **exponentially expand** the number of individuals with **biotech expertise** and **access** to the **needed equipment**. Therefore, while we have yet to experience a catastrophic bioterror attack, **rapid advances** in **synthetic bio**logy are nonetheless creating a ‘**black swan** waiting to happen’ (Bennett et al., 2009, p. 1110), and the risk is that such **black swans** could become increasingly ‘**normal**’ if this technology becomes a **key engine** of **econ**omic **growth** and **green tech**nological **innovation**.

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Cybersecurity in an age of ‘smart everything’ The second key problem with the FIR is that ‘exponential technologies’ deployed to decouple growth from environmental impact will also intensify ongoing cybersecurity threats. Cybercrime has increased to the point of costing the global economy an estimated $500–600 billion per year, while new vulnerabilities in civilian infrastructures continue to be discovered and exploited more quickly than they can be secured (Goodman, 2016). We are thus dealing with an already significant problem, though it remains important to consider how it will deepen in a world reliant on FIR-dependent solutions to the earth system crisis, especially once we take into account the cyber vulnerabilities posed by next generation information systems (Goodman, 2016). In particular, we must consider the risks associated with the incipient IOT, which is a key component of the solution-set offered by techno-optimists for decoupling economic growth by dramatically improving efficiencies in energy, transportation, and agriculture (Falk et al., 2018; World Economic Forum, 2018). One of the prerequisites of a future renewable energy system capable of providing at least 80 per cent of growing electricity demand would be the creation of national or regional ‘smart grids’ in which energy surpluses in areas with lots of wind and sun at a given time can be transmitted to areas with energy deficits. While this system would itself increase cyber vulnerabilities relative to more modular systems, the efforts of Cisco and others to enhance the efficiency of smart grids via the IOT would intensify these vulnerabilities even more. In this vision, the smart grid would form ‘an intelligent network of power lines, switches, and sensors able to monitor and control energy down to the level of a single lightbulb’, which would be enabled by IOT connected sensors that ‘monitor energy use and manage demand, time shifting noncritical applications like delaying the start of your dishwasher to the middle of the night, when energy is cheaper’ (Diamandis and Kotler, 2014, pp. 169–171). In this way, every connected device – from iPhones and laptops to dishwashers and microwaves – would become a possible point of entry for hackers to the overall network (Goodman, 2016). The IOT is also envisioned as a possible solution to traffic congestion and fuel efficiency for the future fleet of self-driving electric vehicles that are set to (potentially) transform the market over the next decade. While advocates of ‘smart’ cars and ‘smart’ cities are enthusiastic regarding the possibilities for improved energetic and economic efficiency, it would also leave vehicles vulnerable to remote hijacking, as researchers Chris Valasek and Charlie Miller demonstrated in 2014 by taking control of a 2014 Jeep Cherokee (Markey, 2015). Adding further to the IOT-hype, a recent World Economic Forum report proposes deploying it to create ‘precision agriculture’ systems, which could link farms with global positioning systems and weather data collection to monitor water and soil conditions while enabling farms to automatically optimize inputs (World Economic Forum, 2018). If these IOT powered energy, urban, and agricultural systems come into being, this would constitute an exponential expansion of attack vectors for would-be hackers, whether they come from states, criminal organizations, or non-state terrorist networks. Cybersecurity analyst Mark Goodman effectively captures the scale the problem: The IoT will be a global network of unintended consequences and black swan events … we cannot even adequately protect the standard desktops and laptops we presently have online, let alone the hundreds of millions of mobile phones and tablets we are adding annually. In what vision of the future, then, is it conceivable that we will have any clue how to protect the next fifty billion things to go online? (Goodman, 2016, pp. 301–302). In short, while the expansion of cyber vulnerabilities is already stressing if not overwhelming the defense capacities of governments, corporations, and public utilities, it is also practically assured that these vulnerabilities will expand significantly if the global economy relies on smart energy grids and the IOT to maximize energy efficiency and decouple growth from growing resource use. State securitization and totalitarian dangers The third key risk domain involves the securitization powers of states. FIR technologies may not qualitatively transform state power individually, though their convergent character could offer immense power to states that are able to systematically harness these capabilities for surveillance and militarization purposes. Unsurprisingly, such capacities are being intensively pursued by leading states. In particular, the US and China appear to be engaged in an AI arms race, with China aiming to create a $150 billion AI industry by 2030 and the Pentagon seeking to triple its AI warfare budget to match China’s ambition (Ashizuka, 2019). Military robotics is also a key field of competition, with worldwide spending tripling between 2000 and 2015 from $2.4 to $7.5 billion, and which some estimate will double again by 2025 (Allen and Chan, 2017). The US has also spent $29 billion on nanotechnology research since 2001, with about 20 per cent of its investments involving military applications (National Nanotechnology Initiative, 2019). A short list of potential military applications includes powerful and lightweight body armor, microscopic and networked nano-bots with capacities for ‘swarm intelligence’, and more compact and powerful chemical and nuclear weapons (Drexler, 2013; National Nanotechnology Initiative, 2019). The full extent of the capabilities these technologies may unleash cannot be known in advance, though it seems possible that they could become an ‘axial’ capability of states. As Deudney (2007) describes, an axial capability is one that can dominate an entire system due to its unique character. While FIR technologies may not offer axial capabilities individually, their convergent character is such that they could collectively offer an axial advantage to states able to systematically harness their potential. This could take the form of a globally networked and nano-IOT-AI powered system harnessing vast capacities for force mobilization and information gathering and processing. By integrating nanotechnology, the IOT, big data, and robotics while harnessing the processing power and flexibility of advanced AI, states may in this way be in the midst of unleashing technological capabilities that will enable them to informationalize and monitor human populations while mobilizing destructive power with an unprecedented degree of precision and sophistication. Of course, without speculating on the future, we can already see how states are taking advantage of the global information infrastructure to enhance control over the security environment. In particular, the metastasizing US security state is already in process of forging an incipient Techno-Leviathan – a ‘global-surveillance-state-in-the-making’ – whose drive for informational omniscience is pushing it beyond territorial boundaries in an effort to control the global infosphere and erode all pretense of legality and democratic oversight (Engelhardt, 2014, p. 107). And we are seeing comparable developments in China, where advances in AI, the IOT, and big data are being used to construct a ‘citizen score’ system that incentivizes ‘good’ (i.e. regime-friendly) behavior and punishes citizens for critical thinking (Mitchell and Diamond, 2018). Thus, while securitization trends in the US and China should already give us pause, they will only become more extensive and intensive by integrating increasingly advanced FIR technologies over time, which would likely be the case if the latter are relied upon to achieve decoupling.

<<PARAGRAPH BREAKS RESUME>>

The spiral of insecurity and securitization

Overall, due to the combination of **democratized violence capacities** and totalitarian state powers that it would create, the FIR would likely generate a **reinforcing spiral** of **insecurity** and securitization that produces a qualitatively new kind of **techno-authoritarianism** on a global scale. To understand how this may come about, it is first important to recognize that even if the FIR enables the global economy to grow while stabilizing the climate at 1.5 or 2 degrees C (a highly optimistic assumption), this would still (according to one study) leave 16 to 29 per cent of the world’s population (mostly in the Global South) vulnerable to lethal climate impacts (Byers et al., 2018). Technological advance could certainly improve adaptation capacities even amidst such environmental changes, but **poverty** and **deprivation** will remain difficult to reverse, and **deep grievances** felt towards the Global North – due to its primary responsibility in creating the problem whose consequences are primarily suffered in the Global South – will make **militant** and/or **terror**ist violence a **likely response**. Second, we can see that the increasing dependence of the global economy on FIR technologies would create an exponential expansion of possible bio and cyber attack vectors. In conjunction with steady advances in technologies of securitization and rising fear among policy makers and populations, it may only require a relatively ‘minimal’ attack (e.g. something comparable to 9/11, rather than the kind of million or even billion casualty attack feared by some bioterror experts) to catalyze a further threshold of intensified global securitization.

What might this threshold entail? Abstractly, it could be understood as a shift from a predominant ‘liberal’ security apparatus to an ‘authoritarian’ mode that establishes a permanent ‘state of emergency’ on a global scale (Opitz, 2011). While we can only speculate on what this might look like in practice, especially as technologies of securitization advance, it would likely involve a conjoined transformation in and integration of both technological-surveillance and institutional-legal assemblages, with the former being intensified and extended while the latter sheds all pretext of democratic oversight to become an increasingly absolutist form of sovereign authority on a global scale. Surveillance would reach from the planetary to the molecular scale through a network of satellites, distributed environmental sensors, and AI-facilitated data collection and processing techniques; military force mobilization capacities of nearly absolute speed and global reach could be created through a combination of space-based and networked AI-robotic weapons systems; and the right of the planetary sovereign to detain individuals, mobilize force without legal pretext, and constrict the mobility of people and goods to more tightly regulated territories, would be enshrined. While such an apparatus may seem far-fetched, philosopher and futurist Nick Bostrom envisions a similarly totalitarian global surveillance system as the necessary prerequisite of global security in an age of democratized weapons of mass destruction (Bostrom, 2018). And he notes that ‘thanks to the falling price of cameras, data transmission, storage, and computing, and the rapid advances in AI-enabled content analysis, [it] may soon become both technologically feasible and affordable’ (Bostrom, 2018, p. 25).

In sum, while techno-authoritarian trends are already evident in the US and China, FIR technologies would further **enhance** their capabilities while ‘**democratizing**’ WMD capacities among **n**on-**s**tate **a**ctors (Blum and Wittes, 2015). This would incentivize states to extend and deepen surveillance as far as possible while making democratic populations more willing to accept intensified securitization, therefore making it difficult to avoid an authoritarian global security apparatus.

Conclusions

To return to the question that opened this essay: can global **capitalism** solve the earth system crisis? I have shown that the answer is an ambiguous maybe: the FIR may enable economic growth to decouple sufficiently rapidly from CO2 emissions and broader environmental impacts to stabilize the earth system, though these **tech**nological **solutions** would then **intensify risks** in the domains of biosecurity, cybersecurity, and state surveillance, thereby **unleashing** a **spiral** of **insecurity** and securitization that will push global **capitalism** towards a new kind of **techno-authoritarianism**. It is thus worth showing, in a way that differs from, yet complements the arguments of degrowth advocates, that **even if** global **capitalism** can **succeed** in **stabilizing** the earth system in a context of endless **growth**, then it would likely create **security threats** and totalitarian dangers that would undermine the **desirability** of such a system.

This conclusion reinforces the need for a set of global policies that break decisively from the growth-oriented status quo. On one hand, to **dampen** these **tech**nological **trends** and improve the prospects of earth system stabilization, the **pursuit** of **GDP growth** should be **replaced** by alternative goals based on new metrics (e.g. the Genuine Progress Indicator or Index of Sustainable Economic Welfare) that more accurately represent social welfare (Kallis, 2018). The European Commission’s Beyond GDP project shows that steps are being taken in this direction, though they should go further by explicitly ending reliance on growth by placing hard caps on material-energy throughput while restructuring economies so that livelihoods are not dependent on increasing GDP (Hickel, 2019; O’Neill et al., 2018). On the other hand, many FIR technologies (especially open source synthetic biology) offer great promise for improving human welfare through advances in sustainable energy, agriculture, and medicine. Thus, transitioning beyond growth should not necessarily entail abandoning these technologies, and strong global regimes for regulating and monitoring their use would therefore be necessary. However, rather than simply strengthening existing regimes like the Biological Weapons Convention (Charlet, 2018) or relying on private sectorled initiatives to regulate emerging risks ‘without impeding the capacity of research to deliver innovation and economic growth’ (Schwab, 2017, p. 90), more far-reaching changes are needed to enhance democratic control over the pace and direction of technological innovation, thereby counterbalancing the influence of multinational firms and militaries. In particular, ‘citizens assemblies’ should be empowered to debate the relative benefits and risks posed by FIR technologies (from synthetic biology to IoT, nanotechnology, and AI) and set mandates regarding investment levels and priorities, the direction of research, and the pace of deployment, while also having the right to ‘relinquish’ certain technological trajectories if their risks are perceived to outweigh the benefits.5

#### Extinction.

**Millet ’17** [Piers and Andrew Snyder-Beattie; August 1; PhD, Senior Research Fellow at the Future of Humanity Institute, where he focuses on pandemic and deliberate disease and the implications of biotechnology; Director of Research at the Future of Humanity Institute, University of Oxford; PubMed Central, “Existential Risk and Cost-Effective Biosecurity,” https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5576214/]

How worthwhile is it spending resources to study and mitigate the chance of human extinction from **bio**logical **risks**? The risks of such a catastrophe are presumably low, so a skeptic might argue that addressing such risks would be a waste of scarce resources. In this article, we investigate this position using a cost-effectiveness approach and ultimately conclude that the expected value of reducing these risks is large, especially since such risks **jeopardize** the existence of **all future** human **lives**.

Historically, disease events have been **responsible** for the **greatest death tolls** on humanity. The 1918 flu was responsible for more than 50 million deaths,1 while smallpox killed perhaps 10 times that many in the 20th century alone.2 The Black Death was responsible for killing over 25% of the European population,3 while other pandemics, such as the plague of Justinian, are thought to have killed 25 million in the 6th century—constituting over 10% of the world’s population at the time.4 It is an open question whether a **future** pandemic could result in **outright** human **extinction** or the irreversible collapse of civilization.

A **skeptic** would have many **good reasons** to think that existential risk from disease is **unlikely**. Such a disease would need to spread worldwide to remote populations, overcome rare genetic resistances, and evade detection, cures, and countermeasures. Even evolution itself may work in humanity’s favor: Virulence and transmission is often a trade-off, and so evolutionary pressures could push against maximally lethal wild-type pathogens.5,6

While these arguments point to a very small risk of human extinction, they do not rule the possibility out entirely. Although rare, there are recorded instances of species going extinct due to disease—primarily in amphibians, but also in 1 mammalian species of rat on Christmas Island.7,8 There are also **historical** examples of large human populations being **almost entirely wiped out** by disease, especially when multiple diseases were simultaneously introduced into a population without immunity. The most striking examples of total population collapse include native American tribes exposed to European diseases, such as the Massachusett (86% loss of population), Quiripi-Unquachog (95% loss of population), and the Western Abenaki (which suffered a staggering 98% loss of population).9

In the modern context, no single disease currently exists that **combines** the **worst-case levels** of **transmissibility**, **lethality**, **resistance** to countermeasures, and global **reach**. But many diseases are **proof** of **principle** that each **worst-case** attribute can be **realized** independently. For example, some diseases exhibit nearly a **100%** case **fatality** ratio in the absence of treatment, such as rabies or septicemic plague. Other diseases have a **track record** of spreading to virtually **every** human community **worldwide**, such as the 1918 flu,10 and seroprevalence studies indicate that other pathogens, such as chickenpox and HSV-1, can successfully reach over 95% of a population.11,12 Under optimal virulence theory, natural evolution would be an unlikely source for pathogens with the highest possible levels of transmissibility, virulence, and global reach. But advances in **biotech**nology might allow the **creation** of diseases that **combine** such **traits**. Recent controversy has already emerged over a number of **scientific experiment**s that **result**ed in viruses with enhanced **transmissibility**, **lethality**, and/or the ability to **overcome therapeutics**.13-17 Other experiments demonstrated that mousepox could be modified to have a 100% case fatality rate and render a vaccine ineffective.18 In addition to transmissibility and lethality, studies have shown that other disease traits, such as incubation time, environmental survival, and available vectors, could be modified as well.19-21

### AT: Disease—2AC

#### No disease extinction.

David **Thorstad 23**, Assistant Professor of Philosophy at Vanderbilt University, was a research fellow at the Global Priorities Institute and Kellogg College, Oxford, did a PhD in philosophy at Harvard and BA in philosophy and mathematics at Haverford College, “Exaggerating the risks (Part 9: Biorisk – Grounds for doubt),” Reflective Altruism, 7/8/23, https://reflectivealtruism.com/2023/07/08/exaggerating-the-risks-part-9-biorisk-grounds-for-doubt/

2. Existential biorisk

We began this series with a distinction between two types of risks.

Effective altruists care deeply about catastrophic risks, risks “with the potential to wreak death and destruction on a global scale”. So do I. Catastrophes are not hard to find. The world is emerging from a global pandemic. There are ongoing genocides throughout the world. And nuclear saber-rattling is on its way to becoming a new international sport. Identifying and stopping potential catastrophes is an effort worth our while.

But effective altruists are also deeply concerned about existential risks, risks of existential catastrophes involving “the premature extinction of Earth-originating intelligent life or the permanent and drastic destruction of its potential for desirable future development”. Most catastrophic risks are not existential risks. A hundred million deaths would not pose an existential risk. Nor, in many scenarios, would a billion deaths. Existential risks are literal risks of human extinction, or the permanent destruction of our ability to develop as a species.

There should be little doubt that biological hazards (`biorisks’) pose a significant **catastrophic** risk to humanity in this century. The world just experienced a global catastrophe in the form of the COVID-19 pandemic and we are ill-prepared to prevent or respond to another. Catastrophic biorisks are important and neglected, and effective altruists are right to worry about that.

However, many effective altruists hold that there is a significant chance of **existential** catastrophe from biological causes.

In The Precipice, Toby **Ord** estimates the chance of irreversible existential catastrophe by 2100 due to engineered pandemics **alone** at **1 in 30**, second **only** to risks posed by **a**rtificial **i**ntelligence.

Participants at the 2008 Oxford Global Catastrophic Risks Conference estimated a median 2% chance of extinction by 2100 from engineered pandemics.

In What we owe the future, Will MacAskill writes that “Typical estimates from experts I know put the probability of an extinction-level engineered pandemic this century at around 1%”.

These are **very high numbers**. These numbers **need** to be supported by a **good deal of solid evidence**. Later in this sub-series, I will review leading arguments for the view that biorisks pose a significant existential threat in this century. I will show that these arguments fall considerably short of grounding anything like the above estimates. Crucially, we will also see that expert consensus is far more skeptical than MacAskill suggests: MacAskill’s claim could only be justified on a view which treats effective altruists as the lone experts on existential biorisk, and dismisses leading scientists, policymakers, and biosecurity professionals as non-experts.

In the meantime, I want to give some initial reasons for **skepticism** about existential biorisk. That is not to say that the bulk of the case against existential biorisk rests on these reasons for skepticism – it rests, instead, on the inability of effective altruists to provide plausible arguments in support of their risk estimates. But it does seem appropriate to begin by saying why many are skeptical of existential biorisk claims.

3. The difficulty of the problem

The main reason why scientists and policymakers are skeptical of existential biorisk is that it is **terribly hard** to engineer a pandemic that **kill**s **everyone**.

First, you would need to **reach everyone**. The virus would have to be transmitted to the most **rural** and **isolated corners** of the earth; to antarctic **research stations**; to **ships** at **sea**, including **nuclear submarines** on uncharted, long-term and isolated paths; to **doomsday preppers** in their **bunkers**; to **hermits** and **uncontacted tribes**; to **astronauts** in **space**; to each **new child** born every second; to **island** nation**s**; and so on. And you would need a transmission mechanism that could spread the virus this far **without being detected**: otherwise, those with the means would be **whisked away** to safety and might well survive.

Second, you would need a virus that was **virtually undetectable** until **all**, or nearly all humans had been **infected**. That conflicts in a **stark way** with the goal of producing a virus that is **100% lethal**, since lethal viruses tend to **leave a trace** as they **spread** through a population.

Third, you would need a virus that is **unprecedentedly infectious**. The virus would need to be capable of being transmitted, without fail, to **every human** being on the planet, in sufficient quantities to actually make them **sick**. It would need to **avoid respirators** and other forms of **protective equipment**. And it would have to **maintain** its transmissibility throughout **many generations** of **mutation**.

Fourth, you would need a virus that is **unprecedentedly lethal**, killing not **90%,** 99%, or 99.999% but effectively **all** of those infected by it, no matter their age, health, or genetic makeup. This lethality would need to be **preserved** even against the **best medical treatments**, including quite possibly vaccines or synthesized antibodies. And it would have to be maintained throughout many generations of **mutation** despite **selective pressures** towards **less lethal variants**.

Fifth, you would need to find a way to evade **basic public health measures** such as masking and social distancing. This **isn’t** as **easy** as it sounds. How do you transmit a virus to someone who doesn’t leave their house?

Sixth, you would need the technological capability and equipment to **synthesize** the hypothesized biological agent, something it is **widely agreed** that humanity **currently lacks**.

Finally, you would need to find someone **crazy enough** to manufacture and **deploy this** biological agent, yet also **competent enough** to **pull it off**, which we have seen is no easy feat.

I am not sure if I would go so far as to say that the above is physically impossible. But without a **very good argument**, we should regard it as **highly implausible** that all of the above will come to pass by the end of the century.