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#### States should

#### - require private entities require all satellites be launched with active debris removal shepherd satellites, launch Active Debris Removal satellites, and require all satellites be equipped with systems to enable spacecraft to deorbit themselves.

#### - inject large amounts of ice particles into the lower stratosphere in late fall, especially in Antarctica.

#### - fully fund and launch the Near-Earth Object Surveyor Mission

#### Plank [1] solves debris – studies prove ADR and self-de-orbit is effective in the context of mega-constellations explicitly

ESA 18 – [European Space Agency, “Curbing space debris in the era of mega-constellations,” 7/18/2018, https://www.esa.int/Enabling\_Support/Preparing\_for\_the\_Future/Discovery\_and\_Preparation/Curbing\_space\_debris\_in\_the\_era\_of\_mega-constellations]

Two ESA-led teams of researchers carried out investigations as part of this endeavour. The MEGACO study, consisting of representatives from Airbus, Braunschweig Technical University and École polytechnique fédérale de Lausanne, set out to understand the complexity of mega-constellations in general, including a focus on collision avoidance and dealing with satellites that have reach b ed the end of their lives. Meanwhile, a team from Thales Alenia Space explored two specific methods of removing debris, including failed satellites, from orbit.

The MEGACO team investigated three theoretical mega-constellations. For each one, they analysed the space and ground infrastructure required to operate the constellation, assessed different end-of-life strategies, looked at collision avoidance requirements, and investigated associated costs and risks.

"One aim of MEGACO was to design a set of spacecraft that can deorbit themselves, and to figure out what to do with failing spacecraft,” explains Kate Symonds, systems engineer responsible for the MEGACO study on ESA’s side.

The team selected one mega-constellation concept for further study and looked at more specific operational requirements.

“Our final investigations included exploring having spare satellites, carefully controlling launches and orbits to avoid collision, and using ‘shepherd satellites’ – in the same plane but in a lower orbit – that capture dead spacecraft and deorbit them,” Symonds continues. “This research will feed into future ESA studies on mega-constellations.”

The team from Thales Alenia Space looked more closely into actively deorbiting dead satellites. They identified two theoretical constellations (named Mega1000 and TAS3200) and produced a different Active Debris Removal (ADR) design for each.

“Without ADR, a failed spacecraft can remain in orbit for hundreds of years,” explains Robin Biesbroek, the ESA systems engineer overseeing the project. “This could affect other spacecraft in that orbit and result in lots of debris and many collisions.”

Similar to MEGACO’s shepherd satellite idea, the first ADR design includes a chaser satellite containing capture equipment that is launched with the rest of the constellation. When a spacecraft fails, the chaser captures it using a net and both spacecraft re-enter Earth’s atmosphere and burn up.

The other design puts three ADR spacecraft into space at once in a dedicated launch. Each spacecraft uses a robotic arm to capture and de-orbit at least 35 pieces of debris, one after another, before completely burning up on re-entry.

“Both techniques are viable options for Active Debris Removal, with the second being especially effective at removing a lot of debris,” Biesbroek concludes.

These two studies present exciting ideas for dealing with end-of-life mega-constellation spacecraft, and they will feed into new research by Clean Space, which continues to develop technologies required for ADR and collision avoidance.

#### Plank 2 solves ozone depletion

* Note: PSCs = polar stratospheric clouds

Nagase et al. 15 (H. Nagase, D. E. Kinnison, A. K. Petersen, F. Vitt, G. P. Brasseur, 3/30/15, American Geophysical Union, “Effects of injected ice particles in the lower stratosphere on the Antarctic ozone hole”, <https://doi.org/10.1002/2014EF000266>, Accessed 1/27/22, HKR-RKT)

In this study, it was found that the depth of the ozone hole could be significantly reduced by supplying ice to the Antarctic lower stratosphere in late fall (May) before heterogeneous reactions on the surface of natural PSC particles start to activate chlorine. If a sufficiently large amount of ice is injected under favorable conditions, it should remain during several days as ice, and could provide an uptake mechanism for HCl before the formation of PSCs and the activation of chlorine species, if the size of the particles is sufficiently large and sedimentation is sufficiently fast. Without any action, it will take about 40 years for the Antarctic ozone hole to disappear. During this period, the Antarctic region will continue to be exposed to UV-B, with potential impact on living organisms. The proposed approach, which supplies ice to the stratosphere, is designed to accelerate the recovery of ozone in the Antarctic without generating major side effects. Furthermore, because Antarctic ozone is projected to recover in the coming decades, the changes in tropospheric climate forced by ozone depletion in the last decades, specifically in the southern hemisphere, are likely to be reversed in the 21st century. The recovery of ozone may counteract on the tropospheric circulation change caused by increase of greenhouse gases [Son et al., 2008, 2010; Gillett and Son, 2012], and climate may therefore benefit from the proposed geo-engineering approach. It was also found that CFCs were transported upward by supplying ice, so that their atmospheric degradation may be accelerated under the proposed method. Thus, because CFCs are strong greenhouse gases, supplying ice may be useful for mitigation of global warming. The impact of injecting ice in the stratosphere on climate forcing and the related climate response needs to be further investigated, using comprehensive three-dimensional climate-chemistry models and investigate possible influences on the climate system over a long period.

**Plank 3 solve collisions – ground astronomy is useless**

**McFall-Johnsen 21** – [Morgan, NASA is finally advancing a space telescope that could track down dangerous asteroids before they strike Earth, <https://www.businessinsider.com/nasa-advances-asteroid-tracking-space-telescope-after-years-of-limbo-2021-6>] note – the Near-Earth Object Surveyor Mission is referred to as “NEO Surveyor” for short

**To protect the planet from an** incoming **asteroid, experts estimate they'd need five to 10 years' warning that a space rock was headed our way.** Right now, an asteroid could easily approach Earth without anyone seeing it, since **telescopes on the ground can only do limited surveillance. "What you want to do is** find them early, **find them as early as possible —** as in years, or even decades, before they pose a threat," Paul Chodas, the manager of NASA's Center for Near-Earth Object Studies, [previously told Insider](https://www.businessinsider.com/nasa-might-advance-asteroid-hunting-space-telescope-2021-5). "The dinosaurs didn't have a space program, and look what happened to them. We have a space program. And given enough time, we can do something about this threat." **NEO Surveyor would help NASA catalogue nearby asteroids and chart their paths through the solar system, so that** someday — if necessary — **humanity may have a shot at destroying or deflecting any space rocks on a collision path with Earth.** For years, work on this kind of infrared telescope had been caught in "NASA mission limbo hell," MIT astronomer Richard Binzel [previously told Insider](https://www.businessinsider.com/nasa-might-advance-asteroid-hunting-space-telescope-2021-5). Now the project is finally moving forward. **NASA needs a space telescope to defend Earth from city-crushing asteroids** Experts from around the world [practiced for a hypothetical asteroid strike](https://www.businessinsider.com/nasa-asteroid-simulation-reveals-need-years-of-warning-2021-5) in April. It didn't go well. At the Planetary Defense Conference, a group of 200 participants from about two dozen countries worked through a hypothetical scenario in which an asteroid was set to crash into Earth in six months. They determined that no existing technologies could stop the space rock, since the time frame was too short to launch a mission that could destroy or deflect an asteroid. W**ithout a space telescope like NEO Surveyor, it's very possible that an asteroid could sneak up on our planet like the one in the April simulation. It has already happened a few times.** In 2013, a house-sized asteroid screamed into the skies above Chelyabinsk, Russia and exploded. The blast sent out a shock wave that broke windows, damaged buildings, and injured more than 1,400 people. No one on Earth saw it coming. That same day, a [larger asteroid](https://www.npr.org/sections/thetwo-way/2013/02/15/172080937/no-link-between-meteor-that-hurt-hundreds-and-asteroid-about-to-fly-by) came within 17,000 miles of the planet. Jim Bridenstine, who served as the Trump administration's NASA Administrator, said in 2019 that the agency's [modeling](https://www.businessinsider.com/nasa-threat-of-meteor-crashing-into-earth-is-bigger-than-you-think-2019-5) suggests an event like the Chelyabinsk meteor occurs about every 60 years. But the Chelyabinsk rock was small — about 50 feet wide. In 2019, a 427-foot, ["city-killer" space rock](https://www.businessinsider.com/asteroid-flies-close-to-earth-surprising-scientists-2019-7) flew within 45,000 miles of Earth, and NASA had almost no warning about that either. Then last August, an asteroid the size of a car passed closer to Earth than any known space rock had ever come without crashing. It missed our planet by about 1,830 miles. Astronomers didn't know the asteroid existed until about six hours after it whizzed by. Nobody saw it coming, because it was approaching from the direction of the sun. **Telescopes on the ground can only observe the sky at night, which means they miss almost everything that flies at us from the sun. NEO Surveyor, from its perch in Earth's orbit, would be able to spot such space rocks. Since it would use infrared light, it could also spot asteroids that are too dark for Earth-based telescopes.** Plans for this kind of space telescope have been in the works since 2005, when Congress mandated that NASA find and track 90% of all near-Earth objects 140 meters (460 feet) or larger in size. That's big enough to obliterate a city like New York. The NEO Surveyor team is forging ahead — maybe with a budget boost Mainzer first submitted the idea for an asteroid-hunting space telescope in 2006. NASA declined to take it on as a mission, funding other projects instead. She submitted proposals in 2010 and 2015 as well, but the agency kept passing. NEO Surveyor finally [became an official NASA mission](https://www.businessinsider.com/nasa-space-telescope-to-detect-deadly-asteroids-2019-9) in 2019. Since then, the project has been in what NASA calls "Phase A" — a stage focusing on design and technology development. Now that they're moving on to Phase B, Mainzer and her team can start building prototypes and developing hardware and software. **They could soon get a major influx of cash, too. NASA's budget request for 2022 allots** [**$197 million**](https://www.nasa.gov/sites/default/files/atoms/files/fy2022_congressional_justification_nasa_budget_request.pdf) **for planetary defense, including $143 million for NEO Surveyor — though Congress must still approve it. That would be a significant increase from the $28 million the mission received in 2021. NASA Associate Administrator Thomas Zurbuchen** [**estimated**](https://spacepolicyonline.com/news/nasas-new-neo-mission-will-substantially-reduce-time-to-find-hazardous-asteroids/) **in 2019 that developing the telescope could cost about $500 to $600 million in total.**

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#### Private LEO mega constellations drive rapid SatCom 6G innovations – that’s key to pervasive communication services that solve medical data flow deficits and solve UN SGDs

Höyhtyä et al 22 Marko Höyhtyä, Senior Member, IEEE, Sandrine Boumard, Anastasia Yastrebova, Pertti Järvensivu, Markku Kiviranta, Senior Member, IEEE and Antti Anttonen, Senior Member, IEEE. "Sustainable Satellite Communications in the 6G Era: A European View for Multi-Layer Systems and Space Safety." arXiv preprint arXiv:2201.02408 (2022)

THE two main disruptions driving the development and rapid growth of satellite communications (SatCom) are increasing satellite constellations sizes and integration of satellite and terrestrial networks. The former also aims to provide broadband services to currently underserved areas with improved performance. The latter is related to the evolution of mobile networks where different wireless and wired technologies converge together. This creates vast amount of new opportunities in different application fields such as public safety, digital health, logistics and Internet services in developing countries. The annual space business related to 5th generation (5G) and 6th generation (6G) of communication systems is expected to grow to more than €500B during the next two decades [1]–[3]. This is more than the whole space business currently including scientific missions, earth observation (EO) and navigations. At the same time the whole space sector is in the transformation phase due to so called New Space Economy. Significant reduction of launch costs and easy and affordable access to space have attracted new innovative players to space business [4], [5]. Especially Low Earth Orbit (LEO) systems and small satellites are increasing rapidly. The most typical orbit heights are above 500 km but there are significant efforts to use also very low Earth orbits (vLEO) to provide sensing and communications services. The so called Karman line, defining where atmosphere ends and space begins, is above 80 km and orbiting objects can survive multiple perigees passages at altitudes around 80–90 km [6]. Small satellites in the range of 80-220 kg can be seen as a sweet spot [5] since they are large enough for payloads to support e.g. broadband communications [7]–[9] or synthetic aperture radar (SAR) imaging [10], [11]. A. Multi-Layer Networks 6G systems will be used to provide pervasive services worldwide in order to support both dense and less dense areas. To achieve this goal, 6G systems will need to integrate terrestrial, airborne (drones, high-altitude platforms (HAPs)) and satellite communications at different orbits [12], [13]. This means that in contrast to traditional research and development (R&D) work, network analysis, planning and optimization will be updated from two dimensions to three dimensions (3D), where also the heights of communications nodes are taken into consideration [12]–[15]. In this way, 6G networks will be able to provide drastically higher performance to support e.g., passengers in ships and airplanes. The initiatives spawned recently range from very high throughput geostationary orbit (GEO) systems to unmanned aerial vehicles (UAVs) [16]–[18] and small satellite systems dedicated to machine-to-machine (M2M) and Internet-of- things (IoT) services [19]–[21]. Especially interesting are mega-constellations consisting of hundreds to thousands of small and medium size satellites like those proprietary ones envisaged by OneWeb, Starlink, Orbcomm and Telesat to mention but a few. There is also ongoing active work in the 3rd Generation Partnership Project (3GPP) standardization to define non-terrestrial networks (NTN) with interoperable interfaces in order to have truly seamless connectivity in the future, described in detail in Section V.B. B. Space Safety and Sustainability There are not only technical drivers in the development of the multi-layer 6G networks. It is essential to develop services and technologies in a sustainable way in order to ensure high quality services also to coming generations. To mention a few examples: 1) According to International Telecommunication Union (ITU) only half of the world’s population has access to broadband services above 256 kbits/s currently [22]. 2) The COVID-19 pandemic has shown that video communications provide means for people and businesses, including medical professionals, and their patients to remain in virtual contact, avoiding the need for travel while remaining socially, professionally, and commercially active [23]. A comprehensive analysis to linkage between 6G and the United Nations Sustainable Development Goals (UN SDGs) from technological, business and regulation perspectives has been provided in [24], [25]. A very good overview on how European Space Agency (ESA) programs support SDGs is given in [26]. For instance, satellite communication technologies

provide e-learning in Congo, tools for telemedicine and transmission of key medical data to and from remote locations, and means to gather and share data on arctic sea and climate conditions. Thus, it supports multitude of SDGs including good health and wellbeing, climate action, quality education, sustainable cities and communities, reduced inequalities, and life on land by helping to protect terrestrial ecosystems. Therefore, modern communication networks will be purposefully designed to be socially, economically and environmentally sustainable, and they will provide means to support equality globally. The main sustainability aspects are visualized in Figure 1. In the following, we list a couple of key points from the SatCom point of view.

**SDGs stop extinction**

**UNSC 17**, \*United Nations Security Council, (December 20th, 2017, “Prevention, Development Must Be at Centre of All Efforts Tackling Emerging Complex Threats to International Peace, Secretary-General Tells Security Council”, https://www.un.org/press/en/2017/sc13131.doc.htm)

Prevention, Development Must Be at Centre of All Efforts Tackling Emerging Complex Threats to International Peace, Secretary-General Tells Security Council

Prevention and **development** must be at the **centre** of **all efforts** to address both the **quantitative** and **qualitative** changes that were emerging in threats around the world, the Secretary‑General of the United Nations told the Security Council today, as some 60 Member States participated in an all‑day debate tackling complex contemporary challenges to international peace and security. António Guterres said the perils of **nuclear weapons** were once again front and centre, with tensions higher than those during the Cold War. Climate change was a **threat multiplier** and **technology advances** had made it **easier** for extremists to communicate. Conflicts were longer, with some lasting **20 years** on average, and were more complex, with armed and extremist groups linked with each other and with the worldwide threat of **terrorism**. Transnational **drug smugglers** and **human traffickers** were perpetuating the chaos and preying on **refugees** and **migrants**. The changing nature of conflict meant rethinking approaches that included integrated action, he said, stressing that prevention must be at the centre of all efforts. **Development** was one of the **best instruments** of **prevention**. The 2030 Agenda for Sustainable Development would help build **peaceful societies**. Respect for human rights was also essential and there was a need to invest in social cohesion so that all felt they had a stake in society. He also emphasized that women’s participation was crucial to success, from conflict prevention to peacemaking and sustaining peace. Where women were in power, societies flourished, he pointed out. Sexual violence against women, therefore, must be addressed and justice pursued for perpetrators. Prevention also included preventive diplomacy, he said, noting that the newly established High-level Advisory Board on Mediation had met for the first time. The concept of human security was a useful frame of reference for that work, as it was people‑centred and holistic and emphasized the need to act early and prioritize the most vulnerable. “Let us work together to enhance the Council’s focus on emerging situations, expand the toolbox, increase resources for prevention, and be more **systematic** in avoiding **conflict** and **sustaining peace**,” he said, emphasizing the need for Council unity. Without it, he said, the parties to conflict might take more **inflexible** and **intransigent** positions, and the drivers of conflict might push situations to the point of **no return.** Japan’s representative, Council President for December, spoke in his national capacity, noting that in the 25 years since the end of the Cold War, there had been a rise in complex contemporary challenges to **international peace** and **security**. That included the proliferation of **w**eapons of **m**ass **d**estruction, the expansion of **terrorism**, and **non‑traditional challenges** such as non‑State actors and inter‑State criminal organizations. While the Council had been tackling those challenges, in most cases through a country or region‑specific context, he stressed that a human security approach was highly relevant when addressing complex contemporary challenges to international peace and security. Such an approach placed the individual at the centre, based on a cross‑sectoral understanding of insecurities. It also entailed a broadened understanding of threats and challenges. In the ensuing debate, speakers emphasized the need to **adjust** to the changing challenges to international peace and security and welcomed the Secretary General’s reform of the Organization’s security pillar and other initiatives. Many stressed the need to address **root causes** of **instability** and **conflict**, including climate change, non‑State armed groups, extremism and terrorism, as well as **poverty** and **underdevelopment**.

#### 6G uniquely solves emerging biodisasters – extinction

**Su ’21** [Zhaohui; 2021; Center on Smart and Connected Health Technologies, Mays Cancer Center, School of Nursing, UT Health San Antonio; The Hong Kong Polytechnic University, “Addressing Biodisaster X Threats with Artificial Intelligence and 6G Technologies: Literature Review and Critical Insights,” https://arxiv.org/pdf/2105.08870.pdf]

A disaster can be defined as “a serious disruption of the functioning of a community or society involving widespread human, material, economic, or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources” [47]. Based on the contributing causes, disasters are usually categorized as **natural** (eg, **earthquakes**, infectious disease-inducing epidemics, or **pandemics** of natural origin) and **anthropogenic** (eg, armed **conflicts**, **nuclear accidents**, or the release of **pathogenic genetically modified organisms** from laboratory settings). In the context of this study, **biodisasters** are defined as disasters that occur as a result of **infectious** **pathogens** **with bioweapon potential**, which are unleashed by state or nonstate actors **accidentally** and **intentionally** (eg, the Japanese government’s controversial decision to dump Fukushima’s contaminated water into the boundless and borderless ocean shared by all life forms on earth, including humans and sharks [48]). In the context of biodisasters, a state actor often takes the form of a nation that deliberately and systematically designs and develops infectious pathogens with its national interest in mind. In contrast, a nonstate actor is an individual or group acting independently to obtain or manufacture a pathogen either owing to misguidance or malice. Of note, although existing multilateral agreements prohibit the production and use of bioweapons by state actors (termed biowarfare) [49], the presence of signed agreements **does not imply** that accidental or intentional development and release of pathogens by state actors **will not occur**. The concept of “bioterrorism,” defined as the deliberate release of pathogens that could cause illnesses and deaths in society, is not the focus of this study because “**bioterrorism**” entails both deliberation and malice (eg, to elicit terror to the public) [50]; antecedents **may not necessarily apply** to Biodisaster X threats. Insights from behavioral science [51-53] and evidence regarding individual-caused mass casualty events (eg, indiscriminate mass shootings) [54-56] suggest that individual actors’ behaviors, potentially leading to the onset of Biodisaster X, may or may not include conscious deliberation to harm. In other words, while it is possible that individual actors’ malicious actions might cause **some** biodisasters, it is also possible that some individual-caused biodisasters are **accidental**. Furthermore, the term bioterrorism is **limited**, in that “**terror**” is the main outcome. We believe that for Biodisaster X, which could **upend lives**, **livelihoods**, and **economies**, “**disaster**” is a more appropriate description that sheds light on the **scale** and **severity** of its consequences and is more diverse than “terror.” Drawing insight from real-world examples, similar to the prevalent ransomware hacks, it is possible that state or individual actors could develop and utilize infectious pathogens as “ransomgens” for financial gain rather than merely aiming to generate terror in society. Therefore, under the current research context, we adopted the term “biodisaster” instead of “bioterrorism.” Furthermore, considering that various studies have discussed approaches to address state actor–initiated biodisasters [57-61], this study focuses on biodisasters that are infectious in nature, caused by individual actors, and can result in catastrophic human and economic consequences. Biodisaster X vs Disease X The risk of biodisasters, such as Biodisaster X, is **increasing** **in likelihood**: advances in technology, particularly the **availability** and **maturity** of **biotech**nology, have grown **considerably** in recent years. Inadvertently, these advances may resemble those of **Oppenheimer** [62] in facilitating the release of destructive factors. One example of the misuse of biotechnology is a microbiologist, vaccinologist, and senior biodefense researcher who worked at the United States Army Medical Research Institute of Infectious Diseases, who allegedly engineered the 2001 anthrax attacks [63-65]. While the scale of the 2001 **anthrax** attacks was minor, it demonstrated how **easily** biodisasters can occur and how **unprepared** society was for these events. As seen in the lack of **adequate preparation** and **coherent responses** to infectious disease–induced **pandemics**, including **COVID**-19 [66-69], Biodisaster X’s effects may be **compounded** to the same, if not greater, degree by **incompetence** across international, national, and regional agencies and organizations. The concept of Biodisaster X can be best understood in contrast with Disease X. In terms of similarities, both Biodisaster X and Disease X are driven by pathogens unknown to humans and have the potential to cause crippling effects on society. Furthermore, based on previous inadequacies in response to emergency events including pandemics [66-74], the world at large may be ill-prepared for both Biodisaster X and Disease X. In terms of unique attributes, compared to Disease X, Biodisaster X is more likely to have the following characteristics: (1) having a pathogen directly affiliated to a laboratory; (2) having distinctive and engineered attributes tailored by the capabilities and intentions of the developer; and (3) the origin, development, and history can be definitively ascertained upon identification of the developer, which is not possible for naturally occurring pathogens (eg, the 1918 influenza pandemic), where there is always uncertainty regarding the origin and evolutionary history of the disaster [75-77]. The Imperative of Preparing for Biodisaster X Some of the **deadliest** **pandemics**—the most recent ones ranging from AIDS, severe acute respiratory syndrome, Middle East respiratory syndrome, Ebola, and COVID-19—all have zoonotic origins [78]. Studies have further shown that for viruses that can transmit from animals to humans, especially those that can infect a diverse range of host species, the transmission speeds are **substantially amplified** once human-to-human transmission is established, and the diseases can **quickly evolve** into **global pandemics** [79]. Consequently, once a pathogen is transmissible within a population, there is a **low access threshold**: an individual actor can “obtain” these deadly pathogens **without** the need for **advanced laboratory skills** or **extensive financial resources**. However, costs to physical and mental health may reveal a counternarrative. Based on available evidence, it is difficult to determine whether an individual can be a malicious “patient zero”; an individual who intentionally contracts a novel virus intending to cause infectious disease outbreaks in a society [80]. It is not impossible to purposely study and capture known or unknown deadly pathogens that can trigger infectious diseases; microbial surveys are commonly conducted to identify novel pathogens before they pose a threat to public health [81-84]. In theory, there could be individual actors, with adequate knowledge or experience (similar to the microbiologist allegedly behind the 2011 anthrax attacks [63-65]), who may take the same actions but with different motives, ranging from scientific curiosity to ill-guided intentions. Considering the **rich biodiversity** of wildlife, along with the large number of “**missing viruses**” and “missing **zoonoses**” that remain unidentified [85], close contacts with latent deadly pathogens are **nearly impossible** to control, which in turn, renders it challenging to locate or identify individual actors who might utilize them. Advances in **synthetic biology** may further compound the situation, especially considering the scholarly endeavors using pathogens in laboratory settings, which could amount to the level of real-world pandemics (eg, laboratory-cultured viruses such as smallpox [86-88]). The likelihood of Biodisaster X increases in proportion to these factors. Overall, considering the species diversity of wildlife, the unknown factors related to the scale and severity of viruses in animals, which have the latent potential to infect humans, and the varying degrees of competency of community health centers in detecting infectious disease outbreaks in a bottom-up manner, it could be tremendously difficult for health experts and government officials to monitor potentially emerging Biodisaster X threats. However, not all hope is lost. Technology-based solutions, especially those utilizing AI and 6G technologies, can help address these issues. The Need for Advanced Technology Solutions for Monitoring and Managing Biodisaster X The Need for Technology-Based Solutions Once Biodisaster X becomes a reality, human contact will drive transmission and become the primary fuel for exacerbating infections and deaths caused by the disaster. As seen during the COVID-19 pandemic, owing to virus spread and subsequent public health policies (eg, lockdowns), many **critical** **societal** **functions** could be **substantially** **disrupted**. The potential to **control** and **contain** human and economic **consequences** of Biodisaster X, such as the functionality of the health care systems (eg, infected health care professionals) [89-91], may also become **critically undermined**. In these circumstances, **tech**nology-based solutions could be the **key** to addressing these crises, as they are different from conventional solutions; they are **not** **highly** **dependent** on physical interactions and transportation. Overall, technology-based solutions require **limited** human resources (eg, with the ability to operate without human input), can be delivered **independent** of physical human contact (eg, web-based and remote deployment), and are **immune** to infectious diseases (eg, can function in contaminated environments). Furthermore, technology-based solutions are **less vulnerable** to issues ranging from physical fatigue to mental health burdens, which are health challenges that frontline workers often face amid emergency events. The Need for Advanced Technologies To effectively predict, control, and manage Biodisaster X, which is an event with a low probability (ie, difficult to detect preemptively) and a high impact (ie, difficult to control and contain), advanced technologies are needed. While many emerging technologies can address the dangers and damages associated with Biodisaster X [92,93], 2 families of advanced technology-based solutions show particular promise, namely AI techniques and 6G technologies. Unique Capabilities of AI AI is generally considered synonymous with “thinking machines” [94], or techniques that can facilitate “a computer to do things which, when done by people, are said to involve intelligence” [95]. With AI technologies, machines can identify patterns too intricate for humans to identify and process quickly. AI techniques are widely used in areas such as natural language processing, speech recognition, machine vision, targeted marketing, and health care, including efforts to combat COVID-19 [96-99]. While technologies such as virtual reality, smart sensors, drones, and robotics could play a positive role in supporting health care professionals to cope with the pandemic [100-102], AI technologies are arguably most instrumental in addressing some of the most prominent issues health experts and government officials are faced with, ranging from pandemic surveillance to COVID-19 drug and vaccine development [103-106]. AI and machine learning techniques are particularly valuable in their ability to identify trends and patterns across large amounts of data promptly and cost-effectively; for example, in identifying or searching for specific patterns. With natural language processing, for instance, data can be extracted retrospectively from clinical records or prospectively in real time and statistically processed for insights, which, in turn, can supplement existing structured data to enrich actionable information [86]. During the COVID-19 pandemic, natural language processing models have been used to analyze publicly available information such as tweets, tweet timestamps, and geolocation data, to identify and map potential COVID-19 cases cost-effectively, without utilizing testing devices or other medical resources that involve health care professional [107]. Overall, most, if not all, AI techniques are irreplaceable in regard to administering complex tasks such as extracting useful information from large data sets. Moreover, with the continuously increasing speed of its technological advancements and applications, AI technologies are often utilized as core components in other emerging technologies [108]. Smart sensors that perform advanced tasks, such as effectively identifying and recognizing captured motions and images, often need to integrate deep learning technologies (a subgroup of AI) [109-111]. These combined insights suggest that AI techniques have great potential in monitoring and managing Biodisaster X threats. Unique Capabilities of 6G Networks 6G technologies are the next generation of wireless communication systems following 5G networks [112]. While 6G is still under development, it is envisioned as the most capable communication network currently available [112-119]. The advantages of 6G networks derive from their high data transmission speed (up to 1 terabyte per second), wireless hyper-connectivity (100 million connections per km2), low end-to-end latency (< 1 ms), reliability (1-10-9) (reliability in terms of the frame error rate, which is defined as the ratio of the number of incorrectly decoded frames to that of total transmitted frames), and high-accuracy positioning capabilities (indoor: <10 cm in 3D; outdoor: <1 m in 3D) [112-119]. Adding the fact that 6G networks also excel in their energy efficiency and spectrum efficiency, these networks can provide fast and efficient wireless reporting and access to remote computational facilities, facilitating mobile biomonitoring and disaster management. For instance, the high reliability and data transmission speed of 6G technologies will be of critical importance amid global emergency events with the scale of Biodisaster X. At the onset of the COVID-19 pandemic, many internet companies and service providers experienced outrage and were forced to reduce the amount of data individuals and organizations could utilize to ensure continuous communication for all [120]. This limitation of existing communication networks could compromise the ability of health experts and government officials to monitor and manage COVID-19–related threats and other disasters promptly and properly. Of note, in the face of an extremely deadly, contagious, and fast-developing Biodisaster X, information will be predominantly updated and exchanged remotely and over the internet. The speed and success of updating and exchanging information are highly dependent on the reliability of communication networks, in which 6G technologies excel, especially when spatial big data have been introduced for disease control and prevention since the COVID-19 pandemic [27,108,121]. Figure 1 lists visual comparisons in communication capabilities between 6G and 5G networks.

# OFF

#### Counterplan:

#### Private entities ought to invest into the appropriation of Outer Space through large satellite constellations in Low Earth Orbit in Asia for the purposes of emergency communications in the event of disaster relief or external shocks

#### Private LEO constellations are economically viable in the long term, but require upfront investment – those uniquely solve disaster response because of satellite internet’s connectivity options for island countries

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Satellite communication plays a necessary role in the global connectivity ecosystem, connecting rural and remote populations, providing backhaul connectivity to mobile cellular networks, and rapidly establishing communication in emergency and disaster response scenarios. This Asian Development Bank (ADB) Sustainable Development Working Paper, the first in a series reviewing emerging innovations in connectivity technologies, focuses on low Earth orbit (LEO) satellites, which have been in deployment for decades and are again a subject of intensive investment as new large constellations are in early stages of deployment. These new LEO constellations, such as those being deployed by Starlink by SpaceX, Project Kuiper by Amazon, OneWeb, Lightspeed by Telesat, among others, may prove to be transformational to the connectivity landscape based on their global coverage and their suitability for areas not served by fiber optic cable networks. ADB’s developing member countries are well placed to leverage and benefit from this expansion of internet connectivity, particularly for underserved geographies and countries with limited international internet bandwidth, such as landlocked developing countries and small island developing states. With their global reach and coverage, LEO constellations are expected to dramatically expand the availability of high-speed broadband internet access with levels of service that rival fiber optic cables in terms of speed and latency, and at significantly reduced price levels compared to traditional geostationary satellites. A proactive engagement with LEO solutions is likely to yield benefits as the relevant business models are still evolving. Well-informed early action by regulators and investors can ensure that developing member countries prepare for opportunities presented by the anticipated expansion of connectivity bandwidth. I. IntRoDUCtIon This Emerging Connectivity Innovations Case Study on SpaceX Starlink and low Earth orbit (LEO) satellite constellations is intended to provide readers, particularly in developing countries in Asia and the Pacific, with a background understanding of the role of satellite communications in global internet connectivity and an exploration of the potential impact of the next generation of LEO constellation systems. While the adoption of internet connectivity across the world has generally increased incrementally, some innovations have been transformational, dramatically expanding the geographic reach of connectivity and bandwidth capacity. For example, the introduction of basic mobile phones in the late 1990s and early 2000s led to rapid adoption of mobile telephony across low- and middle-income countries (a phenomenon known as the “mobile miracle”). Similarly, public and private investment in undersea fiber optic cables circling sub-Saharan Africa in the 2000s significantly reduced the cost of bandwidth in many countries in the region. Satellites have used low Earth orbits since the beginning of space exploration; however, private investment in LEO constellations, consisting of hundreds or thousands of satellites, has been limited because significant up-front capital expenditure is required. While it remains to be seen how the next generation of LEO satellite constellations will evolve, LEOs are forecasted to significantly increase the available internet bandwidth in remote and rural geographies not currently served by fiber optic cables. This increased bandwidth could be leveraged to increase economic and social development opportunities for individuals, organizations, businesses, and government facilities (including public schools) located in these areas, provided that the private sector satellite companies investing in LEO constellations see market opportunities to extend service to these areas. This case study is intended to introduce to Asian Development Bank developing member countries how to start preparing for the expansion of LEO satellite communication services. II. BACKGRoUnD: sAteLLIte ConneCtIVItY As A MeAns FoR BRoADBAnD InteRnet Internet connectivity has become a necessary component of every country’s critical infrastructure given the reliance of all aspects of economic activity, governance, and social development on internet communications. The coronavirus disease (COVID-19) pandemic dramatically increased the importance of internet communications infrastructure. Trade, employment, learning, leisure, and communications quickly shifted into the digital sphere and countries with robust internet infrastructure and high adoption rates of internet-enabled devices were better able to adjust and adapt to the shift to digital activity. The United Nations estimates that 1.6 billion learners were affected by school closures in 2020, affecting 94% of the world’s student population and up to 99% in low and lower middle-income countries.1 1 United Nations. 2020. Policy Brief: Education during COVID-10 and beyond. 2 ADB Sustainable Development Working Paper Series No. 76 Access to distance learning opportunities varies greatly by country and income groups, with estimates of less than half of students in low-income countries able to access distance learning.2 Internet access and adoption in the developing member countries (DMCs) of the Asian Development Bank (ADB) continues to grow, particularly as a result of public and private investment in telecommunications infrastructure, increased competition, and allocation of shared resources, such as spectrum auctions and assignment. Despite these efforts, large access gaps remain in Asia, where the most remote, difficult to reach, or sparsely populated districts remain disconnected, leaving more than half of the population without access to the internet. This lack of digital infrastructure represents a missed opportunity to accelerate economic and social development. Despite the rapid expansion of internet connectivity infrastructure across the world, significant gaps in internet adoption and infrastructure access remain. This highlights the importance of satellite communications that can bridge gaps, swiftly expand network coverage, and enhance existing infrastructure. The latest estimates from the International Telecommunication Union (ITU) show that 3.7 billion people are still not participating online (49% of the global population), and 63% of rural households are without internet access (Figure 1).3 Also, 1.5 billion people reside in areas without high-speed mobile data coverage (fourth generation long-term evolution or 4G LTE), while 607 million people reside in areas with no mobile data coverage at all (at least 4G or third generation [3G] coverage). Furthermore, 313 million people reside in areas with only basic voice and short messaging service (SMS) coverage (second generation [2G]), and 220 million people reside in areas with no cellular coverage. The ITU estimates that nearly $428 billion is required to achieve universal access to broadband globally, $251 billion of which is required for Asia, with approximately 75% coming from the private sector and the remainder with support from the public sector.4 The majority of the world’s population, over 5 billion people, live more than 10 kilometers (km) away from any fiber optic cable infrastructure (3.6 billion reside more than 25 km away).5 Other issues, such as affordability, digital literacy, and the lack of relevant or local language content, have resulted in 2.4 billion people who live within 4G coverage not subscribing to 4G data services. [FIGURE 1 OMITTED] Satellite connectivity is predominantly used for backhaul connectivity for remote cellular base stations and as a last-mile connection for individual subscribers and enterprises. Figure 2 provides an overview of the internet infrastructure network components, from international connectivity to the last mile. Because of the higher relative cost of bandwidth transmitted via satellite versus terrestrial technologies, satellite is currently primarily used in situations where fiber optic cables and other high-capacity technologies are not financially viable due to low population densities and large distances between high-capacity networks and last-mile networks.6 However, in a few cases, satellite connectivity is relied upon for international internet gateway traffic or as part of a country’s core network. For landlocked developing countries that are dependent on terrestrial fiber connectivity, in some cases, satellite connectivity serves as a substitute to complex bilateral and multilateral negotiations to extend costly fiber connectivity to their country. [FIGURE 2 OMITTED] Satellite connectivity is predominantly used for backhaul connectivity for remote cellular base stations and as a last-mile connection for individual subscribers and enterprises. Figure 2 provides an overview of the internet infrastructure network components, from international connectivity to the last mile. Because of the higher relative cost of bandwidth transmitted via satellite versus terrestrial technologies, satellite is currently primarily used in situations where fiber optic cables and other high-capacity technologies are not financially viable due to low population densities and large distances between high-capacity networks and last-mile networks.6 However, in a few cases, satellite connectivity is relied upon for international internet gateway traffic or as part of a country’s core network. For landlocked developing countries that are dependent on terrestrial fiber connectivity, in some cases, satellite connectivity serves as a substitute to complex bilateral and multilateral negotiations to extend costly fiber connectivity to their country. Particularly in situations where a high degree of data throughput is required per site, such as satellite backhaul for broadband cellular networks, the data volumes as well as the distance to the nearest backbone node play a significant role in cost comparisons between satellite connectivity versus terrestrial network deployments (microwave backhaul, in particular). Figure 4 illustrates how higher data bandwidth requirements are more cost-effectively supplied by terrestrial ground networks; however, a crossover point occurs where satellite capacity may end up being more cost-competitive, depending on different price points of satellite bandwidth and total traffic demand per month.12 Satellite connectivity is also well- suited to deploy in emergency situations, such as in response to natural disasters or other external shocks, that require expeditious deployment of network connectivity where terrestrial infrastructure is either nonexistent or destroyed. For many rural and remote communities, satellites are the only connectivity option. For geographies without direct access to fiber optic cable infrastructure or at great distances from high- capacity bandwidth capacity, satellite connectivity is the only option available. Even where terrestrial network infrastructure that could be used for backhaul connectivity is available, satellite deployments may still be preferred because satellite terminals require only electrical power and a clear line of sight to the sky. However, an expansion of terrestrial infrastructure usually requires extensive civil works (underground fiber ducts, pole attachments, or tower construction for cellular base stations), which comes with challenges such as securing the rights-of-way, permits, and having to pay the related fees. Satellite broadband is poised to become an even more important technology for addressing the growing digital divide. As information and communication technologies play an increasingly important role in commerce, government services, health care, education, and other sectors, satellite connectivity allows communities to get connected swiftly, bypassing the infrastructure deployment challenges that come with terrestrial infrastructure deployments. The role of satellite connectivity in emergency telecommunications has also been vital where the communications satellites are heavily relied upon in disaster recovery efforts.13 Satellite technology may also be complementary with traditional wired and mobile broadband, which are better suited for densely populated areas. Satellite service could become a default solution for remote areas, allowing terrestrial services to focus on improving access in their current coverage areas. Satellite connectivity is already being used for network redundancy at national levels for international internet capacity, as well as for backup in core and backhaul networks.14 The recent $50 million loan to Kacific by ADB for the deployment of a broadband satellite, which covers large parts of Southeast Asia and the Pacific, demonstrates the relevance of satellite connectivity for unserved and underserved regions.15 By deploying new satellite technology (in the Ka-band16), Kacific’s service offering is commercially viable despite the existing presence of other major competitors in Asia and the Pacific, including global entities such as Intelsat, SES, and Eutelsat, as well as more regional players such as AsiaSat, Thaicom, MEASAT, and SKY Perfect JSAT.

#### The Asia-Pacific is the most disaster-prone region in the world – the next catastrophe is a question of when, not if

Thomas Bickford et al 15, Ph.D., senior research scientist in CNA Corporation’s China Studies division, “The Role of the U.S. Army in Asia,” May, https://www.cna.org/CNA\_files/PDF/CRM-2015-U-010431-Final.pdf

Natural disasters As Typhoon Haiyan amply demonstrated when it hit the Philippines in November 2013, natural disasters can represent a significant threat to human security. In 2012, the Asia-Pacific region experienced 93 natural disasters, which affected some 75 million people.206 It is one of the most disaster-prone regions in the world:207 it is prone to typhoons and cyclones; it contains some of the world’s most active faults and volcanos; and many areas experience massive flooding. As former USARPAC commander Lieutenant General Wiercinski has noted, the only questions are when and where the next big disaster will occur. Admiral Locklear, Commander, USPACOM has noted that climate change is one of the region’s most pressing security challenges.209 While the ability to respond to natural disasters varies widely among countries in the region, even advanced countries can require international assistance, as Japan did after the March 2011 earthquake and tsunami.

#### Disasters are an existential threat---it’s try or die for response and coordination.

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As the three spheres of our habitat evolve and erupt, human beings frequently get in the way. Natural hazards become humanitarian disasters when they expose and exacerbate human vulnerabilities—those characteristics of societies that limit their ability to avoid major damage and recover quickly.3 Such vulnerabilities range from very concrete weaknesses in infrastructure or the exposed locations of large populated areas to more intangible dimensions of economic fragility, social cohesion, and political capacity, which affect both preparedness and recovery. Although the recent historical pattern of major storms, droughts, and earthquakes can be traced (see map 1 at the end of this report), the extent of human vulnerabilities is a complex and subjective matter, often evident only after the fact. Mortality figures are typically used as indicators of the severity of disasters. By that measure, the three worst disasters in the world since 1950 were the earthquake in Tangshan, China, in 1976 (250,000 dead), the earthquake and tsunami in the Indian Ocean in 2004 (240,000 dead), and the earthquake in Haiti in 2010 (316,000 dead).4 These three earthquakes were by no means the largest in that sixty-year time frame, but they occurred where large numbers of people were exposed and unable to protect themselves. Severity also can be measured by other direct effects: destruction, dislocation, and disease. The 2010 earthquake in Haiti not only killed more than 300,000 people but injured an additional 300,000, affected 3.7 million (30 percent of the total population), caused $8 billion in damage, and was followed by 470,000 cases of cholera with 6,631 attributable deaths. The death rate from an earthquake, hurricane, or epidemic is generally much higher in poorer societies than in richer ones, where economic damage is usually the more numerically impressive consequence. Because their constituents have come to recognize how much the damage from “acts of God” can be affected by the actions, or inactions, of human beings, political leaders are increasingly being held accountable for minimizing the foreseeable risks of extreme events. “Natural Hazards, UnNatural Disasters: The Economics of Effective Prevention” is the indicative title of one important report by the United Nations and the World Bank. Reducing the risks begins with the recognition of how vulnerable many people have become. Throughout the world, in both wealthy and poor countries, ever-larger concentrations of people live in exposed locations under fragile or unprotected conditions. Infrastructure is often inadequate or deteriorating, and there is little or no awareness or preparation even for likely natural events. Those most exposed include millions in low-lying shorelines or coastal wetlands, marginal urban slums, and huge “temporary” settlements of internally displaced persons or refugees. Many of these populations depend on international humanitarian agencies to provide food and medicine and to assist local authorities in assuring adequate water, sanitation, health services, and shelter. As urban populations grow and conditions deteriorate further, reliable access to these necessities is becoming increasingly problematic for more and more people. Demographic trends best convey the scale of the challenges. In less than twenty years, the global population will rise from 7.1 billion to more than 8 billion. Key countries will grow even more rapidly. Between 2010 and 2025, Egypt is projected to grow from 81 million people to 106 million, Pakistan from 174 million to 234 million, and Nigeria from 159 million to 258 million.5 Many more people around the world will attain middle-class incomes, but a large percentage in many countries will be young and unemployed. Half the world’s population is already twenty-five years old or younger. Projections suggest that, by 2030, the world will need to provide fifty percent more food and additional fresh water equivalent to twenty new Nile Rivers.6 In that time frame, the needs of many countries, including India and China, will begin to exceed foreseeable water supplies for consumption and irrigation. The growth of earthquake-prone megacities is perhaps most telling of all. In just over a decade, metropolitan Jakarta will go from 9.6 million to 12.8 million people, Mexico City from 20 million to 24.6 million, Delhi from 22 million to 32.9 million, and Tokyo from 37 million to nearly 40 million—and these are just four of the thirty-seven cities that will then have populations greater than 10 million.7 There were only twenty-three in 2011. One of every seven or eight people in the world will be living in one of these massive metropolises, many in huge urban slums that have few, if any, services or infrastructure. Such concentrated population centers are extremely vulnerable to even normal patterns of earthquakes, storms, drought, and disease (see map 2). Epidemics that spread within such populations are especially difficult to contain. Climate volatility adds a further dimension of growing risk. Current changes in the climate of key regions portend severe near-term effects, whether or not the consequences of global warming match the worst predictions for the longer term. Since the 1980s the number of recorded natural disasters related to weather and climate has roughly doubled. According to the above-mentioned United Nations-World Bank report, “If there is no conscious change in adaptation policies to extreme events, baseline damages [even] without climate change are expected to triple to $185 billion a year from economic and population growth alone”8 (emphasis added). Nor are these risks confined to poor or middle-income countries. The world’s largest reinsurance companies, Munich Re and Swiss Re, warn of major increases in weather-related damage in both North America and Europe over the next decade.9 Contrary to critiques from global warming skeptics, the scientific and intelligence communities actually have been cautious in predicting the human effects of climate change. The April 2012 report of the Intergovernmental Panel on Climate Change (IPCC) is relatively conservative in forecasting future climate-induced disasters.10 Likewise, the National Intelligence Council handles climate change and natural disasters in a largely conventional and understated manner.11 However, an increasing number of authoritative reports have begun to highlight the dire risks of current climate trends and the need to begin assessing the potential for plausible adverse scenarios. Both the World Bank and the UN Environment Programme warned recently that the likely rise in global mean temperatures will exceed key thresholds sooner than previously expected, with implications for both severe weather and ocean surges.12 Security specialists are beginning to take these trends to heart. The Defense Science Board warned in its 2011 report that climate changes in key regions will interact with other vulnerabilities to become serious “threat multipliers.”13 The World Economic Forum highlights the interactive implications of climate changes with governance, fiscal, population, and technology vulnerabilities.14 A recent report of the National Research Council called on foreign policy experts to consider more systematically the political and security implications of foreseeable climate changes, suggesting that “it is prudent for security analysts to expect climate surprises in the coming decade, including unexpected and potentially disruptive single events as well as conjunctions of events occurring simultaneously or in sequence, and for them to become progressively more serious and more frequent thereafter, most likely at an accelerating rate.”15 Despite the pervasive dysfunction of most governments in addressing “climate surprises” and other disaster vulnerabilities, we will no doubt see environmental risks beginning to shape the political expectations of senior officials and thought leaders. As in the Cold War or the current ”war on terror,” responsible policymakers must look not only to the familiar and most imminent threats but also to less likely but higher-impact scenarios that could be truly catastrophic for national security, particularly if sudden and unanticipated.16 Not unlike other threats to peace and security, the inability to predict with certainty the location and timing of future natural disasters should not obscure a nation’s vital interest in assessing their likelihood and potential aftereffects.

Local Catastrophes and Global Repercussions

The challenge is to envision plausible threats and sequential patterns of potential danger—not to scare people but to anticipate potential consequences and devise strategies to prevent or reduce economic, political, and social damage. The National Research Council suggests using analytical “stress” tests of particular countries or regions to envision the effects of major disasters, or clusters of disasters, even if some of them should be considered unlikely. History offers examples of catastrophes that illustrate the possible ripple effects from otherwise local disasters. The Lisbon earthquake, tsunami, and fire of 1755 destroyed that city and decisively degraded Portugal’s role as an imperial power.17 The Spanish flu epidemic of 1918–20 killed an estimated fifty million to one hundred million people worldwide and was particularly lethal among young adults, compounding the immense losses to that generation from World War I. More recently, the destruction from Hurricane Katrina on the U.S. Gulf Coast in 2005; the earthquake, tsunami, and nuclear shutdown in Fukushima, Japan in 2011; and Tropical Storm Sandy on the U.S East Coast in 2012 exposed the interconnected vulnerabilities of coastal settlements, energy infrastructures, health-care facilities, and large-scale relief and recovery operations—a complex combination for which neither the United States nor Japan was adequately prepared. Major localized disasters do not always result in irreversible setbacks. The Chicago Fire of 1871, the Boston Fire of 1872, and the San Francisco Earthquake of 1906 resulted in the major reconstruction of all three cities, making each of them more economically vibrant and resilient.18 New York will undoubtedly be better prepared after Sandy, as New Orleans was after Katrina when it faced Hurricane Isaac in August 2012. Yet both disaster specialists and mainstream media too often treat natural disasters as limited and local matters. Media focus has typically been more on immediate suffering than larger implications, direct effects than long-term consequences, and infrastructure repair than major institutional reforms. Nevertheless, as the number and scale of natural disasters increases, we are likely to witness growing public awareness and anxiety about the vulnerability of certain areas, which will become a strong political factor adding to the wider and longer-term consequences of disasters. Internet technologies will facilitate not only the rapid dissemination of distressing information about natural disasters and severe environmental conditions but also the potential for exaggerated predictions, political incitement, conspiracy theories, or even popular panic. Worst-case scenarios may then become urgent political focal points, especially those that illustrate the fragility of economic necessities, social cohesion, or public safety.19 Economic Cascades The most troubling scenarios of natural disasters involve those with simultaneous effects on major essentials: food, water, land, medicine, energy, or subsistence income. An overlapping series of earthquakes, floods, and food shortages affecting a megacity could overwhelm the capacity of national and international agencies to respond adequately. Other consequences could follow: The Fukushima nuclear meltdown, for example, led both the Japanese and German governments to announce the phasing out of their nuclear power industries—a major blow to any prospect of curbing global carbon emissions.20 Disruptive disasters in major food-producing regions could have dire global consequences. Corn, wheat, and rice crop failures would lead to price hikes and shortages in far-flung locations. The worldwide collapse of one of these major staples—for example, from a new fungal infestation in one region and a drought in another—could lead to famines, export cutoffs, stockpiling and hoarding, or cartelized supply arrangements. Such developments could create new zones of instability, hostility, and populist pretexts for aggressive steps to secure new supplies or assure future access. The drive to guarantee food sources has already prompted the governments of China, Korea, Saudi Arabia, and others to buy land in Africa and Latin America for growing food that could be diverted from global markets during shortages. Water shortages could be another cause of future conflicts. Recent intelligence analyses suggest that countries are unlikely to go to war over water,21 but the larger patterns of depletion and diversion—glacial melts in South Asia and the Andes; upstream dams in the Middle East, East Africa, and Southeast Asia; widening drought in sub-Saharan Africa—suggest that peacefully resolving some disputes over severe water shortages could be very difficult. The genocides in Rwanda and Darfur owed much to the pressures of land, food, and water competition in fomenting ethnic conflicts.22 Medicine can be another life-and-death necessity in times of emergency. It is not difficult to imagine that the government of a state facing the prospect of a deadly epidemic would take steps to seize or intercept supplies of essential medicines. After European and U.S. laboratories cloned the lethal H5N1 virus, Indonesia demanded access to the vaccine formulas to assure adequate supplies for its huge population at reasonable cost. A global pandemic from that virus or a similar microorganism could lead to travel restrictions, news blackouts, and other isolationist reactions, but also to more aggressive measures to obtain lifesaving medicine. Massive casualties could undermine the standard protocols of global cooperation among international and national agencies, reducing global effectiveness in containing disease.23 Natural disasters can also sever transportation and communication links and global supply chains—life lines for necessities—compounding the catastrophe where the disaster occurs and affecting employment even in distant locations. In 2011 both the Thai floods and the Japanese earthquake and tsunami disasters affected hard-disk and auto suppliers, causing factory shutdowns and end-product shortages on other continents. The volcanic dust cloud from Iceland in 2010 halted European air traffic for only a week or so but even then had significant effects on both business and tourism. Compare this with the massive 1883 eruption of Krakatoa and the 1815 eruption of Mount Tambora, both in Indonesia, which created longer-lasting effects around the world. The Tambora event led to what was then called “The Year Without a Summer,” because of the adverse effects on U.S. and European weather patterns.24 Social Collapse Major disasters can have social consequences when the intense stress of damage and recovery causes breaks along ethnic, religious, class, or geographic fault lines. A major earthquake in a megacity could produce violent confrontations among groups competing for scarce relief supplies and recovery assistance. Or the disaster might create reverse-urbanization pressures for millions of homeless and jobless people in suddenly uninhabitable slums. Once again, the purpose of discussing such scenarios is not to suggest that social chaos following a disaster is a given but rather to consider ways to prevent, or at least reduce, that possibility. The major quake that struck Mexico City in 1985 produced not widespread strife but inspiring solidarity in local relief and recovery operations, even among the poorest citizens.25 That city is now a prime candidate for even bigger quakes, affecting an even larger population. Joint planning for such a crisis by the United States and Mexico could reduce the possibility of greater casualties and infrastructure losses that might impel hundreds of thousands to seek entry into the United States. Sudden large-scale migrations are an increasing prospect among the effects of climate change. Low-lying islands, flood-prone coastal areas, large refugee camps, and regions of prolonged drought could provoke major population movements. The possibility of Bangladeshis pouring into India to escape delta flooding has already led the Indian government to construct a 4,000-kilometer fence to forestall such influxes. Mass migration from Africa to Europe could also result from the droughts and floods affecting an increasing number of areas. Within the continent, such forced movement could compound urbanization trends. Such cataclysms are unlikely to occur without violence.

Political Catalysts

Natural disasters can dramatically expose deep social inequities and government indifference or incompetence, fomenting opposition movements. In 1970, the government in western Pakistan responded so poorly to the cyclone that struck eastern Pakistan that it strongly contributed to the secession of what became Bangladesh. The Nicaraguan earthquake in 1972 fatally discredited the Somoza regime. The Myanmar government’s heartless response to Cyclone Nargis in 2008 was likely a further factor in the military regime’s political vulnerability and may have accelerated the recent transition there. An unprecedented drought in Syria from 2006 to 2010 disrupted agriculture in regions that then became strong supporters of the armed resistance.26 The rise in global food prices that began with a severe drought in Russia in the summer of 2010 was a key factor in provoking popular uprisings in various Arab states the following year.27 An earthquake and tsunami near Jakarta—40 percent of which is below sea level and frequently inundated by heavy rains—could render much of that city uninhabitable and set back Indonesia’s economic growth and democratic development for years. It could also reduce the country’s ability to cooperate on global issues, such as deforestation or pandemic prevention, on which its involvement has been crucial.28 An earthquake in Karachi or Delhi or a major flood in Mumbai or Lagos could cripple the economies of their respective countries and further degrade the effectiveness of government authorities to avoid serious ethnic, sectarian, or even international conflicts. Major deterioration of any one of these cities could undermine the stability of their respective regions, with direct economic and possibly military consequences for the United States. Weak governments or failed states lack the capacity to prevent even moderate disasters from becoming severe crises. For any of the above scenarios, it is insufficient for only government agencies to be aware or prepared. As the extent of global fragility in the face of natural disasters becomes more widely felt, the public may sense the start of a regional or even global slide toward scarcities of various kinds, leading to political pressures for more secure sources of necessities. Such pressures increase the risk of international confrontation and present opportunities for exploitation by terrorists, criminals, or fanatics who see increased mayhem as in their interest.29

Defensive Measures and Strategic Adjustments

Efforts to reduce the severity of natural disasters and contain their larger consequences will require three kinds of initiatives: stoic, heroic, and “ecozoic.”

Stoic Resilience

Humans continue to cope with natural disasters largely as they always have, by “weathering” them: riding out storms, putting out fires, waiting out droughts, and helping out their neighbors. The capacity of societies to withstand catastrophes is generally referred to as resilience. Such resilience depends on physical, economic, cultural, and political factors that determine a society’s ability to plan for and recover from disasters without creating major social and economic fallout. These capabilities are almost entirely the “stoic” achievements of local people—namely, doing what is necessary to survive and prosper in the places they inhabit. As with all preventive efforts, the benefits of investing in resilient infrastructure and sensible preparedness far outweigh the costs of coping with the consequences after disasters strike. Strong and enforced building codes; zoning restrictions in coastal areas; prepositioned shelters and supplies; accessible hospitals, clinics, and health workers; wellpublicized evacuation routes; and other aspects of public awareness all make a substantial difference in reducing casualties and damage. Media coverage can sometimes give the impression that those most affected by disasters depend mainly on responses from outsiders, but the reality in most cases is otherwise. People in the path of a natural event are almost always most effective in helping each other, comprising the overwhelming proportion of first and subsequent responders.30 However, the United States is neglecting a range of major domestic vulnerabilities to natural hazards that could have catastrophic consequences.31 Stephen Flynn has most ably summarized these and other ominous features of what he calls our “brittle nation.”32 The vulnerability of coastal developments along the Eastern seaboard, so tragically demonstrated during Tropical Storm Sandy, is one continuing danger. On the opposite side of the country, earthquakes present the more ominous threat. As Flynn recounts, the deteriorating earthen levees that currently protect the massive farmlands of California’s Central Valley are vulnerable to seismic effects. If seawater were to breach the levees after a major earthquake, it would contaminate one of the country’s most important food and employment sources for years to come. Prolonged heat waves and drought in the Midwest, even worse than those in 2012, could permanently devastate croplands and damage the country’s strained and outdated electrical grid. As the U.S. public health infrastructure continues to degrade, deadly epidemics could severely reduce national economic performance and shake citizens’ confidence in the competence and reliability of government at all levels. The current economic stress and political paralysis in the United States complicate the country’s physical vulnerabilities. Debt levels and ongoing deficits substantially reduce the capacity of government agencies at all levels to address infrastructure and preparedness investments that reduce disaster risks. In 2012, even normally routine federal appropriations for disaster relief after Sandy became a political football.33 While most investments in community resilience, as well as in industrial and agricultural facilities, are state and local matters, congressional gridlock on many major issues indicates the difficulty that new assertions of federal authority or leadership would face in directing infrastructure changes or restricting flood zone settlements. The domestic vulnerabilities of the United States are further compounded by the global risks to vital U.S. interests resulting from the vulnerabilities of critical infrastructure and large populations around the world. While national development strategies increasingly emphasize “disaster risk reduction” and “sustainable economies”34 and certain countries, such as Bangladesh, Vietnam, and Mozambique, have successfully lowered their casualty rates from recurrent flooding through better preparedness and infrastructure changes, their examples are not widely imitated. Even their successes may be overwhelmed eventually by the expected scale of storms and ocean surges. Ethiopia and Rwanda have implemented food security policies that have increased their ability to cope with drought and other environmental challenges. But despite initiatives such as the U.S. Agency for International Development’s (USAID) Feed the Future program, the global prospects for substantial increases in food production are uncertain at best. Worldwide expenditures on health care, including infrastructure and training, experienced an exceptional increase over the last decade, especially from the U.S. government. However, both health and agricultural improvements depend on continued donor assistance, which has already fallen significantly since the global recession.35 Most fundamental to stoic readiness is the political capacity of societies to mobilize in the face of crises. Such capacity includes the ability to make decisions quickly and cohesively, to redirect funding rapidly without corruption, and to deliver supplies and support efficiently. Even effective democratic governments, such as those of Turkey or Indonesia, might find regional, ethnic, or religious diversity becoming a source of conflict in the wake of a massive natural disaster. More troubled federal polities, such as Pakistan or Nigeria, could unravel, although Pakistan has handled three successive seasons of massive flooding with remarkable resilience. In failed or failing states, government capabilities are especially lacking, and such political capacity is the most difficult set of skills and institutions to improve, even with major development assistance from outsiders.36 International organizations and financial institutions increasingly promote disaster risk reduction. Both the World Bank and the agencies of the UN system, led by the United Nations Development Programme, advocate investments that increase resilience to environmental challenges. But the resources to back up these recommendations are not commensurate. For example, under the impetus of the 1997 Kyoto Protocol on climate change, an adaptation fund to assist with risk reductions was initiated in 2001. But that fund was not actually launched until 2007, and despite the creation of a similar green climate fund at the Copenhagen climate change summit in 2009, both initiatives remain woefully underfunded—as highlighted in the latest global gathering on climate change in Doha.37 With a huge imbalance between growing global risks to large populations and declining investments in resilience, U.S. leaders will be forced to make difficult choices. U.S. policies on development assistance will likely have to adopt a form of preventive triage, placing scarce assistance dollars where they will have the most enduring effects on resilience and adjustment, rather than where the needs of poverty reduction and other objectives of the UN’s Millennium Development Goals (MDGs) might otherwise seem greatest. Already the efforts to set a new agenda for development after the deadline for the MDGs in 2015 include some recognition of the need for a more pragmatic view of sustainability. But as with the MDGs, the political dimensions of resilience continue to receive little emphasis in current drafts of these global manifestos.

Heroic Relief

Increased resilience must be matched with enhanced capabilities for effective relief. Improving the scale and effectiveness of assistance to the victims of disasters is an essential priority not only for limiting immediate effects but also for containing political fallout. In the United States, specialized national agencies, such as the Federal Emergency Management Agency (FEMA) and the American Red Cross, are the principal organizers of emergency support, supplemented by state-level agencies, the National Guard, and countless local and national non-governmental organizations (NGOs).38 Since Hurricane Katrina in 2005, all these actors have demonstrated improved capacities to deal with storms, even as available resources for future crises are in decline. Most other developed countries have similar, though mainly national, agencies to lead relief operations. In poorer countries, capacities are more variable, often either completely localized or highly dependent on national military agencies, as evidenced during the 2004 tsunami in the Indian Ocean. The National Disaster Management Authority of Pakistan, in its response to the massive floods of 2010 and 2011, has been one of the notable civilian exceptions. Assistance to the most at-risk countries to increase their own capacity for humanitarian relief should be a donor priority. Resources for humanitarian assistance from national donor agencies have seen major growth in the past twenty years. In the United States, funding for foreign disaster assistance has had strong bipartisan support in Congress for many years, and humanitarian relief resonates strongly with large portions of the U.S. electorate. The Office of Foreign Disaster Assistance (OFDA) within USAID has had a record of operational excellence and effectiveness. Other governments also have made international humanitarian assistance a high priority. Scandinavian ministries, the United Kingdom’s Department for International Development (DFID), and the European Commission’s Solidarity Fund have been especially generous contributors to relief operations in recent times, both directly and through UN agencies. The role of major international NGOs, corporate philanthropy, and foundations has also grown, with resources that sometimes exceed those from official sources. With the expansion of heroic generosity, the delivery of disaster assistance has become a major international industry. Large companies and suppliers sell their goods and services in the wake of each major event. NGOs similarly follow devastation and suffering from place to place. Many take advantage of public attention and sympathy for disaster victims to raise large amounts of money for relief. However, the effectiveness of relief operations, and especially the transition from relief to recovery, often has been less than optimal. Repeated proposals have been made to create a more centrally coordinated system, and UN agency leaders have made major advances over the past two decades in coordinating and funding major international relief operations. In 1991, the General Assembly created an Inter-Agency Standing Committee (IASC) of UN agencies, a Central Emergency Revolving Fund (CERF), and an Emergency Relief Coordinator (ERC) within the UN secretariat. The latter evolved by the end of the 1990s into the Office for the Coordination of Humanitarian Affairs (OCHA), headed by the ERC with the rank of under-secretary-general. In 2005, following the Indian Ocean tsunami, IASC members agreed on an intensified approach to collaboration, dubbed the “cluster system,” which divided relief operations into major functional components and designated lead agencies in each sector to coordinate the work of both international organizations and NGOs. The current ERC, Valerie Amos from the United Kingdom, has undertaken further efforts to improve the performance of the relief community, in the process raising billions of dollars through consolidated appeals, including urgent “flash appeals” to donors. The January 2010 earthquake in Haiti, which received huge publicity and donations, highlighted both the best and worst features of the international cluster system—and of heroic relief efforts in general.39 Assistance followed a familiar pattern of initial energy and compassion that dissipated once the atmosphere of emergency and improvisation shifted to the long-term demands for major reconstruction and local government control. The influx of supplies and aid workers during the first year of relief was overwhelming. One year later, agencies reluctantly faced the need to shift their promises from “building back better” (as former President Clinton likes to put it)40 to the harsher choices involved in satisfying donors that their resources were accomplishing more immediate concrete effects. Addressing short-term basic human needs for water, food, and shelter—often to people living in large tent cities—is a different task from that of rebuilding basic infrastructure, restarting large and small businesses, and forging political institutions that endure after agencies depart. As all too often happens, the initial humanitarian response to Haiti was overly romantic, inconsistent, and insufficiently attuned to the unique features of the local culture, economy, and political system.41 With intense economic pressures on virtually all major donors, disillusionment with relief operations may result in political pressures to reduce assistance. Popular support for even the most sympathetic causes may begin to wither, including among generous Americans, especially if foreign crises multiply, or if the U.S. homeland itself is struck by major natural disasters that divert attention and resources to domestic priorities. The multilateral institutional cushions needed to mitigate the social, economic, and political fallout from extreme events remain ad hoc and undeveloped. G-8 and G-20 summit agendas pay some attention to these issues but with little evident follow-through from national governments.42 The UN Security Council, despite one famous session to address the security implications of HIV/AIDs in early 2000, has been erratic and unfocused in dealing with the broader security challenges of disease and disasters. As the council is the principal global institution responsible for addressing international “threats to the peace,” such neglect will need to be remedied. International financial institutions have standard approaches for assisting with disaster recovery, such as the emergency response programs of regional development banks, as well as the World Bank’s Emergency Recovery Loan program, Hazard Management Unit, and Global Facility for Disaster Reduction and Recovery (GFDRR). The International Monetary Fund has an emergency assistance facility designed to ease the fiscal effects of major disasters.43 But these economic mechanisms are not scaled for the size of the challenges ahead, and the international diplomatic and intelligence channels needed to address urgent political and security risks are relatively undeveloped. Even the example of the successful global efforts led by the World Health Organization in responding to pandemic threats from the SARS and avian flu viruses may not prevent national budget cuts in preventive and public health capacity.44 The same budgetary fate could befall otherwise promising initiatives to reduce food insecurities, such as those which the G-20 governments have endorsed. The international community deserves great credit for its recent heroic efforts to aid societies affected by natural disasters. But it is highly unlikely that multilateral relief operations are prepared to work at the necessary scale when disaster incidents multiply. As with future investments in resilience, some form of priority setting or triage may become the imposed standard for major international relief as well. Ecozoic Relocation Even the most effective combination of stoic and heroic efforts will not sustain vulnerable populations indefinitely. As sea levels and storm surges continue to rise, as key fisheries are contaminated or extinguished, as certain regions become inhospitable to agriculture, or as earthquakes or epidemics degrade the capacity of megacities to provide for their citizens, some currently inhabited parts of the planet will have to be scaled back, or even abandoned, for large-scale settlement. Particularly if global warming trends fulfill some scientific projections, the planet may impose wholesale and dramatic adjustments to the locations, dimensions, and lifestyles of human settlements on a scale akin to the major migrations imposed by ancient ice ages. Anticipating future adaptations of this magnitude, some scientists and philosophers have begun to refer to a coming “ecozoic” age of human adaptation.45 In the United States, such speculation will likely surface initially as more intense versions of familiar controversies over development or rebuilding in coastal areas or floodplains. These issues involve decisions about zoning, taxes, subsidized flood insurance,46 and the various publicly funded programs that promote or sustain coastal growth, such as beach reclamation or the building of wave barriers and dikes.47 Developers and local politicians often downplay disaster risks and the pressures from local citizens are almost always to rebuild rather than to abandon or relocate. Yet even the most stoic impulses must confront difficult choices. New Orleans is a prominent case in point regarding resettlement and reconstruction in areas prone to further flooding, such as the lower Ninth Ward. Hurricane Isaac demonstrated that the huge post-Katrina investments in floodwalls and levies involved decisions to protect certain areas at the expense of others. Such choices now confront officials and citizens on the Jersey Shore, Staten Island, and Long Island in the wake of Tropical Storm Sandy. The same issues will be replicated around the world. Government subsidies for hazard insurance or expensive engineering for stopgap measures, such as dikes, imported water supplies, or beach reclamation, will at some point no longer protect exposed populations enough to justify the resources needed to maintain them. As media coverage and public discussion increasingly focus on the most exposed areas, many people will begin to vote with their feet and look to resettle their families and businesses in areas less exposed to the hazards they witness across the globe. Real estate prices and infrastructure investments will increasingly reflect the realities of that new marketplace. Obvious areas of special exposure already justify “exit strategies” or migratory transitions. The former president of the Maldives, Mohamed Nasheed, has become a prominent spokesman for the fundamental threats of sea level increases to small island states.48 In other exposed areas—such as low-lying estuaries of Bangladesh, Burma, and Vietnam, as well as large areas of Africa—desertification, erosion, or salinization could render agriculture or adequate supplies of potable water infeasible. Water shortages may make areas of Central Asia and the Middle East impractical for continued settlement. On an even larger scale, some experts suggest that the expected growth of certain megacities will reach practical ceilings because of the physical and economic limitations of distributing food and water.49 Major epidemics could accelerate these pressures to limit or reduce some urban populations. The political and social dimensions of massive shifts in environment and population are difficult to predict, but the likelihood is that over time large groups of people will become ecologically displaced persons or “environmental refugees,” forced from their historic homelands and needing relocation to more hospitable places within or beyond national boundaries.50 Such transitions will present large political and economic challenges, both for long-term humanitarian support and for immigration laws and enforcement. If these movements involve millions of desperate people, geographic and political boundaries will become increasingly problematic. Recommendations: National Security and Global Solidarity The incidence of military conflicts between states is at a historic low; even the number of conflicts within states has declined steeply since the twentieth century.51 However, both trends could be slowed or reversed by increased vulnerabilities to natural disasters and the limits of political and economic capacity to deal with them. How should the challenges ahead be framed in terms of U.S. national security and the larger “threats to the peace”?

Citizen Safety Most governments place their highest priority on national security, which begins with ensuring the physical safety of their citizens, or as John Jay famously put it in The Federalist: “Among the many objects to which a wise and free people find it necessary to direct their attention, that of providing for their safety seems to be the first.”52 While they are used to thinking of such safety in terms of protection from attacks by military or terrorist adversaries, Americans also regard their fundamental security as dependent on access to reliable supplies of air, water, food, medicine, and shelter.53 All would likely place these subsistence needs above any threat currently on the horizon, foreign or domestic. However, it is leaders—thought leaders as well as political leaders—who define the priorities for government policy and expenditures in dealing with what they perceive as the greatest threats to the country and its citizens. Such definitions of national security generally arise as narratives developed in the course or aftermath of major international attacks or threats of attack. Historical turning points in these narratives over the last hundred years include, for example, the German attacks on U.S. shipping that provoked the country into World War I; the Japanese attack on Pearl Harbor that plunged the United States into World War II; the Berlin crisis, Korean War, and Soviet nuclear tests that intensified the Cold War; and the September 11, 2001, attacks that provoked the U.S. War on Terror. Whether or not all Americans agreed with the security rationales their leaders offered at those times, they provided bold assessments of the threats confronting the country, which gained wide acceptance. Each narrative was a necessary, and apparently sufficient, political basis to enlist political support for executive orders, policies, legislation, appropriations, treaties, and other international commitments that were consistent with the leaders’ justifications. At present there is no reasonable prospect that U.S. leaders would create a national security narrative focused on the cumulative threats from an overstressed planet.54 To mobilize popular support for the major initiatives necessary to reduce foreseeable risks, U.S. leaders would eventually have to shift their characterizations of such threats from environmental to existential and from futuristic (after 2050) to imminent (before 2020). That shift is unlikely until Americans experience a pattern of severe crises that would shift popular perceptions and political attitudes in decisively different directions. No one wants to contemplate the horrific disasters that might drive such a shift in attitudes, especially when the destruction from Katrina and Sandy seem not to have had such an effect on most political leaders. Political resistance to the recognition of these likely threats is reinforced by a suspicion that those who highlight them are also seeking to justify major government interventions and expenditures, involving severe changes in lifestyles. References to global warming, or even to obvious climate changes, sound to some audiences as code words to justify carbon caps and oil taxes. Therefore this report assumes that such mitigation programs are not foreseeable in time to avoid the climatic, economic, and demographic consequences of current trends. Indeed, it is because these trends will not be changed in time that steps must be taken to adapt to their likely effects. U.S. political and thought leaders need to fulfill their highest responsibility—for the safety of citizens—by beginning to consider a range of risk reduction policies, infrastructure investments, and preparedness strategies, including the necessary legislative and budgetary changes, that might constitute an approach to national security aimed at reducing the direct and secondary consequences of natural disasters. Whether or not the necessary stoic and heroic steps are all politically palatable, the larger arguments for them should at least be actively under current debate. As Stephen Flynn has emphasized, most of these steps would not only reduce U.S. vulnerability to extreme natural events but would also reduce the opportunities for terrorists to exploit the same vulnerabilities.55 How these competing political pressures will play out depends not only on the timing and locations of disasters but also on how soon the growing public perception of our vulnerabilities becomes a political reality. The combination in 2012 of major tornados, midwestern drought, Texas floods, Hurricane Isaac, western wildfires, Arctic ice depletion, and Tropical Storm Sandy could mark the beginning of a sea change in the electorate’s expectations of present and future exposure to natural disasters. In that event, the hardest challenge for U.S. leaders may well be to prevent the country from turning inward to focus on domestic priorities and resisting involvement in the crises of other countries or regions. Such isolationism could be expressed through intensified calls for energy independence, food selfsufficiency, foreign assistance cutoffs, and even military retrenchment. Reversing decades of generosity and pragmatism, donor fatigue and domestic needs could generate a new version of an “America First” constituency that opposes all such international engagement and punishes at the polls any politician who supports it. Collective Containment U.S. leaders also cannot ignore the national security implications of the most serious risks of disaster beyond our borders. The safety of U.S. citizens is inextricably bound through the global economy with the course of environmental events in other parts of the world. Disasters or extreme conditions that degrade major agricultural areas (Russian, Australian, or Argentinean wheat fields, Japanese, Burmese, Philippine rice), disrupt for prolonged periods key manufacturing, transportation, or communications infrastructure (greater Bangkok, Bosporus, European airspace), or create immense casualties among large stressed populations (pandemics in Pakistan, Brazil, Nigeria) could affect the stability of entire regions. The severe degradation of a megacity could snowball into wider instability and conflict if not managed collaboratively. The sooner and more deliberately U.S. leaders can articulate geographic, cultural, or economic justifications for targeting scarce assistance, the sooner they are to be persuasive to U.S. citizens. Political preparation is equally required of other governments and populations. If disasters multiply, U.S. influence with these countries will likely depend on the level of U.S. engagement, generosity, and leadership in promoting a sense of global solidarity through an agenda for collaboration on resilience, relief, and relocation options. For this purpose, the U.S. government will need to complement its domestic security rationale with a compelling diplomatic narrative that advocates the needs and priorities for dealing with events that might otherwise spark major confrontations. The alternative could well be aggressive measures by governments, desperate for necessities, to bypass market allocations or seize supplies by intercepting transports, deploying covert operations, or even initiating outright invasions. A series of functionally focused collaborations to identify and manage key risks could be indispensable to contain the political consequences of future extreme events. Whether the Security Council, the G-20, the World Health Organization, or some new or combined political coalition would be the locus for such negotiated understandings is unclear. But the likelihood is that all international institutions will have to elevate their focus and resources to address disaster scenarios and environmental vulnerabilities. The security agendas of politicians, policymakers, and intelligence personnel will likely be distracted, for the time being, by perceived dangers from rogue states armed with nuclear weapons, failed states and ungoverned areas as safe havens for terrorists, and economic criminals, such as cyberburglars, unfair traders, and intellectual property thieves. Meanwhile, the safety and prosperity of the United States, as well as peace throughout the world, increasingly will be endangered by unaddressed vulnerabilities to natural disasters and extreme environmental crises. Contention and conflict could also result from the sudden realization—or opportunistic exaggeration—among large groups of alarmed citizens that such vulnerabilities are both existential and irreversible. Given demographic and environmental trends, and the increasing vulnerabilities and probable shortages to be expected within this decade—and certainly before 2030—the threats to the peace from Mother Nature may soon come to dwarf any of the threats posed by mere mortals.

# Case

## Solvency

#### Their plan has private entities as the actor – there’s no term of art definition of Large Satellite Constellations – proves circumvention because private entities will classify whatever they want as large or not

## Collisions

#### No debris cascades, but even a worst case is confined to low LEO with no impact

Daniel Von Fange 17, Web Application Engineer, Founder and Owner of LeanCoder, Full Stack, Polyglot Web Developer, “Kessler Syndrome is Over Hyped”, 5/21/2017, http://braino.org/essays/kessler\_syndrome\_is\_over\_hyped/

Kessler Syndrome is overhyped. A chorus of online commenters great any news of upcoming low earth orbit satellites with worry that humanity will to lose access to space. I now think they are wrong.

What is Kessler Syndrome?

Here’s the popular view on Kessler Syndrome. Every once in a while, a piece of junk in space hits a satellite. This single impact destroys the satellite, and breaks off several thousand additional pieces. These new pieces now fly around space looking for other satellites to hit, and so exponentially multiply themselves over time, like a nuclear reaction, until a sphere of man-made debris surrounds the earth, and humanity no longer has access to space nor the benefits of satellites.

It is a dark picture.

Is Kessler Syndrome likely to happen?

I had to stop everything and spend an afternoon doing back-of-the-napkin math to know how big the threat is. To estimate, we need to know where the stuff in space is, how much mass is there, and how long it would take to deorbit.

The orbital area around earth can be broken down into four regions.

Low LEO - Up to about 400km. Things that orbit here burn up in the earth’s atmosphere quickly - between a few months to two years. The space station operates at the high end of this range. It loses about a kilometer of altitude a month and if not pushed higher every few months, would soon burn up. For all practical purposes, Low LEO doesn’t matter for Kessler Syndrome. If Low LEO was ever full of space junk, we’d just wait a year and a half, and the problem would be over.

High LEO - 400km to 2000km. This where most heavy satellites and most space junk orbits. The air is thin enough here that satellites only go down slowly, and they have a much farther distance to fall. It can take 50 years for stuff here to get down. This is where Kessler Syndrome could be an issue.

Mid Orbit - GPS satellites and other navigation satellites travel here in lonely, long lives. The volume of space is so huge, and the number of satellites so few, that we don’t need to worry about Kessler here.

GEO - If you put a satellite far enough out from earth, the speed that the satellite travels around the earth will match the speed of the surface of the earth rotating under it. From the ground, the satellite will appear to hang motionless. Usually the geostationary orbit is used by big weather satellites and big TV broadcasting satellites. (This apparent motionlessness is why satellite TV dishes can be mounted pointing in a fixed direction. You can find approximate south just by looking around at the dishes in your northern hemisphere neighborhood.) For Kessler purposes, GEO orbit is roughly a ring 384,400 km around. However, all the satellites here are moving the same direction at the same speed - debris doesn’t get free velocity from the speed of the satellites. Also, it’s quite expensive to get a satellite here, and so there aren’t many, only about one satellite per 1000km of the ring. Kessler is not a problem here.

How bad could Kessler Syndrome in High LEO be?

Let’s imagine a worst case scenario.

An evil alien intelligence chops up everything in High LEO, turning it into 1cm cubes of death orbiting at 1000km, spread as evenly across the surface of this sphere as orbital mechanics would allow. Is humanity cut off from space?

I’m guessing the world has launched about 10,000 tons of satellites total. For guessing purposes, I’ll assume 2,500 tons of satellites and junk currently in High LEO. If satellites are made of aluminum, with a density of 2.70 g/cm3, then that’s 839,985,870 1cm cubes. A sphere for an orbit of 1,000km has a surface area of 682,752,000 square KM. So there would be one cube of junk per .81 square KM. If a rocket traveled through that, its odds of hitting that cube are tiny - less than 1 in 10,000.

So even in the worst case, we don’t lose access to space.

Now though you can travel through the debris, you couldn’t keep a satellite alive for long in this orbit of death. Kessler Syndrome at its worst just prevents us from putting satellites in certain orbits.

In real life, there’s a lot of factors that make Kessler syndrome even less of a problem than our worst case though experiment.

* Debris would be spread over a volume of space, not a single orbital surface, making collisions orders of magnitudes less likely.
* Most impact debris will have a slower orbital velocity than either of its original pieces - this makes it deorbit much sooner.
* Any collision will create large and small objects. Small objects are much more affected by atmospheric drag and deorbit faster, even in a few months from high LEO. Larger objects can be tracked by earth based radar and avoided.
* The planned big new constellations are not in High LEO, but in Low LEO for faster communications with the earth. They aren’t an issue for Kessler.
* Most importantly, all new satellite launches since the 1990’s are required to include a plan to get rid of the satellite at the end of its useful life (usually by deorbiting)

So the realistic worst case is that insurance premiums on satellites go up a bit. Given the current trend toward much smaller, cheaper micro satellites, this wouldn’t even have a huge effect.

I’m removing Kessler Syndrome from my list of things to worry about.

#### It takes centuries and adaptation solves

Ted Muelhaupt 19, Associate Principal Director of the Systems Analysis and Simulation Subdivision (SASS) and Manager of the Center for Orbital and Reentry Debris Studies at The Aerospace Corporation, M.S., B.S. Aerospace and Aeronautical Engineering & Mechanics, University of Minnesota - Twin Cities, Senior Member of the American Institute of Aeronautics and Astronautics, “How Quickly Would It Take For the Kessler Syndrome To Destroy All The Satellites In LEO? And Could You See This Happening From Earth?”, Quora, 2/28/2019, https://www.quora.com/How-quickly-would-it-take-for-the-Kessler-Syndrome-to-destroy-all-the-satellites-in-LEO-And-could-you-see-this-happening-from-Earth

The dynamics of the Kessler Syndrome are real, and most people studying it agree on the concept: if there is sufficient density of objects and mass, a chain reaction of debris breaking up objects and creating more debris can occur. But the timescale of this process takes decades and centuries. There are many assumptions that go into these models. Though there is still argument about this, many people in the field think that the process is already underway in low earth orbit. But others, including myself, think we can stop it if we take action. This is a slow motion disaster that we can prevent.

But in spite of hype to the contrary, we will never “lose access to space”. Certain missions may become impractical or too expensive, and we may decide that some orbits are too risky for humans. Even that depends on the tolerance for the risk. But robots don’t have mothers, and if we feel it is worthwhile we will take the risk and fly the satellites where we need to.

To the specifics of the question, it will take many decades. It will not destroy all satellites in LEO. You won’t be able to see it from the ground unless you were extraordinarily lucky, and you happened to see a flash from a collision in the instant you were looking, with just the right lighting.

#### Squo tracking, shielding, and removal plans solve

Dr. Brian Koberlein 16, Professor of Physics at the Rochester Institute of Technology and PhD in Astrophysics from the University of Connecticut, “Cascade Effect”, 5-4, https://archive.briankoberlein.com/2016/05/04/cascade-effect/index.html

In the movie Gravity the driving force of the plot is a catastrophic cascade of space debris. An exploding satellite sends high speed debris into the path of other satellites, and the resulting collisions create more space debris until everything from a space shuttle to the International Space Station faces an eminent threat of destruction. Not unexpectedly, the movie portrayal of such a situation is not particularly accurate, but the risk of a debris cascade is very real.

It’s known as the Kessler syndrome, after Donald Kessler, who first imagined the scenario in the 1970s. The problem comes down to the fact that small objects in Earth orbit can stay in orbit for a very long time. If an astronaut drops a bolt, it can stay in orbit for decades or centuries. Because the relative speed of two objects in orbit can be quite large, it doesn’t take a big object to pose a real threat to your spacecraft. On the highway a small pebble can chip your car windshield. In space it can be done by a chip of paint traveling at thousands of kilometers per hour. In the history of the space shuttle missions, there were more than 1,600 debris strikes. Because of such strikes, more than 90 space shuttle windows had to be replaced over the lifetime of shuttle missions.

While that might sound alarming, it’s actually quite manageable. Upgrades and maintenance were quite common on the shuttle missions, and we tend to err on the side of caution when it comes to replacing parts. Modern spacecraft also have ways to mitigate the risk of small impacts, such as Whipple shields made of thin layers of material spaced apart so that objects disintegrate when hitting the shield rather than the spacecraft itself. We also have a tracking system that currently tracks more than 300,000 objects bigger than 1 cm, so we can make sure that most spacecraft avoid these objects.

But the risk of big collisions isn’t negligible. In 2009 the Iridium 33 and Kosmos-2251 satellites collided at high speed, destroying both spacecraft and creating more dangerous debris. It wouldn’t take many collisions like this for the debris numbers to rise dramatically, and more debris means a greater risk of collisions. In Gravity the cascade happens very quickly, triggered by a single event. The reality is not quite so grave. Instead of happening overnight, Kessler syndrome would occur gradually, raising collision risks to the point where certain orbits become logistically impractical. It could occur so gradually that we might not notice it early on, and there are some that argue it’s already underway.

The good news is that we’re aware of the threat. And, as the old saying goes, knowing is half the battle. Already we take steps to limit the amount of debris created. New spacecraft include end of life plans

to remove them from orbit, either by sending them into Earths atmosphere to burn up, or sending them to a “graveyard orbit” that poses little risk to other spacecraft. There are also plans on the drawing board to clear orbits of debris, particularly in low-Earth orbit where the risk is greatest. The cascade effect is a real risk, but it’s also one we can likely manage with a bit of ingenuity.

#### No cyber war and they prevent escalation

Longergan 4-15 [Erics Lonergan, 4-15-2022, "The Cyber-Escalation Fallacy," https://www.foreignaffairs.com/articles/russian-federation/2022-04-15/cyber-escalation-fallacy ERICA D. LONERGAN is Assistant Professor in the Army Cyber Institute at West Point and a Research Scholar at the Saltzman Institute of War and Peace Studies at Columbia University. Previously, she served as Senior Director on the U.S. Cyberspace Solarium Commission. The views expressed here are her own. HKR-MK]

In fact, the negligible role of cyberattacks in the Ukraine conflict should come as no surprise. Through war simulations, statistical analyses, and other kinds of studies, scholars have found little evidence that cyber-operations provide effective forms of coercion or that they cause escalation to actual military conflict. That is because for all its potential to disrupt companies, hospitals, and utility grids during peacetime, cyberpower is much harder to use against targets of strategic significance or to achieve outcomes with decisive impacts, either on the battlefield or during crises short of war. In failing to recognize this, U.S. officials and policymakers are approaching the use of cyberpower in a way that may be doing more harm than good—treating cyber-operations like any other weapon of war rather than as a nonlethal instrument of statecraft and, in the process, overlooking the considerable opportunities as well as risks they present.

THE MYTH OF CYBER-ESCALATION

Much of the current understanding in Washington about the role of cyber-operations in conflict is built on long-standing but false assumptions about cyberspace. Many scholars have asserted that cyber-operations could easily lead to military escalation, up to and including the use of nuclear weapons. Jason Healey and Robert Jervis, for example, expressing a widely held view, have argued that an incident that takes place in cyberspace, “might cross the threshold into armed conflict either through a sense of impunity or through miscalculation or mistake.” Policymakers have also long believed that cyberspace poses grave perils. In 2012, Secretary of Defense Leon Panetta warned of an impending “cyber-Pearl Harbor,” in which adversaries could take down critical U.S. infrastructure through cyberattacks. Nearly a decade later, FBI Director Christopher Wray compared the threat from ransomware—when actors hold a target hostage by encrypting data and demanding a ransom payment in return for decrypting it—to the 9/11 attacks. And as recently as December 2021, Secretary of Defense Lloyd Austin noted that in cyberspace, “norms of behavior aren’t well-established and the risks of escalation and miscalculation are high.”

Seemingly buttressing these claims has been a long record of cyber-operations by hostile governments. In recent years, states ranging from Russia and China to Iran and North Korea have used cyberspace to conduct large-scale espionage, inflict significant economic damage, and undermine democratic institutions. In January 2021, for example, attackers linked to the Chinese government were able to breach Microsoft’s Exchange email servers, giving them access to communications and other private information from companies and governments, and may have allowed other malicious actors to conduct ransomware attacks. That breach followed on the heels of a Russian intrusion against the software vendor SolarWinds, in which hackers were able to access a huge quantity of sensitive government and corporate data—an espionage treasure trove. Cyberattacks have also inflicted significant economic costs. The NotPetya attack affected critical infrastructure around the world—ranging from logistics and energy to finance and government—causing upward of $10 billion in damage.

But the assumption that cyber-operations play a central role in either provoking or extending war is wrong. Hundreds of cyber-incidents have occurred between rivals with long histories of tension or even conflict, but none has ever triggered an escalation to war. North Korea, for example, has conducted major cyberattacks against South Korea on at least four different occasions, including the “Ten Days of Rain” denial of service attack—in which a network is flooded with an overwhelming number of requests, becoming temporarily inaccessible to users—against South Korean government websites, financial institutions, and critical infrastructure in 2011 and the “Dark Seoul” attack in 2013, which disrupted service across the country’s financial and media sectors.

No cyber operation has ever triggered a war.

It would be reasonable to expect that these operations might escalate the situation on the Korean Peninsula, especially because North Korea’s war plans against South Korea reportedly involve cyber-operations. Yet that is not what happened. Instead, in each case, the South Korean response was minimal and limited to either direct, official attribution to North Korea by government officials or more indirect public suggestions that Pyongyang was likely behind the attacks.

Similarly, although the United States reserves the right to respond to cyberattacks in any way it sees fit, including with military force, it has until now relied on economic sanctions, indictments, diplomatic actions, and some reported instances of tit-for-tat cyber-responses. For example, following Russia’s interference in the 2016 U.S. presidential election, the Obama administration expelled 35 Russian diplomats and shuttered two facilities said to be hubs for Russian espionage. The Treasury Department also levied economic sanctions against Russian officials. Yet according to media reports, the administration ultimately rejected plans to conduct retaliatory cyber-operations against Russia. And although the United States did use its own cyber-operations to respond to Russian attacks during the 2018 midterm elections, it limited itself to temporarily disrupting the Internet Research Agency, a Russian troll farm.

These measured responses are not unusual. Despite decades of malicious behavior in cyberspace—and no matter the level of destruction—cyberattacks have always been contained below the level of armed conflict. Indeed, researchers have found that major adversarial powers across the world have routinely observed a “firebreak” between cyberattacks and conventional military operations: a mutually understood line that distinguishes strategic interactions above and below it, similar to the threshold that exists for the employment of nuclear weapons.

But it is not just that cyber-operations do not lead to conflict. Cyberattacks can also be useful ways to project power in situations in which armed conflict is expressly being avoided. This is why Iran, for example, might find cyberattacks against the United States, including the 2012–13 denial of service attacks it conducted against U.S. financial institutions, appealing. Since Iran likely prefers to avoid a direct military confrontation with the United States, cyberattacks provide a way to retaliate for perceived grievances, such as U.S. economic sanctions in response to Iran’s nuclear program, without triggering the kind of escalation that would put the two countries on a path to war.

THE ADVANTAGE OF AMBIGUITY

In addition to the ways they are used, cyber-operations also have two general qualities that tend to distinguish them from conventional military operations. First, they typically have limited, transient impact—especially when compared with conventional military action. As the Hoover Institute fellow Jacquelyn Schneider recently told The New Yorker, “If you’re already at a stage in a conflict where you’re willing to drop bombs, you’re going to drop bombs.” Unlike traditional military hardware, cyberweapons are virtual: even at their most destructive, they rarely have effects in the physical world. In the extraordinary instances when they do—such as the Stuxnet cyberattack, which caused the centrifuges used to enrich uranium in Natanz, Iran, to speed up or slow down—cyber-operations do not inflict the kind of damage that can occur in even a minor precision missile strike. And when states have launched cyberattacks against civilian infrastructure, such as Russia’s 2015 hit on Ukraine’s power grid, the impact has been short-lived. To date, cyberattacks have never caused direct physical harm; the only known indirect death associated with a cyberattack occurred in 2020, when a German patient with a life-threatening condition died as a result of a treatment interruption caused by a ransomware attack on a hospital’s servers.

In practice, governments themselves have also recognized the contrasting impacts of cyberattacks and conventional military attacks. Consider the incident between Iran and the United States that occurred in the summer of 2019: according to reports in the U.S. media, when Iran attacked oil tankers in the region and downed a U.S. drone, the Trump administration chose to respond in cyberspace, allegedly by hacking Iranian computer systems to degrade their ability to conduct further attacks against oil tankers. What stands out about this case is that there was a credible military option on the table that was subsequently revoked: President Donald Trump called off plans to conduct military strikes against Iranian targets. At the time, Trump tweeted that he changed his mind after learning of the potential for civilian casualties. By implication, a cyber-operation may have been seen as less risky precisely because it was unlikely to cause loss of life or even major destruction.

Second, in contrast to most military strikes, cyber-operations tend to be shrouded in secrecy and come with plausible deniability. Analysts have argued that uncertainty about responsibility makes interactions in cyberspace perilous and undermines deterrence. Cloaked in anonymity, so the logic goes, malicious actors can provoke conflict while remaining in the shadows. It is true that false-flag cyberattacks are common. For example, when a group linked to the Chinese government conducted cyber-operations against Israel in 2019 and 2020, it masqueraded as Iranian, presumably to confuse Israeli attribution efforts. Yet secrecy need not have negative implications: it can provide opportunities for states to maneuver in crises without the drawbacks that more conventional uses of hard power might have, such as exacerbating domestic political tensions. It can also offer a way to explore the extent to which the other side is willing to negotiate or resolve the crisis: ambiguity creates breathing space.

For example, when the United States withdrew from the Iran nuclear deal in 2018, experts worried that Iran might retaliate, perhaps by attacking U.S. personnel or U.S. interests in the Middle East. Instead, Iran appeared to respond with increased cyber-activity that was ambiguous and not escalatory. Although the Iranian cyber-operations were noted within a day of the U.S. announcement, they were not the kind of massive attack that many commentators had anticipated; they mostly appeared to be attempts to conduct reconnaissance and probe for vulnerabilities. If Iran intended for this activity to be uncovered, it would largely serve symbolic purposes—communicating Iran’s presence to the United States.

Put simply, cyber-operations by their very nature are designed to avoid war. They can act as a less costly alternative to conflict because they are ambiguous, rarely break things, and don’t kill people. By continuing to depict cyberspace as an escalatory form of warfare itself, policymakers risk overstating the role of cyber-operations in armed conflict and missing their true importance.

TOOLS NOT WEAPONS

The recognition that cyber-operations are unlikely to lead to military escalation—and that they play at most a supporting rather than decisive role in actual armed conflicts—has direct consequences for U.S. policy and strategy. For one thing, it means that the United States may have greater room to use cyberspace to achieve objectives without precipitating new crises or exacerbating existing ones. Since 2018, for example, the U.S. Defense Department has treated cyberspace as an arena in which the military can operate more routinely and proactively rather than wait to respond to an adversary’s activity. According to the Pentagon, Washington needs to “defend forward to disrupt or halt malicious cyber activity at its source.” This approach encompasses maneuvering on networks controlled by U.S. adversaries or third parties and even conducting offensive cyber-operations.

At the time that the 2018 cyber strategy was released, many experts expressed alarm that it could provoke military escalation. Adding to the concerns, in the 2019 National Defense Authorization Act, Congress authorized the secretary of defense to conduct cyber-operations as a traditional military activity, which meant that cyber-operations would no longer be treated as a form of covert action requiring a presidential finding to be approved. Yet in the four years since the defend forward concept was implemented, the escalation that many feared has not materialized. This should give some assurances to policymakers that the United States can continue to conduct offensive cyber-operations without risking a wider conflict.

In 2021, for example, U.S. Cyber Command, working with a partner government, conducted a cyber-operation to limit the ability of the Russian-linked criminal group REvil to conduct ransomware attacks. Several months later, U.S. officials acknowledged that the military had “imposed costs” against ransomware groups. There is also some evidence that efforts to counter Russian cyber-activity during the current Ukraine crisis may have blunted a more effective Russian cyberoffensive, with Nakasone alluding to work done by the Ukrainians and others to hinder Moscow’s plans.

But just because the Pentagon’s plan has not led to escalation does not mean it is tool the U.S. can use to solve all of the cyber challenges it faces. For the very same reasons that offensive cyber-operations have not led to escalation, their constraints should cast doubt on the notion that the United States can use them to coerce adversaries into changing their behavior or punish them by inflicting high costs.

Cyber operations rarely break things, or cause loss of life.

Second, the reality that cyber-operations are used by states in many different ways means that policymakers need to develop a more nuanced approach for responding to cyberthreats. Because cyber-operations are consistently seen as representing an existential threat to the United States, Washington has tended to deal with cyber-incidents of contrasting scope and scale with the same policy tools. For instance, senior U.S. officials described both Russia’s 2016 election interference and 2021 SolarWinds operation as acts of war. But the first was a cyber-enabled information operation and the second was in fact a large-scale cyber-espionage campaign—and neither resembled open war in any conventional sense. Moreover, the policy responses in both of these cases (as in many other cyber-incidents) were similar: a combination of public attribution, indictments, and sanctions. Instead of responding with inflammatory language and standard forms of retaliation, policymakers should consider how to employ cybertools and non-cybertools in ways that are tailored to specific incidents, taking into account the extent and gravity of a given operation. Responses can also be proportionate without being symmetrical. Rather than responding in kind, the United States should apply varying and more creative approaches that reflect differences in adversaries’ centers of gravity. What is important to Beijing and therefore what may motivate its behavior is different from what is important to Moscow, Tehran, and so on.

A one-size-fits-all approach to adversary cyber-operations may raise particular problems in the Ukraine conflict. Anticipating potential Russian cyberattacks against member states, NATO leaders have reaffirmed that Article 5, the treaty’s collective defense clause, applies to cyberspace, but they have also expressed ambiguity about what specific operations might trigger it. A lack of clarity about how thresholds and responses are defined risks undermining the credibility of this pledge and the effectiveness of NATO’s overall cyberstrategy.

A third lesson of cyber-operations over the past decade is that U.S. officials should adopt a more flexible mindset in their response to them. Rather than focusing on retaliatory action, the United States should devote more resources to enhancing resilience—the ability to absorb and rapidly recover from disruptive occurrences. Embracing this type of approach means accepting that cyberattacks are likely to take place and, more important, that the overwhelming majority of them will not have cataclysmic effects. Over the past several years, the United States has improved its resilience to such attacks, expanding the agencies responsible for working with and maintaining critical infrastructure, such as the Cybersecurity and Infrastructure Security Agency. The U.S. government has also created the Office of the National Cyber Director to harmonize its cybersecurity efforts and collaborate with the private sector. But these entities are still relatively new, and efforts to implement meaningful regulation of the private sector to promote resilience still have a long way to go.

A CYBER ESCAPE VALVE?

Just because cyber-operations have not yet caused escalation does not mean that they will never do so. If conflicts such as the war in Ukraine lead to greater instability in the international system and increased great-power competition, the risks of cyber-escalation may grow. The opposite is also possible, however: in a more unstable world, cyber-operations may provide an important outlet for recurring tensions, given their lack of physical violence and relatively limited effects. As international politics become more dangerous, cyberspace can offer a way for states to respond to perceived aggressions without causing physical destruction or loss of life, thus providing a kind of stability in itself.

Ultimately, escalation is in the eye of the beholder—it depends as much on the target’s perception of an event as on the perpetrator’s intent or the reality of the strategic context. Therefore, a further priority of U.S. policymakers should be to improve their understanding of how adversaries interpret Washington’s activities in cyberspace and leverage that knowledge to conduct cyber-operations that minimize the risk of escalation. During a crisis, for instance, the United States may want to avoid conducting cyber-operations in a manner that an adversary might perceive as a precursor to conflict or to a military strike, especially if that is not the intent. If there is a pressing strategic or military imperative to conduct these types of operations, they should occur in tandem with efforts to communicate their purpose to avoid misunderstandings.

For too long, policymakers have drawn the wrong lessons from cyber-operations. The absence of escalation across decades of strategic interaction in cyberspace—a record that has only been reinforced in the conflict in Ukraine—should cause policymakers to reevaluate long-standing assumptions about the cyber-domain. In doing so, they may be able to see how cyber-actions are but one of a number of strategic tools that, properly understood, can limit the risk of conflict as much as increase it. Of course, the potential for cyberattacks to temporarily paralyze large information networks or even whole sectors of an economy should not be discounted. But in a world in which armed conflict continues to destroy entire cities and wreak terrible human costs, both civilian and military, cyber-operations should be regarded less as another form of hard power than as a way for states to pursue strategic goals by other means.

#### No one’s going to war over a downed satellite

Bowen 18 [Bleddyn Bowen, Lecturer in International Relations at the University of Leicester. The Art of Space Deterrence. February 20, 2018. https://www.europeanleadershipnetwork.org/commentary/the-art-of-space-deterrence/]

Space is often an afterthought or a miscellaneous ancillary in the grand strategic views of top-level decision-makers. A president may not care that one satellite may be lost or go dark; it may cause panic and Twitter-based hysteria for the space community, of course. But the terrestrial context and consequences, as well as the political stakes and symbolism of any exchange of hostilities in space matters more. The political and media dimension can magnify or minimise the perceived consequences of losing specific satellites out of all proportion to their actual strategic effect.

## Astronomy

#### Astronomy -- they dont' solve it their evidence says that astronomy would be blocked and then they've made the jump that asteroids cause extinction without connecting why astronomy solves asteroid collisions

#### No asteroids extinction

**Walker 14** [Robert, graduate degrees in Math and philosophy, November 3 2014, Science20, “Why We Can't "Backup Earth" On Mars, The Moon, Or Anywhere Else In Our Solar System,” http://www.science20.com/robert\_inventor/why\_we\_cant\_backup\_earth\_on\_mars\_the\_moon\_or\_anywhere\_else\_in\_our\_solar\_system-148364, accessed 7/8/16, TB]

POSSIBLE DISASTERS AND BACKUPS FOR THEM So - one disaster that's often mentioned is the issue of an asteroid impact. And you often see this artist's impression, reproduced so many times in this context: If we had an impactor as big as this, a respectable size for a moon (far larger than Phobos or Deimos), 1000 kms across - that's large enough to make large areas of the Earth molten, perhaps boil the seas etc etc. It might indeed make humans extinct, or result in a devastated Earth where the few survivors can't do much. But **asteroids as large as that only hit the Earth in the first few hundred million years soon after the formation of the Moon in the late heavy bombardment, when the solar system was still settling down and full of half formed planets and embryo planets and assorted debris from their formation.** That's also when the large dark patches were created on the Moon. There is pretty close to zero chance of us getting hit by one of those now. The biggest asteroid impact crater in the geological record, two billion years ago, is a 300 km diameter crater in South Africa. Vredefort crater which was probably created by an asteroid between 5 and 10 kms in diameter. The impact that ended the Dinosaur era was 66 million years ago, and that's not that much smaller - a crater 180 km in diameter, the impactor was probably 5 to 8 km in diameter. These would have a global impact for sure. They would create an "impact winter" for several years afterwards. They might cause a global firestorm for the first few hours after the impact. If they land in the sea, they would cause enormous tsunamis. However - many humans, especially on the other side of the world, would survive, especially if given a bit of warning to shelter from the worst effects. Then - all the way through the following "impact winter" Earth would remain by far the most habitable place in the solar system, a far better place to be than Mars. Impacts of this size certainly are a possibility. But not as likely as you might guess. **The chance is about one in ten million, or 0.00001**% (given that we have found 90% of them already - found all the NEOs larger than 10 km, and thought to be probably 10% of those impacts come from longer period comets). HOW TO BACKUP Still, I agree, even a 0.00001% chance of a civilization destroying event is worth protecting against. I'm not convinced we need to devise a backup yet though, the Spaceguard approach seems more appropriate. Better to devote our efforts to detecting meteorites and to find ways to deflect them. **The dinosaurs didn't have** the **technology** that we have. With our technology - first - **we are** almost **bound to see an incoming asteroid** or comet this big, probably a couple of decades before. So - if there is an imminent strike like this - and if we can't destroy or deflect it, then I'm sure that we'd devote much of the capabilities of our civilization, for those last twenty years, to preparing for it. **We'd evacuate the impact zone**. Build shelters to shelter from the firestorm underground. If necessary supplied with oxygen and anything else needed during the firestorm. **We'd organize protection for important collections** of seeds and plants and animals. And do what **we can to create as many shelters of that kind as we can**. **We wouldn't go extinct** after such an impact, unlike the dinosaurs.

## Ozone

**No impact---positive impacts offset negative costs**

J.F. **Bornman 15**, International Institute of Agri-Food Security, Curtin University, “Solar ultraviolet radiation and ozone depletion-driven climate change: effects on terrestrial ecosystems,” Photochemical and Photobiological Sciences, Volume 14, 2015, pp. 88-107

In this assessment we summarise advances in our knowledge of how UV-B radiation (280–315 nm), together with other climate change factors, influence terrestrial organisms and ecosystems. We identify key uncertainties and knowledge gaps that limit our ability to fully evaluate the interactive effects of ozone depletion and climate change on these systems. We also evaluate the biological consequences of the way in which stratospheric ozone depletion has contributed to climate change in the Southern Hemisphere. Since the last assessment, several new findings or insights have emerged or been strengthened. These include: (1) the increasing recognition that UV-B radiation has specific regulatory roles in plant growth and development that in turn can have beneficial consequences for plant productivity via effects on plant hardiness, enhanced plant resistance to herbivores and pathogens, and improved quality of agricultural products with subsequent implications for food security; (2) UV-B radiation together with UV-A (315–400 nm) and visible (400–700 nm) radiation are significant drivers of decomposition of plant litter in globally important arid and semi-arid ecosystems, such as grasslands and deserts. This occurs through the process of photodegradation, which has implications for nutrient cycling and carbon storage, although considerable uncertainty exists in quantifying its regional and global biogeochemical significance; (3) UV radiation can contribute to climate change via its stimulation of volatile organic compounds from plants, plant litter and soils, although the magnitude, rates and spatial patterns of these emissions remain highly uncertain at present. UV-induced release of carbon from plant litter and soils may also contribute to global warming; and (4) depletion of ozone in the Southern Hemisphere modifies climate directly via effects on seasonal weather patterns (precipitation and wind) and these in turn have been linked to changes in the growth of plants across the Southern Hemisphere. Such research has broadened our understanding of the linkages that exist between the effects of ozone depletion, UV-B radiation and climate change on terrestrial ecosystems.

Introduction

We have focused mainly on recent work in order to highlight the progress made to date, and to attempt an analysis of the complexity of both independent and interacting factors on terrestrial ecosystems in terms of UV radiation and other environmental constraints, including emerging evidence of the role of stratospheric ozone trends in affecting climate.

Ozone depletion, changed exposure to ultraviolet-B (UV-B, 280–315 nm) radiation, and climate change exert both individual and interactive effects on biological systems, with intricate feedbacks.1,2 Some of the key factors interacting with UV radiation that affect organism response are water availability, temperature, and nutrient availability. UV radiation has also been implicated as a contributor to global warming through its stimulation of volatile organic compounds from plants, plant litter and soils. Emission of carbon dioxide (CO2) from plant litter and soils may also contribute to global warming.3,4

Ozone depletion modifies Southern Hemisphere summer weather through its effect on the Southern Annular Mode (SAM), with consequences for plant growth in South America, New Zealand, and Antarctica already reported.5–7 These impacts of ozone depletion on other climate factors (e.g. wind patterns, precipitation, and warming) may result in an increase in the interactive effects of UV radiation with drought and temperature. Other seasonal weather phenomena need to be taken into account to gain an accurate perspective of the different determinants of UV exposure on terrestrial organisms. These include La Niña and El Niño events, which change cloud cover, winds, sea surface temperatures, and atmospheric pressure at sea level. In addition, changes in land-use and vegetation cover, which also feed back to climate systems, have implications on the exposure, and thus response, of organisms to UV radiation.

During the course of research on the effects of UV radiation, much emphasis has been placed on the potential detrimental impacts on plants and ecosystems. However, the balance of recent evidence is shifting to show that while some detrimental effects do occur, UV radiation is also a key regulator of plant morphology and physiological, biochemical and genetic processes, and is important in animal and plant signalling. Following on from this line of investigation, it has also become apparent that UV radiation and climate variables can be usefully exploited for value-adding to, e.g., agricultural crops.8 The emerging concept, that agricultural2,9 plants can become more hardy through exposure to UV radiation, represents a marked shift in perspective.8,9 In addition, certain plants produce more medicinal compounds with exposure to UV radiation.10 The overall objective is to boost the quality and/or quantity of the yield, usually selectively, e.g. by making plants less prone to attack by pests and diseases. Concepts such as that of “eustress” are also relevant. Eustress is analogous to “priming” where a stress is imposed on plants to acclimate them and develop tolerance, which facilitates better growth when exposed to a more severe stress.9,11

Exposure to ecologically-relevant levels of UV radiation is generally not deleterious as long as plants are able to acclimatise, although this depends on the environmental conditions, including climate variables, latitudinal location12 and plant type (e.g. whether plants are herbaceous or woody). Consequently, the direct negative effects of exposure to UV-B radiation on plant growth, photosynthesis, and productivity are generally minor, or not detectable (summarised in meta-analyses by Searles et al.13 and Newsham and Robinson14). However, indirect effects of exposure to UV radiation are often more pronounced than direct effects and need to be addressed to obtain a holistic perspective of the role of UV radiation as a regulator and modifier of ecosystem and organism response.

In this current assessment, we focus on the way in which UV radiation, stratospheric ozone trends, climate and other phenomena affect the biosphere, in order to better understand the current interactive effects from different stresses and to identify possible new interactions and their implications. This will allow for an evaluation of the capability of terrestrial ecosystems to adapt to a changing environment in which UV radiation plays an integral part in the response. Additionally, an assessment of these interactive processes on organisms and ecosystems recognises that the effects of UV radiation often represent a balance of both positive and negative influences.2 Although the role of UV-B radiation is a major consideration in this paper, other relevant and often interacting factors, such as stratospheric ozone trends and climate change cannot be meaningfully separated.

**Alt causes -- loopholes, poor reports**

**Lerner 20** [Sharon Lerner, investigative reporter for The Intercept, covering health and the environment, 1-18-2020, "Ozone Layer Recovery Is Being Undermined by Pollution From U.S. Companies," Intercept, accessed 7-16-2020, https://theintercept.com/2020/01/18/ozone-layer-epa-united-states-pollution/]

THE GLOBAL RESPONSE to the “ozone hole,” as it came to be known in the 1970s, has long been held up as a model for environmental problem-solving — and the hope that we might yet be able to fix the climate crisis. After scientists realized that chemicals used for cooling and in aerosol sprays were causing the Earth’s protective ozone layer to thin, threatening to cause vast increases in cancers and other diseases, countries around the world came together to fix it. Even the companies that made and sold the chemical culprits — chlorofluorocarbons, or CFCs — participated in the Montreal Protocol, the international treaty that began phasing them out in 1989. Since then, the ozone layer has partially recovered.

The international commitment to eliminating ozone-depleting chemicals has held so firm that in 2018, when some Chinese factories were discovered to be using a substance banned by the treaty known as CFC-11, they were met with condemnation from the U.S. and other countries. Erik Solheim, head of the United Nations Environment Program, which oversees the Montreal Protocol, called the release of the ozone-depleting substance “nothing short of an environment crime which demands decisive action.” China quickly addressed the problem.

Yet evidence has recently emerged that U.S. companies are also releasing ozone-depleting chemicals. While the ozone layer is rebounding overall, scientists have observed decreasing levels of the gas in certain areas. Chemicals used for everything from fracking to cooling appear to be the culprits, according to comments the nonprofit Environmental Investigation Agency submitted to the Environmental Protection Agency in December. The chemical pollution, some of which is coming from the U.S., EPA records show, has already delayed progress on the ozone layer. The resulting setback appears to be worse in highly populated southern latitudes, where it could cause the most damage. Continued emissions of the chemicals could delay the healing of the ozone layer by up to 30 years, according to a 2017 article published in Nature Communications.

Despite the threat, the EPA has not considered impacts on ozone in initial phases of its assessment of 14 chemicals with ozone-depleting potential now being conducted under the Toxic Substances Control Act. Asked about the decision, an EPA spokesperson wrote in an email that “because ozone depletion risks are adequately assessed and effectively managed under the Clean Air Act, EPA does not expect to include ozone-depletion potential in risk evaluations” of three of the chemicals. The agency response did not address the other 11 chemicals under scrutiny.

Loopholes and Untracked Emissions

Both the Clean Air Act and the Montreal Protocol do regulate some of these short-lived chemicals that erode the ozone layer. But they make an exception when the chemicals are byproducts or used as feedstock for making other products, a loophole that may explain why some of them are still accumulating in the atmosphere more than 30 years after the treaty took effect.

Carbon tetrachloride, for instance, a potent ozone-depleting chemical that was used to make CFCs, is tightly regulated under the treaty. Nevertheless, the amount of the chemical in the atmosphere has been rising. While the exact sources of the pollution have been treated as a mystery, some of the discrepancy appears to be due to the increasing use of carbon tetrachloride as a feedstock for other chemicals, which the EPA has acknowledged is its main use. Between 2012 and 2018, U.S. companies released 1.3 million pounds of the chemical into the air. Among the biggest emitters are a Dover Chemical plant in Ohio and two plants in Geismar, Louisiana — one owned by Rubicon and the other by Occidental — according to an analysis of EPA data by the consulting firm Material Research.

Asked about Rubicon’s emission of carbon tetrachloride, Mark Dearman, the company’s general manager, said that “We’re currently operating under our air permits under the EPA and the Department of Environmental Quality of the state of Louisiana and we’re constantly working year on year to reduce our emissions and be good environmental stewards.” Occidental and Dover Chemical did not respond to requests for comment.

Levels of another ozone-depleting chemical, methylene chloride, are also on the rise, climbing 8 percent per year between 2000 and 2012, according to the most recent analysis. Methylene chloride was not regulated under the treaty because it lasts for only a short time in the atmosphere and so was once thought to have a minimal impact on ozone. But its release is responsible for much of the delay in the recovery of the ozone layer, according to the Nature Communications article.

U.S. companies, including the SI Group, 3V Sigma, and CR Bard, all of which are based in South Carolina, released 19.8 million pounds of methylene chloride into the air between 2012 and 2018, according to company reports to the EPA. In an emailed statement, SI Group spokesperson Melissa Quesnel wrote, “When methylene chloride is in use, we have engineering controls in place to recover and recycle as much as possible to limit our emissions, complying with all emission regulations.” 3V Sigma and CR Bard did not respond to The Intercept’s inquiries for this article.

But the key to understanding the chemical’s increasing levels may be what’s not tracked by the agency, since the industrial emissions of methylene chloride reported by the EPA are dwarfed by the amounts scientists estimate is in the atmosphere.

The gap may be partially explained by the chemical’s use in oil and gas production, one of the sectors whose emissions of these substances aren’t disclosed in publicly available EPA data. In addition to being used to make pesticides and plastic, methylene chloride is used in the “oil and gas drilling, extraction, and support activities sector,” according to a 2017 EPA report, and has been found in the air near fracking wells. As the number of fracking wells has increased, so have methylene chloride levels in the atmosphere.

Ironically, both chemicals are also used as feedstocks to make the next generation of coolants, which were introduced to replace CFCs and other coolants because they **won’t destroy the ozone layer**.

Nevertheless, the U.S. companies that release the chemicals undermining one of the world’s biggest environmental achievements have so far faced little pressure to stop. “China was bashed internationally for the production of CFC-11,” said Avipsa Mahapatra, who leads the Environmental Investigation Agency’s climate campaign. The U.S. and other countries pushed hard on China to stop releasing substances like CFC-11, which erode ozone, Mahapatra continued. “But even in America substances that damage the ozone layer are being released.”