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#### Counterplan:

#### Private entities in Asia should significantly invest in the exclusive use of Low Earth Orbit via Large Satellite Constellations for the purposes of emergency communications in the event of disaster relief or external shocks.

#### All other private entities ought not engage in the exclusive and permanent use of Low Earth Orbit via Large Satellite Constellations

#### SpaceX, OneWeb, Google, Amazon, and Telesat should immediately halt their engagement in the exclusive use of Low Earth Orbit via Large Satellite Constellations.

#### Private entities that engage in the exclusive use of Low Earth Orbit via Large Satellite Constellations should substantially harden their cybersecurity by instituting the following measures: Multi check for IoT devices, Identity and Access Management, Intrusion Detection System, Supply Chain Risk Program, Independent Command Logging, Physical Separation of Network Components, Crisis Communication Plans, Machine Learning that detects abnormal activity, and Collision Avoidance Procedures

#### Private entities should ban rocket propellants that produce alumina particles in the stratosphere or deposit black soot in the stratosphere.

#### Private entities should mandate 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.

#### 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

Garrity and Husar 21 Garrity, John, and Arndt Husar. John Garrity is an economist, policy advisor, and project manager focusing on digital inclusion, universal internet access policy, and last-mile connectivity. He has coauthored numerous reports on technology and development and has presented around the world on efforts to close the digital divide. Arndt Husar facilitates the effective use of digital technology, advising ADB clients, regional departments, as well as sector and thematic groups on digital transformation. " Digital Connectivity and Low Earth Orbit Satellite Constellations: Opportunities for Asia and the Pacific." (2021).

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 w

here 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.

#### Natural disasters are an existential threat – but increased preparation solves – outweighs all other risks

Anders **Sandberg 18**. Future of Humanity Institute, University of Oxford. 02/26/2018. “Human Extinction from Natural Hazard Events.” Oxford Research Encyclopedia of Natural Hazard Science. oxfordre.com, doi:10.1093/acrefore/9780199389407.013.293.

Systemic Risks

**Localized** disasters or slow-moving risks are unlikely **on their own** to spell doom for H. sapiens. It may appear that an unlikely intense global event or confluence of disasters need to occur in order to cause extinction. **However**, many risks are potentially **systemic**: a **sequence** or **combination** of disasters may **reduce resiliency** and the ability to **recover**, especially when interacting with the **human systems**. A model of how compound risks can act is the synchronous failure model of Homer-Dixon et al. (2015). **Multiple stresses** (such as climate change, resource shortages, or conflicts) can **interact** and **accumulate** in a social-ecological system, **pushing** **it** **to**ward a state where its **coping capacity** is **diminished**. Different sub**systems** become **coupled** because they require support from each other to function in the stressed state. When a **crisis occurs** (either externally triggered or because an internal component finally fails) it **rapidly cascades through the system**, spreading between subsystems and causing the **whole to fail**. Simultaneous damage is often **multiplicative in severity**. Many **human systems** such as **food, energy, finance and comm**unication**s** are **global**, densely interconnected systems where failures can **cascade** **rapidly** (Helbing, 2013). They have **developed** in a locally rational way: the gains in efficiency and reliability have been significant. However, the probability of global failures also has **increased** compared to more local, modular and redundant systems (Goldin & Vogel, 2010). While societal collapse does not imply extinction, humans are **dependent** on complex societies and their high productivity, and **any** long-term **collapse** would **reduce the human carrying capacity significantly**. A stressor such as **climate change** may **increase** the probability and severity of global failure, and once this occurs **vulnerability to further risks increases**. Various example scenarios can be constructed where plausible events produce gradual deterioration of the human system before it can recover; see, for example, Tonn and MacGregor (2009) and other papers in the same issue. Another example is sudden geoengineering cessation. If, as a response to climate change, solar radiation management geoengineering is used to maintain temperature, this will require ongoing technological maintenance. If a global disaster disrupts civilization, besides the damage from the primary disaster there would also be a rapid temperature change to close to what the un-modified climate would have been. This will likely produce massive **disruptions of ag**riculture and other human systems at the time when **vulnerability is maximal** (Baum, Maher, & Haqq-Misra, 2013). In this case a risk mitigation effort adds to systemic risk. Systemic effects are **hard to predict** (trade can both strengthen human societies by providing an adaptive system of distribution, prosperity, and incentives for innovation as well as destabilize them due to market bubbles, dependencies, and spread of pathogens). Taking uncertainty into account is possible but tends to lead to conservative policies (Weitzman, 2009). Another approach is to engineer human systems so they are naturally redundant, modular, and otherwise resilient to systemic stresses (Helbing, 2013). Probabilities Estimating existential risks can be done in many ways, each with their own merits and drawbacks; see (Tonn & Stiefel, 2013) for a review. It is possible to place upper bounds on extinction risks due to natural disasters by considering the fossil record. This can be done in several ways; the following will be based on the work of Toby Ord (2017). The simplest bound is based on the observation that H. sapiens has existed for 200,000 years: this observation would be unlikely if the extinction risk was higher than about 1 in 3,000 per century. One can say that an extinction rate of 0.15% or higher per century is ruled out at a 95% confidence level. Another bound uses now-extinct related hominin species as a reference class, producing estimates in the range 0.001% to 0.05% per century. This is in line with survival times for mammalian species, which typically is 1–2 million years (Raup, 1978) but shorter than for the entire fossil record where lifetimes of 5–10 million years are typical (Raup, 1986; May, Lawton, & Stork, 1995). H. sapiens is an unusually populous, well-dispersed, and adaptable large mammal species. However, it also has high food requirements and a long generation time. It may then be that the most likely risk to lead to extinction would be a mass-extinction level risk. Large mass extinctions occur at a rate of about 1 in 100 million years, producing a risk estimate of 0.0001% per century. One issue is that we are still discovering new kinds of existential risks. As noted above, supernovas have been recognized as a risk since the 1950s but gamma ray bursts were recognized as a risk first in the 1990s. High-energy physics risks were suggested in 1970s and later. Recognition of supervolcanism as a risk dates to the 1990s, in turn based on the models of nuclear winter in the 1980s. “Big rip” early endings of the universe were noticed in 2003 (Caldwell, Kamionkowski, & Weinberg, 2003). Since the rate of discovery does not seem to have slacked off, it is plausible that more natural hazards exist that we are unaware of, yet could pose a threat. At the same time, the above estimates bound the total risk: we are merely refining our understanding of what hazard categories exist. It should be noted that using past geological or fossil records to estimate risks that could have influenced the emergence of the species doing the risk estimation requires some care: risks that would have precluded the emergence of the species would naturally be underrepresented (Ćirković, Sandberg, & Bostrom, 2010). It is also clear that the peculiarities of the current situation may exacerbate some risks (e.g., pandemics) while reducing others (e.g., local disasters); these estimates merely show the risk magnitude for the earlier stages of the species’ history. The current probability is dynamically changing depending on human action. Probability estimates are on their own irrelevant: the point of risk assessment is to motivate rational risk management. This includes prioritizing mitigation efforts (typically toward the largest, most urgent, and most controllable risks) and research to reduce uncertainty and find more options. Mitigation Human extinction is an unusual risk since it can only occur once. Mitigation efforts need to succeed every time. Mitigating extinction risk can be done by reducing the probability of sufficiently severe hazards occurring, improving resilience mechanisms to reduce the damage, and endurance mechanisms to ensure that survivors can rebuild and repopulate. Many astrophysical extinction risks, supervolcanism and the emergence of new diseases are likely impossible to prevent, requiring resilience strategies. Impacts from near earth objects or comets can in principle be prevented given enough lead time and the right technological level (NRC, 2010). The amount of impulse needed to avoid an earth collision scales inversely with the lead time and proportional to the impactor mass: with enough time, even a high-precision weak intervention can move large objects. Managing atmospheric emissions and possibly intervening with geoengineering can influence climate risks (Wigley, 2006; Moreno-Cruz & Keith, 2013). Human systems can be designed to be resistant to various forms of systemic risks (Helbing, 2013). Prediction of extreme events is often impossible since they are the outcome of cascades in noisy, chaotic systems with hidden variables, and past data of less extreme cases often does not constrain models of phenomena of this magnitude. This requires using robust strategies taking large uncertainty into account (Weitzman, 2009). Although exact prediction may not be possible, rapid and improved response is possible and can enhance the resiliency against many of the listed threats. This includes better risk surveillance, preparation of responses and resources, as well as intergovernmental coordination. Many ex

tinction risks have joint pathways. For example, supervolcanism, large meteor impacts, and nuclear winters (not discussed in this article) do most of their harm by precluding agricultural/fishing over a span of years leading to widespread starvation (Engvild, 2003). While they also cause other harms this particular shared pathway can be dealt with by emergency food stores or alternative food sources (Denkenberger & Pearce, 2014). Shielding in space against radiation sources could in principle mitigate the risk from supernovas, GRBs, superflares, and similar risks (Ćirković & Vukotić, 2016). Improved resiliency against particular damage pathways can hence improve chances against a large set of risks. Endurance mechanisms aim at ensuring survival, adaptation, and eventual recovery after a near-extinction disaster (Maher & Baum, 2013). An occasionally suggested endurance mechanism against extinction risks is the deliberate construction of refuges where people can survive (or the encouragement of natural refuges in isolated regions, nuclear submarines etc.). Ideally such refuges would be self-sufficient and independent of the earth’s surface (Baum, Denkenberger, & Haqq-Misra, 2015; Jebari, 2015). However, refuges only help against certain categories of disasters and their cost-effectiveness depends on the relative value of current and future generations (Beckstead, 2015). Undersupply of Mitigation Preventing extinction is important; **at least** as important as saving the lives of 7.2 billion people, and quite possibly **far more important** when taking future generations and their value into account (Parfit, 1984; Bostrom, 2003; Bostrom, 2013; Häggström, 2016). **Mitigating** extinction risk is an **undersupplied global public good**. For example, traditional statistical life valuations suggest that a $16–$32 billion annual investment in asteroid defense would be cost-effective yet U.S. government spending on asteroid detection (with no mitigation) is around $4 million per year, orders of magnitude smaller than funding for hazardous waste sites per unit of risk (Gerrard, 2000; Matheny, 2007). The annual cost to the world due to pandemic influenza has been estimated to $570 billion per year or 0.7% of global income, comparable to estimates of the long-term costs of climate change (Fan, Jamison, & Summers, 2016): the global influenza vaccine market has been estimated to less than $4 billion per year (Kaddar, 2013). These estimates merely take lives saved into account, not the value of future generations. Since existential risk mitigation is non-excludable and non-rivalrous there is a free-rider problem (non-participants gain the benefit without having to pay) and each producer of risk reduction would only gain a fraction of the total benefit. This is amplified by the transgenerational nature of risk reduction: most of the benefit will accrue to future generations. In principle the value to them of our present preventing extinction is near-infinite, but they cannot pay us any compensation (Matheny, 2007; Bostrom, 2013). Beside the normal logic of undersupply and lack of global coordination mechanisms there are also **cognitive** and **cultural** factors making existential risk mitigation rare. Part of the problem may be discomfort with the topic leading to willful denial or ignorance (Epstein & Zhao, 2009). Part of the problem is the difficulty to fit the topic with human **cognitive biases** (Yudkowsky, 2008; Wiener, 2016). Humans have **heuristics** that provide quick and adequate answers for many situations but lead to **systematic biases** in many situations removed from our ancestral everyday ones. For example, since extinction has not occurred in the past, the **availability heuristic** (“probabilities of events are roughly proportional to how easy examples of past events come to mind”) will underestimate likelihood. **Scope neglect** makes us relatively **insensitive** to the **number of lives** affected, making the willingness to make an effort scale sublinearly with the size of the problem. In general, without rich context information people are generally bad at judging differences between low probability events (Kunreuther, Novemsky, & Kahneman, 2001). Risks are judged not just by probability and severity but also by psychological aspects such as outrage and dread (Slovic, 1987). This can sometimes support efforts to mitigate global risks (since they tend to score highly on dread) but makes the focus strongly dependent on what is and is not discussed in public (Yudkowsky, 2008). This makes constructing risk management strategies that are resistant to behavioral biases vitally important for extreme risks (Kunreuther & Heal, 2012; Wiener, 2016). Conclusion There is **clear ev**idence that **natural events could cause** **the** **extinction** **of H. sapiens**. While astronomical risks may be the most dramatic, geophysical risks to food security and pathogenic risks appear to be more significant. It is unlikely that a **single disaster** will be severe enough to directly cause extinction, but it is plausible that it could place the species in **a vulnerable situation** for a long time, during which **other risks** could lead to **further vulnerability and** **extinction**.

#### Collision avoidance solves

Arif 17 — (Aayesha Arif, Journalist, “This Is How Satellites Avoid Colliding Into Each Other“, Wonderful Engineering, Available Online at https://wonderfulengineering.com/satellite-collision/, accessed 3-22-2022, HKR-AR)

A standard collision avoidance procedure has been established by space agencies to avoid any such accident. Every time a satellite is launched, a Collision On Launch Assessment (COLA) is performed. To make sure that the space vehicle trajectory does not take it too close to any other object in space, the launch window is set such that it has COLA blackout period, the intervals during which the spacecraft does not lift.

The purpose of COLA is to avoid the collision after launch. To avoid any debris or spacecraft collision while in orbit, the satellite performs collision avoidance maneuver also called Debris Avoidance Maneuver (DAM). The collision avoidance maneuver is usually performed to raise or lower the orbit of the craft by a few kilometers. Read more about how the Hubble Space Telescope conducts it to avoid space debris hits.

#### Solves the case

Brooks 22 — (Chuck Brooks, President of Brooks Consulting International, is a globally recognized thought leader and subject matter expert Cybersecurity and Emerging Technologies. Chuck is also Adjunct Faculty at Georgetown University’s Graduate Applied Intelligence Program and the Graduate Cybersecurity Programs where he teaches courses on risk management, homeland security, and cybersecurity. LinkedIn named Chuck as one of “The Top 5 Tech People to Follow on LinkedIn.” He was named as one of the world’s “10 Best Cyber Security and Technology Experts” by Best Rated, as a “Top 50 Global Influencer in Risk, Compliance,” by Thompson Reuters, “Best of The Word in Security” by CISO Platform, and by IFSEC and Thinkers 360 as the “#2 Global Cybersecurity Influencer.” He was featured in the 2020, 2021, and 2022 Onalytica "Who's Who in Cybersecurity" – as one of the top Influencers for cybersecurity. He was also named one of the Top 5 Executives to Follow on Cybersecurity by Executive Mosaic, He is also a Cybersecurity Expert for “The Network” at the Washington Post, Visiting Editor at Homeland Security Today, Expert for Executive Mosaic/GovCon, and a Contributor to FORBES. He has an MA in International relations from the University of Chicago, a BA in Political Science from DePauw University, and a Certificate in International Law from The Hague Academy of International Law., “The Urgency To Cyber-Secure Space Assets“, Forbes, 2-27-2022, Available Online at https://www.forbes.com/sites/chuckbrooks/2022/02/27/the-urgency-to-cyber-secure-space-assets/, accessed 3-22-2022, HKR-AR)

2. Identity and access management (“IAM”) – those accessing flight control information and surfaces need to be identified and verified by an IAM solution that will pass muster on the user using machine learning identifiers to attempt to prevent authorized access to critical vehicle functions.

3. Multi check for IoT related devices – IoT devices must be able to be updated; no hard-coded passwords should be allowed.

4. The backbone of a cyber-resilient spacecraft should be a robust intrusion detection system (IDS). The IDS should consist of continuous monitoring of telemetry, command sequences, command receiver status, shared bus traffic, and flight software configuration and operating states, anticipate and adapt to mitigate evolving malicious behavior. The spacecraft IPS and the ground should **retain the ability to return critical systems** on the spacecraft to known cyber-safe mode. Logging should also be available to cross-check for anomalous behavior.

5. It is critical that spacecraft developers implement a supply chain risk management program. They must ensure that each of their vendors handles hardware and software appropriately and with an agreed-upon chain of custody. Critical units and subsystems should be identified and handled with different rigor and requirements than noncritical units and subsystems and should also be constructed with security in mind. All software on the spacecraft should be thoroughly vetted and properly handled through the configuration management and secure software development processes (DevSecOps).

6. Both the spacecraft and ground should independently perform command logging and anomaly detection of command sequences for cross validation. Commands received may be stored and sent to the ground through telemetry and automatically checked to verify consistency between commands sent and commands received.

7. Protections should be made against communications jamming and spoofing, such as signal strength monitoring and secured transmitters and receivers; links should be encrypted to provide additional security.

Security elements for defending ground-based systems and network assets include but are not limited to (also from the Homeland Security Today article):

1. Adoption of cybersecurity best practices, including those aligned with the NIST cybersecurity framework (“CSF”). As academic professors and pragmatists, we both are ardent supporters of the CSF and see no reason why the hundreds of space and satellite suppliers should not adopt the NIST framework.

2. Key network components should be logically and physically separate to prevent virus-like (ransomware) attacks from spreading throughout the network.

3. All ground-based system and network assets should be required to have the following policies in place: incident response, business continuity and crisis communications plans, patching policies, BYOD policies and backup policies.

4. All ground-based space systems and facilities should be required to hold quarterly employee training for all individuals on things like spear-phishing and socially engineered email attacks.

5. All ground-based space systems and facilities should be required to adopt a fulsome vendor supply chain risk management program that touches all primary and tertiary vendors.

6. All ground-based space systems and facilities must adopt machine learning intrusion detection systems to help guard against anomalous and potential malicious activity.

7. All ground-based space systems, facilities, and space manufacturers and vendors should be required to join the Space ISAC to be able to collaborate by sharing threats, warnings, and incident information.

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#### Large LEO satellite constellations are key to autonomous vehicle rollout – key to rapid, high volume data transfer that cellular can’t provide

Bell 18 Robert Bell is executive director of the Space & Satellite Professionals International. "Bugs on Wheels: The New Generation of Autonomous Vehicles - Via Satellite -." Via Satellite, 8 Nov. 2018, www.satellitetoday.com/innovation/2018/11/08/bugs-on-wheels-the-new-generation-of-autonomous-vehicles.

The new generation of connected cars — especially autonomous vehicles — will be a boom market for satellite, says the satellite industry. Not so fast, says the mobile industry. 5G is the future. Signals from space will have nothing to do with it. But, who is right? One? Both? Neither? Under the Hood When the subject turns to connected and autonomous cars, what are we really talking about? The average automobile today is already a computer on wheels, running about 100 million lines of software to process about 25 gigabytes of data per hour. There are already millions of connected cars on the road, which generally connect over the same cellular network we use for phones. In fact, in 2016, the growth rate for new car connections in the U.S. outpaced that for phones for the first time. What do those connections deliver? Typically, internet access and the ability to stream Spotify and Pandora, plus emergency roadside assistance. In other words, the same services you can get from your phone, built into the car. But try streaming Netflix so your kids can watch a TV show, and you quickly learn the limits. A more important limit, however, is that cellular doesn’t go everywhere. As long as we are just talking about entertainment, that’s not a serious issue. When we are talking about not dying, it’s a different conversation. As cars become increasingly autonomous, the challenges to connectivity rise. Fully autonomous cars will need incredibly accurate and up-to-date maps to supplement their vision systems. They will need to connect with each other to signal their intentions. And they will need massive software updates as frequently as your mobile phone or tablet, especially in the early days of the technology. Without those updates, the autonomous vehicle could rapidly become a collection of bugs on wheels. We are talking about a truly massive amount of data. Thank goodness 5G will provide capacity of 1-10 gigabits per second everywhere, right? The Trials of 5G Eventually, it may. But the roll-out of 5G will be a decades-long affair during which the mobile network will continue running standards from 2G up to 4G LTE under the 5G umbrella. That umbrella is not even due to take final form until 2020. The first 5G deployments will be in big cities where the vast increase in the number of base stations they require will be offset by the density of paying subscribers squeezed into a small area. As your car takes you to the highways, the suburban streets and the rural roads of your nation, however, you will leave that massive capacity behind for years to come. That leaves plenty of opportunity for satellites in Geostationary Orbit (GEO), (Medium Earth Orbit) MEO, and Low Earth Orbit (LEO) to fill the gap, particularly where they can exploit the traditional one-to-many technology advantage. Map and software updates are one example. Entertainment is another, as satellite TV to the car joins satellite radio, which is still adding more than a million new subscribers per year in the U.S. The much-anticipated success of LEO constellations adds even greater opportunity: making available a competitively-priced internet connection everywhere, backing up the terrestrial network so that subscribers can look forward to a seamless, high-quality experience. “Competitively-priced” is the key phrase. Whatever the orbit, service must be excellent, and the price be affordable. Otherwise, the industry risks recreating the debacle of early internet-via-satellite offerings, which charged high prices for over-contended service. If the industry is successful in seizing the connected and autonomous car opportunity while 5G rolls slowly out, we can even dare to envision a future in which the biggest role for terrestrial wireless is in communication between cars, which may require a massive share of all those gigabits. Going to Ground Pricing concerns are not reserved for the sky. At a recent satellite regulatory conference I attended in Washington, D.C., one speaker made a striking point. With all the attention paid to massive LEO constellations, it is rapidly becoming clear that the single most important success factor for LEO broadband is on the ground. The U.S. market bought 17 million cars in 2017. To equip that many cars, the antennas have to be pretty cheap, as well as reliable, versatile, and powerful. Forget $50 thousand or $30 thousand or even $15 thousand per antenna — the kind of numbers that work for commercial aircraft or super-yachts. One company that has built this reality into its design is Kymeta, which is in tests with Toyota, and in serious discussions with other manufacturers. Serving a mass market like automotive will take mass-market pricing, and every successful innovator of flat-panel, electronically-steered antennas is going to march to the beat of the consumer drum. After the billions invested in new LEO ventures, it is ironic that the future of satellite and the connected car is literally in their hands.

#### Large constellations required for VLEO – that’s uniquely key for low latency operations like AVs

The Aerospace Corporation 21. "Fresh Air is Good for Satellites, Too - The Aerospace Corporation - Medium." Medium, Jul 6, 2021 aerospacecorp.medium.com/fresh-air-is-good-for-satellites-too-230a35889425.

Very low Earth orbit (VLEO) is becoming popular for large satellite constellations. According to the European Space Agency (ESA), approximately 5,000 satellites are currently in this orbit, but the historic numbers are dwarfed by future satellite forecasts. The booming commercial space industry has proposed another 20,000 satellites for deployment into non-geostationary orbits, with about 13,000 approved by the FCC thus far. One SpaceX filing from March 2017 alone proposed 7,518 satellites in orbits between 336 km and 346 km altitudes. VLEO satellites typically experience fast orbital decay and require significant propellant for periodic orbital maintenance maneuvers. A proliferated very low Earth orbit (pVLEO) constellation may require a larger initial number of satellites in orbit to provide communication coverage than existing proliferated LEO (pLEO) constellations. A game-changing concept, known as air-scooping electric propulsion (ASEP), could extend the life of these VLEO satellites by providing a means for periodic re-boosting to maintain orbital altitudes. An ASEP satellite uses a solar array and electric propulsion to leverage ambient air as a propellant. This satellite design could offer economic and operational advantages transformational for lower-altitude orbital slots and potentially support a range of long duration missions. Without the finite limit of onboard propellant, an ASEP satellite could have an extended life — potentially reducing vehicle replacement rate and overall cost of the constellation. Air-scooping satellites have the potential to reduce launch cost, improve mission performance for high-resolution Earth observation missions, reduce latency for satellite communications, and introduce new space tug servicing capabilities for existing satellites. With the emergence of pLEO communication satellites such as the OneWeb, SpaceX Starlink, and Amazon Kuiper commercial constellations, air-scooping satellites offer new advantages and capabilities. 60 Starlink satellites stacked together before deployment on May 24, 2019. Courtesy: SpaceX Demand for connectivity to support enterprise and general consumer broadband and Internet of Things needs is driving the rapid design and deployment of pLEO communication constellations. Any company that can fly VLEO ASEP satellites, particularly for those constellations that support latency intolerant applications such as financial transactions and high-speed trading, autonomous vehicle navigation, multiplayer gaming, and remotely operated robotics that need near real-time capabilities, will have a strong competitive advantage.

#### Other orbits don’t solve – LEO sats are crucial to support future AV tech development

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Conclusion Robust PNT services from LEO are here today, providing augmentation to GPS where GPS isn’t available. The addition of navigation signals from LEO provides a number of benefits. The faster LEO motion provides geometric diversity, giving rise to multipath whitening, faster initialization times for carrier-phase differential GNSS, and Doppler-based positioning. Perhaps most importantly, LEO constellations have the advantage of being closer to the Earth than the GNSS core constellations in MEO, experiencing less path loss and delivering signals 1,000 times (30-dB) stronger. This makes them more resilient to jamming and more capable in deep attenuation environments such as in urban canyons and indoors. This extra power allows the LEO-based Satelles STL using Iridium to achieve timekeeping within 1 microsecond and a positioning accuracy of 20 meters, all while deep indoors where GNSS is unavailable. This adds indispensable resilience and security to GNSS that we are increasingly reliant upon, creating a comprehensive satellite navigation system that truly works everywhere. This PNT service using Iridium is perhaps a sign of things to come. We’ve seen a progression in LEO use since the dawn of the Space Age, namely, an order of magnitude increase in constellation size every 30 years. Transit first offered an occasional position update based on a constellation of six satellites in the 1960s. Built in the 1990s, Iridium, with an order of magnitude more satellites at 66, now offers global coverage. On the horizon are constellations like OneWeb, which promise the next order of magnitude with 648+ satellites, slated for the 2020s. This most recent scale gives rise to better satellite geometry than GPS today with the added benefits of LEO. The STL signal using Iridium sets a precedent that could lead to unparalleled navigation services that are robust due to the improved signal strength and precise due to the huge number of LEO satellites coming, each moving quickly and giving the geometric diversity needed to enable fast carrier-phase differential GNSS. The need for such a service is already clear. It would enable a diversity of future technologies and applications, such as safety-critical autonomous vehicles under development that must operate in challenging urban environments.

#### Advanced autonomous vehicle research accelerates the integration of social values into artificial intelligence – it’s the best avenue because of domain similarities – safe alignment stops extinction from numerous societal risks

Critch and Krueger 20 Critch, Andrew, and David Krueger. Andrew Critch Center for Human-Compatible AI UC Berkeley; David Krueger MILA Université de Montréal" AI Research Considerations for Human Existential Safety (ARCHES)." arXiv preprint arXiv:2006.04948 (2020).

9.2.1 Direction 27: Social contract learning This research direction is concerned with enabling AI systems to respect the “terms” of a social contract with multiple stakeholders, including existing institutions such as states, businesses, and human civilization as a whole. Historical note. There is a point of view in moral and political philoso- phy known as social contract theory (Rousseau, 1766; Rousseau and May, 2002). In this view, “persons’ moral and/or political obligations are depen- dent upon a contract or agreement among them to form the society in which they live” (Friend, 2004). The relevance of a social contract to shaping the impact of science and innovation was argued by Gibbons (1999). Social analogue. Suppose Alice works for Alphacorp and Bob works for Betacorp. Neither Alice nor Bob has read the relevant sections of state and federal legal code governing their companies. Nonetheless, some things just feel wrong to do. For instance, suppose Alice and Bob go on a date, and Alice knowingly presents Bob with an opportunity to sell Betacorp widgets to Alphacorp at an inflated price that Bob knows is exorbitant for Alpha- corp. Common sense might say that Alice is acting in “bad faith” with respect to her Alphacorp duties. But what is “bad faith” exactly? Even if Bob doesn’t quite know the definition, he might be uncomfortable with the deal. He might even turn down the deal, not out of loyalty to Betacorp’s shareholders–who would in fact stand to benefit from the sale—but out of respect for the ethical norm that Alice should be more professional in her representation of Alphacorp. While this norm might technically be enforce- able by state or federal law enforcement’s protection of Alphacorp’s right to terminate Alice if she acts in bad faith to her company duties, Bob’s respect for the norm is more difficult to explain in purely legal terms. It seems Bob has learned to respect a certain kind of social order in business dealings that he is not willing to associate with violating. Scenario-driven motivation. Ideally, powerful AI technology should avoid disrupting human society at scales that would pose significant risks to humanity’s continued existence. Thus, an existential catastrophe may be viewed as an extreme form of disruption to social order, which might be entirely preventable if less ex- treme risks of disruption are also avoided. In particular, maintaining certain forms of social order might be necessary to avoid Tier 2 risk (hazardous so- cial conditions), and might be integral to pursuing Objectives 7.2, 7.3, and 7.4 (avoiding races by sharing control, reducing idiosyncratic risk-taking, and existential safety systems). Actionability. The self-driving car industry presents a natural opportu- nity to observe when and how learning algorithms can respect the implicit terms of a social contract (Leben, 2017; Rahwan, 2018; Contissa et al., 2017). For instance, when two self-driving cars interact, there are at least four agents involved: the two cars, and their two passengers. Each car needs to take actions that will respect the other vehicle while protecting their own passenger sufficiently well to retain their loyalty as a customer of the car manufacturer and/or ride provider. With larger numbers of cars, car manufacturers will also need to ensure their cars avoid collectively causing coordination failures in the form of traffic jams. Viewed at this larger scale, any given self-driving car will implicitly be serving numerous human and institutional stakeholders, in way that needs to strike a ’deal’ between these many stakeholders for the self-driving car industry to unfold and continue operating successfully. There is already a strong interest in identifying end-to-end training methods for self-driving cars (Bojarski et al., 2016), as well as interest in the ethical problems the industry could face (Goodall, 2016). Imitation learning via reward learning is already being explored for this application (Laskey et al., 2017). It seems plausible that a better understanding of the social aspects of driving may be crucial to progress in this area, including aspects of driver-to-driver communication via movement (Brown and Laurier, 2017), and how to plan through a series of such signaling behaviors (Fisac et al., 2019). Safety and ethics solutions for driverless vehicles that are sufficiently respectful of human-driven vehicles, and that will alleviate rather than pre- cipitate large-scale coordination problems like traffic jams, may lead to many insights and principles for the safe and gradual introduction of autonomous agents into society.

#### Unaligned tech outweighs everything – expert consensus and it’s not close

Ord 20 Ord, Toby. Toby David Godfrey Ord (born 18 July 1979) is an Australian philosopher. He founded Giving What We Can, an international society whose members pledge to donate at least 10% of their income to effective charities and is a key figure in the effective altruism movement, which promotes using reason and evidence to help the lives of others as much as possible.[3] He is a Senior Research Fellow at the University of Oxford's Future of Humanity Institute, where his work is focused on existential risk. BA in Phil and Comp Sci from Melbourne, BPhil in Phil from Oxford, PhD in Phil from Oxford. The precipice: existential risk and the future of humanity. Hachette Books, 2020. [HKR QC]

I will therefore put numbers on the risks, and offer a few remarks on how to interpret them. When presented in a scientific context, numerical estimates can strike people as having an unwarranted appearance of precision or objectivity.5 Don’t take these numbers to be completely objective. Even with a risk as well characterized as asteroid impacts, the scientific evidence only takes us part of the way: we have good evidence regarding the chance of impact, but not on the chance a given impact will destroy our future. And don’t take the estimates to be precise. Their purpose is to show the right order of magnitude, rather than a more precise probability. The numbers represent my overall degrees of belief that each of the catastrophes will befall us this century. This means they aren’t simply an encapsulation of the information and argumentation in the chapters on the risks. Instead, they rely on an accumulation of knowledge and judgment on each risk that goes beyond what can be distilled into a few pages. They are not in any way a final word, but are a concise summary of all I know about the risk landscape. Existential catastrophe via: Asteroid or comet impact Chance within next 100 years: ∼ 1 in 1,000,000 Existential catastrophe via: Supervolcanic eruption Chance within next 100 years: ∼ 1 in 10,000 Existential catastrophe via: Stellar explosion Chance within next 100 years: ∼ 1 in 1,000,000,000 Existential catastrophe via: Total natural risk Chance within next 100 years: ∼ 1 in 10,000 Existential catastrophe via: Nuclear war Chance within next 100 years: ∼ 1 in 1,000 Existential catastrophe via: Climate change Chance within next 100 years: ∼ 1 in 1,000 Existential catastrophe via: Other environmental damage Chance within next 100 years: ∼ 1 in 1,000 Existential catastrophe via: “Naturally” arising pandemics Chance within next 100 years: ∼ 1 in 10,000 Existential catastrophe via: Engineered pandemics Chance within next 100 years: ∼ 1 in 30 Existential catastrophe via: Unaligned artificial intelligence Chance within next 100 years: ∼ 1 in 10 Existential catastrophe via: Unforeseen anthropogenic risks Chance within next 100 years: ∼ 1 in 30 Existential catastrophe via: Other anthropogenic risks Chance within next 100 years: ∼ 1 in 50 Existential catastrophe via: Total anthropogenic risk Chance within next 100 years: ∼ 1 in 6 Existential catastrophe via: Total existential risk Chance within next 100 years: ∼ 1 in 6 ABLE 6.1 My best estimates for the chance of an existential catastrophe from each of these sources occurring at some point in the next 100 years (when the catastrophe has delayed effects, like climate change, I’m talking about the point of no return coming within 100 years). There is significant uncertainty remaining in these estimates and they should be treated as representing the right order of magnitude—each could easily be a factor of 3 higher or lower. Note that the numbers don’t quite add up: both because doing so would create a false feeling of precision and for subtle reasons covered in the section on “Combining Risks.” One of the most striking features of this risk landscape is how widely the probabilities vary between different risks. Some are a million times more likely than others, and few share even the same order of magnitude. This variation occurs between the classes of risk too: I estimate anthropogenic risks to be more than 1,000 times more likely than natural risks. 6 And within anthropogenic risks, I estimate the risks from future technologies to be roughly 100 times larger than those of existing ones, giving a substantial escalation in risk from Chapter 3 to 4 to 5 . Such variation may initially be surprising, but it is remarkably common in science to find distributions like this spanning many orders of magnitude, where the top outliers make up most of the total. This variation makes it extremely important to prioritize our efforts on the right risks. And it also makes our estimate of the total risk very sensitive to the estimates of the top few risks (which are among the least well understood). So getting better understanding and estimates for those becomes a key priority. In my view, the greatest risk to humanity’s potential in the next hundred years comes from unaligned artificial intelligence, which I put at one in ten. One might be surprised to see such a high number for such a speculative risk, so it warrants some explanation. A common approach to estimating the chance of an unprecedented event with earth-shaking consequences is to take a skeptical stance: to start with an extremely small probability and only raise it from there when a large amount of hard evidence is presented. But I disagree. Instead, I think the right method is to start with a probability that reflects our overall impressions, then adjust this in light of the scientific evidence.7 When there is a lot of evidence, these approaches converge. But when there isn’t, the starting point can matter. In the case of artificial intelligence, everyone agrees the evidence and arguments are far from watertight, but the question is where does this leave us? Very roughly, my approach is to start with the overall view of the expert community that there is something like a one in two chance that AI agents capable of outperforming humans in almost every task will be developed in the coming century. And conditional on that happening, we shouldn’t be shocked if these agents that outperform us across the board were to inherit our future. Especially if when looking into the details, we see great challenges in aligning these agents with our values. Some of my colleagues give higher chances than me, and some lower. But for many purposes our numbers are similar. Suppose you were more skeptical of the risk and thought it to be one in 100. From an informational perspective, that is actually not so far apart: it doesn’t take all that much evidence to shift someone from one to the other. And it might not be that far apart in terms of practical action either—an existential risk of either probability would be a key global priority. I sometimes think about this landscape in terms of five big risks: those around nuclear war, climate change, other environmental damage, engineered pandemics and unaligned AI. While I see the final two as especially important, I think they all pose at least a one in 1,000 risk of destroying humanity’s potential this century, and so all warrant major global efforts on the grounds of their contribution to existential risk (in addition to the other compelling reasons). Overall, I think the chance of an existential catastrophe striking humanity in the next hundred years is about one in six. This is not a small statistical probability that we must diligently bear in mind, like the chance of dying in a car crash, but something that could readily occur, like the roll of a die, or Russian roulette.

### 1NC – Plan

#### Their arg about collision risks is wrong –

#### 1. it’s a misreading of their solvency advocate, who does say it would include constellation density, but doesn’t conclude any one way, and then concludes the vague details are outside the scope of their proposal, so every degree they don’t link is a reason they don’t solve. The plan only says “permanent and exclusive use”, but doesn’t actually explain what that means in the plan text, so this argument is a nonstarter and too late in the debate. Harker is blue

Takaya et al 18 “The Principle of Non-Appropriation and the Exclusive Uses of LEO by Large Satellite Constellations” Yuri Takaya-Umehara [Visiting researcher at the University of Tokyo since April 2017. She was affiliated to the Kobe University to provide a course on space law to post-graduate students (2011-2017). She chairs a working group on the formulation of global norms in space law organized by the Keio University since 2018. She obtained her Ph.D. degree at the IDEST of Paris XI University in France, LL.M. at the Leiden University in the Netherlands.] Quentin Verspieren [Ph.D. in public policy @ The University of Tokyo, Assistant Professor of Space Policy @UTokyo, General Manager, Global Strategy @ArkEdge Space Inc., Associate Research Fellow @ESPI] Goutham Karthikeyan [The University of Tokyo & Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (ISAS-JAXA)] 2018 https://www.researchgate.net/publication/328094878\_The\_Principle\_of\_Non-Appropriation\_and\_the\_Exclusive\_Use\_of\_LEO\_by\_Large\_Satellite\_Constellations SM

This regulatory challenge consists in first defining qualitatively what is the exclusive use of an orbit before translating this definition into measurable, technical rules. In this paper, the authors define an exclusive use of an orbit by a state40 as any use that would prevent/hinder the usage of the same orbit by any other state. Translating this definition into an applicable regulation could consist in defining a threshold of orbital collision risk or a threshold of density of satellites along an orbit based on its altitude, shape, relative velocity of neighbouring objects, etc. It is however not the purpose of this space law paper. What is more appropriate here is to think about which organization or forum would be in charge of elaborating this technical definition. Serious candidates could be the ITU, with excellent track-record in dealing with the use of the GEO region but which would have to review its “first come, first served” principle, or the UNCOPUOS, aiming for the widespread adoption of a new piece of international law. Moreover, even if its rules suffer from a low implementation rates, the IADC would be an appropriate discussion platform thanks to its very deep technical focus.

#### 2nd] I’ve debated this aff like four separate times, the 1AR will make this a big deal on the DA, we get new 2NR arguments when that will inevitably happened – ask yourself if your 1AC to 1AR conception of this advantage changed

#### 3rd]Liang is mentioning what a good separation of satellities could mean, it does not say that having satellites not be at that collision risk consititues “exclusion”. It’s also only analyzing Phase 1 of Starlink’s rollout and Kulper, not large satellite constellations broadly.

#### 4]circumvention -- the risk of collision is always changing for a satellite based on external factors like debris or other satellites, so either they ban all sats and link to our offense or ban none and lose on presumption. The ambiguity alone is sufficient for circumvention because of private interests that would lobby for favorable regs - thats all of their cards about

### 1NC – Adv1

#### only damaging debris generates political pressure

Schladebach, 13—visiting professor at the University of Göttingen in Air Law (Marcus, “Space Debris as a Legal Challenge,” Max Planck Yearbook of United Nations Law Online, Volume 17, Issue 1, 61-85, dml)

A number of stakeholders claim that the removal of inactive satellites or other Space debris would be too expensive.47 According to satellite producers, the production, transport to an orbit in Outer Space and use of a satellite are so cost-intensive that further investments cannot feasibly be borne without severely restricting them. Another reason for the lack of regulation concerning Space debris lies in the fact that political pressure surrounding the problem is still quite weak.48

In many cases, mankind only becomes active when greater damage has occurred. Despite the older and younger incidents mentioned above, damage on a catastrophic level, to such an extent that one could speak of an overwhelming and immediate necessity to regulate, is yet to happen. Although there would be a real chance to avoid damages with foresighted regulation, the law will unfortunately remain in a reactive role. Whether these aspects justify the inactivity of the state community seems doubtful. States are entitled to give their opinion whether they are ready for further investments and to evaluate the question of how intensive the danger of damage is. However, it should be obvious for the state community that the territorial integrity and individual security of states face considerable damage if the state community continues to remain inactive.

#### Low-level debris collisions now are key to infrastructure resilience—otherwise critical systems are decked by 2050

Mureșan and Georgescu, 15—currently leads the EURISC Foundation, served as senior adviser to the Romanian prime minister, the government and the minister of interior AND Research Fellow with the EURISC Foundation (Liviu and Alexandru, “The Road to Resilience in 2050,” The RUSI Journal, Volume 160, 2015 - Issue 6, dml)

By extrapolating these trends to 2050, mindful of potential technological breakthroughs, it is possible to paint a picture of how space systems will both add to and detract from the goal of ensuring societal resilience. By that point, every country developed to at least the economic and technological level of the developed world in the early twentyfirst century will have become critically dependent on space systems, especially for emerging countries which have leapfrogged over technological stages to directly use space services. Countries will be richer and safer from a host of potential disasters and disruptions through ubiquitous surveillance, information gathering and co-ordination at an accessible price through space systems.

However, the benefits of space systems can only accrue through a rate of adoption that engenders a critical dependence. By 2050, the world will be at the height of its vulnerability to space debris and space-weather phenomena. When it comes to deliberate threats, there will be a cautious détente between spacefaring nations maintained by crosscutting issues of dependence, if not on the same systems, then at least on the health and safety of the ‘global commons in space’. Due to the development and propagation of cost-effective technologies with anti-satellite applicability masked by legitimate uses, this will also be a time of opportunity for non-state actors looking to disrupt world affairs to target space systems and commit a ‘victimless’ crime. It is arguable that space systems will themselves have become more resilient – even to deliberate threats, especially of the kind accessible to non-state actors (cybernetics, jamming and so forth) – but security actors must also take into account the financial and market impact of temporary disruptions, based on the psychological effects of prevailing uncertainty, which are beyond the security decision-makers’ ability to affect.

The main barrier to a world that is more resilient in many more respects than today is the task of creating a global governance framework underpinned by real powers to regulate space activity in a way that increases resilience. The current framework, based on voluntary associations between space agencies and other actors, as well as the voluntary adoption of technical standards without power and authority to penalise actors who deviate from these norms, is woefully inadequate. The UN’s Committee on the Peaceful Uses of Outer Space has been developing such technical standards, but with little power of enforcement.33 Different treaties are supported by a mosaic of states, which are at various stages of adopting them, while other treaties lack the support of the most powerful space players, who are holding out for a framework that is to their specific advantage34 (as happened, for instance, with the failed Space Asset Protocol proposed by Unidroit, a private institution dedicated to harmonising commercial law35). Organisations such as the International Telecommunication Union, which regulates and assigns communication frequency bands to avoid ‘frequency fratricide’ between nearby satellites (which can also potentially be used as an ASAT weapon), show that the ‘orbital commons’ can be adequately regulated.36

Looking to the future, a global governance framework conducive to such resilience should: regulate the production and disposal of new space debris; regulate oversaturated orbital bands, preferably through market mechanisms; incentivise the development and application of methods for clearing up orbital debris; promote the adoption of resilient satellite design, taking advantage of new technologies and lower costs of launch (for shielding) to increase lifespan and decrease failures, as well as ensure the greatest possible interoperability; develop a multi-stakeholder model of governance, focused especially on co-opting private actors (who will own the bulk of future satellites) in a securityconscious process while addressing their needs for an environment more conducive to commercial exploitation. Such discussions should also incorporate non-spacefaring states, which must nevertheless take space security into account when devising critical infrastructure protection strategies and activities. This is especially important since, in an interconnected world, one weak link also undermines other countries through cascading disruption, even though they might have considered themselves to be adequately protected from threats. A key part of this will be a comprehensive effort at disseminating knowledge, best practices, and critical technologies and standards, while co-opting as many members as possible into arrangements such as early-warning networks and rapid-intervention initiatives. Last, but certainly not least, a focus on terrestrial infrastructure will also be essential, particularly in hardening it against threats such as space-weather phenomena – this involves not only investments and upgrades on the ground, but the use of space systems for the provision of early warning and further research into the patterns, causes and even warning signs of such phenomena.

In the end, space systems are a critical tool in negotiating the often conflicted relationship between economic development and security concerns. Their use helps to achieve a greater measure of resilience against certain kinds of disasters (such as weather patterns more extreme than ever before), but at the cost of exposure to new threats. By 2050, they will not only be integrated into existing and future critical-infrastructure protection frameworks at national, European and global levels, but they will have also gone through a number of challenges that will have strengthened resilience. Experts studying the various cases of low-intensity space-weather phenomena that have, nonetheless, caused damage have remarked on their utility as stress tests of existing infrastructure, highlighting the need to address the exposed weaknesses. As a result, the various examples of space system disruption and destruction so far have been a positive incentive for security-conscious development. This relates to the concept of ‘anti-fragility’, 37 where repeated low-level crises actually strengthen a system against a major threat which could have otherwise destroyed the system entirely. The philosophy is now being applied to critical-infrastructure protection and to space-security issues.

By 2050, the effects of past incidents will have already spawned a more resilient society, but it will have become obvious that the road to resilience extends much further into the future, as long as societies continue to develop and avoid stagnation. Resilience, in this respect, is not a destination for security experts and decision-makers, but rather a continual journey.

#### Resilience is a non-linear, infinite systemic risk – encompasses and outweighs case

Pamlin & Armstrong 15 (Dennis Pamlin, Executive Project Manager Global Risks, Global Challenges Foundation, and Stuart Armstrong, James Martin Research Fellow, Future of Humanity Institute, Oxford Martin School, University of Oxford, “Global Challenges: 12 Risks that threaten human civilization: The case for a new risk category,” Global Challenges Foundation, February 2015, p.30-93, https://api.globalchallenges.org/static/wp-content/uploads/12-Risks-with-infinite-impact.pdf)

2. Risks with infinite impact: A new category of risks “Most risk management is really just advanced contingency planning and disciplining yourself to realise that, given enough time, very low probability events not only can happen, but they absolutely will happen.” Lloyd Blankfein, Goldman Sachs CEO, July 2013 1 Risk = Probability × Impact Impacts where civilisation collapses to a state of great suffering and do not recover, or a situation where all human life end, are defined as infinite as the result is irreversible and lasts forever. A new group of global risks This is a report about a limited number of global risks – that can be identified through a scientific and transparent process – with impacts of a magnitude that pose a threat to human civilisation, or even possibly to all human life. With such a focus it may surprise some readers to find that the report’s essential aim is to inspire action and dialogue as well as an increased use of the methodologies used for risk assessment. The real focus is not on the almost unimaginable impacts of the risks the report outlines. Its fundamental purpose is to encourage global collaboration and to use this new category of risk as a driver for innovation. The idea that we face a number of global challenges threatening the very basis of our civilisation at the beginning of the 21st century is well accepted in the scientific community, and is studied at a number of leading universities.2 But there is still no coordinated approach to address this group of challenges and turn them into opportunities for a new generation of global cooperation and the creation of a global governance system capable of addressing the greatest challenges of our time. This report has, to the best of our knowledge, created the first science-based list of global risks with a potentially infinite impact and has made the first attempt to provide an initial overview of the uncertainties related to these risks as well as rough quantifications for the probabilities of these impacts. What is risk? Risk is the potential of losing something of value, weighed against the potential to gain something of value. Every day we make different kinds of risk assessments, in more or less rational ways, when we weigh different options against each other. The basic idea of risk is that an uncertainty exists regarding the outcome and that we must find a way to take the best possible decision based on our understanding of this uncertainty.3 To calculate risk the probability of an outcome is often multiplied by the impact. The impact is in most cases measured in economic terms, but it can also be measured in anything we want to avoid, such as suffering. At the heart of a risk assessment is a probability distribution, often described by a probability density function4; see figure X for a graphic illustration. The slightly tilted bell curve is a common probability distribution, but the shape differs and in reality is seldom as smooth as the example. The total area under the curve always represents 100 percent, i.e. all the possible outcomes fit under the curve. In this case (A) represents the most probable impact. With a much lower probability it will be a close to zero impact, illustrated by (B). In the same way as in case B there is also a low probability that the situation will be very significant, illustrated by (C). Figure 1: Probability density function [FIGURE 1 OMITTED] The impacts (A), (B) and (C) all belong to the same category, ~~normal~~ [common] impacts: the impacts may be more or less serious, but they can be dealt with within the current system. The impacts in this report are however of a special kind. These are impacts where everything will be lost and the situation will not be reversible, i.e challenges with potentially infinite impact. In insurance and finance this kind of risk is called “risk of ruin”, an impact where all capital is lost.5 This impact is however only infinite for the company that is losing the money. From society’s perspective, that is not a special category of risk. In this report the focus is on the “risk of ruin” on a global scale and on a human level, in the worst case this is when we risk the extinction of our own species. On a probability curve the impacts in this report are usually at the very far right with a relatively low probability compared with other impacts, illustrated by (D) in Figure 2. Often they are so far out on the tail of the curve that they are not even included in studies. For each risk in this report the probability of an infinite impact is very low compared to the most likely outcome. Some studies even indicate that not all risks in this report can result in an infinite impact. But a significant number of peer-reviewed reports indicate that those impacts not only can happen, but that their probability is increasing due to unsustainable trends. The assumption for this report is that by creating a better understanding of our scientific knowledge regarding risks with a potentially infinite impact, we can inspire initiatives that can turn these risks into drivers for innovation. Not only could a better understanding of the unique magnitude of these risks help address the risks we face, it could also help to create a path towards more sustainable development. The group of global risks discussed in this report are so different from most of the challenges we face that they are hard to comprehend. But that is also why they can help us to build the collaboration we need and drive the development of further solutions that benefit both people and the planet. As noted above, none of the risks in this report is likely to result directly in an infinite impact, and some are probably even physically incapable of doing so. But all are so significant that they could reach a threshold impact able to create social and ecological instability that could trigger a process which could lead to an infinite impact. For several reasons the potentially infinite impacts of the risks in this report are not as well known as they should be. One reason is the way that extreme impacts are often masked by most of the theories and models used by governments and business today. For example, the probability of extreme impacts is often below what is included in studies and strategies. The tendency to exclude impacts below a probability of five percent is one reason for the relative “invisibility” of infinite impacts. The almost standard use of a 95% confidence interval is one reason why low-probability high-impact events are often ignored.6 Figure 2: Probability density function with tail highlighted [FIGURE 2 OMITTED] Climate change is a good example, where almost all of the focus is on the most likely scenarios and there are few studies that include the low-probability high-impact scenarios. In most reports about climate impacts, the impacts caused by warming beyond five or six degrees Celsius are even omitted from tables and graphs even though the IPCC’s own research indicates that the probability of these impacts are often between one and five percent, and sometimes even higher.7 Other aspects that contribute to this relative invisibility include the fact that extreme impacts are difficult to translate into monetary terms, they have a global scope, and they often require a time-horizon of a century or more. They cannot be understood simply by linear extrapolation of current trends, and they lack historical precedents. There is also the fact that the measures required to significantly reduce the probability of infinite impacts will be radical compared to a business-as-usual scenario with a focus on incremental changes. The exact probability of a specific impact is difficult or impossible to estimate.8 However, the important thing is to establish the current magnitude of the probabilities and compare them with the probabilities for such impacts we cannot accept. A failure to provide any estimate for these risks often results in strategies and priorities defined as though the probability of a totally unacceptable outcome is zero. An approximate number for a best estimate also makes it easier to understand that a great uncertainty means the actual probability can be both much higher and much lower than the best estimate. It should also be stressed that uncertainty is not a weakness in science; it always exists in scientific work. It is a systematic way of understanding the limitations of the methodology, data, etc.9 Uncertainty is not a reason to wait to take action if the impacts are serious. Increased uncertainty is something that risk experts, e.g. insurance experts and security policy experts, interpret as a signal for action. A contrasting challenge is that our cultural references to the threat of infinite impacts have been dominated throughout history by religious groups seeking to scare society without any scientific backing, often as a way to discipline people and implement unpopular measures. It should not have to be said, but this report is obviously fundamentally different as it focuses on scientific evidence from peer-reviewed sources. Infinite impact The concept infinite impact refers to two aspects in particular; the terminology is not meant to imply a literally infinite impact (with all the mathematical subtleties that would imply) but to serve as a reminder that these risks are of a different nature. Ethical These are impacts that threaten the very survival of humanity and life on Earth – and therefore can be seen as being infinitely negative from an ethical perspective. No positive gain can outweigh even a small probability for an infinite negative impact. Such risks require society to ensure that we eliminate these risks by reducing the impact below an infinite impact as a top priority, or at least do everything we can to reduce the probability of these risks. As some of these risks are impossible to eliminate today it is also important to discuss what probability can right now be accepted for risks with a possible infinite impact. Economic Infinite impacts are beyond what most traditional economic models today are able to cope with. The impacts are irreversible in the most fundamental way, so tools like cost-benefit assessment seldom make sense. To use discounting that makes infinite impacts (which could take place 100 years or more from now and affect all future generations) close to invisible in economic assessments, is another example of a challenge with current tools. So while tools like cost-benefit models and discounting can help us in some areas, they are seldom applicable in the context of infinite impacts. New tools are needed to guide the global economy in an age of potential infinite impacts. See chapter 2.2.2 for a more detailed iscussion. Roulette and Russian roulette When probability and normal risks are discussed the example of a casino and roulette is often used. You bet something, then spin the wheel and with a certain probability you win or lose. You can use different odds to discuss different kinds of risk taking. These kinds of thought experiment can be very useful, but when it comes to infinite risks these gaming analogies become problematic. For infinite impact a more appropriate analogy is probably Russian roulette. But instead of “normal” Russian roulette where you only bet your own life you are now also betting everyone you know and everyone you don’t know. Everyone alive will die if you lose. There will be no second chance for anyone as there will be no future generations; humanity will end with your loss. What probability would you accept for different sums of money if you played this version of Russian roulette? Most people would say that it is stupid and – no matter how low the probability is and no matter how big the potential win is – this kind of game should not be played, as it is unethical. Many would also say that no person should be allowed to make such a judgment, as those who are affected do not have a say. You could add that most of those who will lose from it cannot say anything as they are not born and will never exist if you lose. The difference between ordinary roulette and “allhumanity Russian roulette” is one way of illustrating the difference in nature between a “normal” risk that is reversible, and a risk with an infinite impact. An additional challenge in acknowledging the risks outlined in this report is that many of the traditional risks including wars and violence have decreased, even though it might not always looks that way in media.10 So a significant number of experts today spend a substantial amount of time trying to explain that much of what is discussed as dangerous trends might not be as dangerous as we think. For policy makers listening only to experts in traditional risk areas it is therefore easy to get the impression that global risks are becoming less of a problem. The chain of events that could result in infinite impacts in this report also differ from most of the traditional risks, as most of them are not triggered by wilful acts, but accidents/mistakes. Even the probabilities related to nuclear war in this report are to a large degree related to inadvertent escalation. As many of the tools to analyse and address risks have been developed to protect nations and states from attacks, risks involving accidents tend to get less attention. This report emphasises the need for an open and democratic process in addressing global challenges with potentially infinite impact. Hence, this is a scientifically based invitation to discuss how we as a global community can address what could be considered the greatest challenges of our time. The difficulty for individual scientists to communicate a scientific risk approach should however not be underestimated. Scientists who today talk about low-probability impacts, that are serious but still far from infinite, are often accused of pessimism and scaremongering, even if they do nothing but highlight scientific findings.11 To highlight infinite impacts with even lower probability can therefore be something that a scientist who cares about his/her reputation would want to avoid. In the media it is still common to contrast the most probable climate impact with the probability that nothing, or almost nothing, will happen. The fact that almost nothing could happen is not wrong in most cases, but it is unscientific and dangerous if different levels of probability are presented as equal. The tendency to compare the most probable climate impact with the possibility of a low or no impact also results in a situation where low-probability high-impact outcomes are often totally ignored. An honest and scientific approach is to, whenever possible, present the whole probability distribution and pay special attention to unacceptable outcomes. The fact that we have challenges that with some probability might be infinite and therefore fundamentally irreversible is difficult to comprehend, and physiologically they are something our brains are poorly equipped to respond to, according to evolutionary psychologists.12 It is hard for us as individuals to grasp that humanity for the first time in its history now has the capacity to create such catastrophic outcomes. Professor Marianne Frankenhaeuser, former head of the psychology division, Karolinska Institute, Stockholm, put it this way: “Part of the answer is to be found in psychological defence mechanisms. The nuclear threat is collectively denied, because to face it would force us to face some aspects of the world’s situation which we do not want to recognise.” 13 This psychological denial may be one reason why there is a tendency among some stakeholders to confuse “being optimistic” with denying what science is telling us, and ignoring parts of the probability curve.14 Ignoring the fact that there is strong scientific evidence for serious impacts in different areas, and focusing only on selected sources which suggest that the problem may not be so serious, is not optimistic. It is both unscientific and dangerous.15 A scientific approach requires us to base our decisions on the whole probability distribution. Whether it is possible to address the challenge or not is the area where optimism and pessimism can make people look at the same set of data and come to different conclusions. Two things are important to keep in mind: first, that there is always a probability distribution when it comes to risk; second, that there are two different kinds of impacts that are of interest for this report. The probability distribution can have different shapes but in simplified cases the shape tends to look like a slightly modified clock (remember figure 1). In the media it can sound as though experts argue whether an impact, for example a climate impact or a pandemic, will be dangerous or not. But what serious experts discuss is the probability of different oucomes. They can disagree on the shape of the curve or what curves should be studied, but not that a probability curve exists. With climate change this includes discussions about how sensitive the climate is, how much greenhouse gas will be emitted, and what impacts that different warmings will result in. Just as it is important not to ignore challenges with potentially infinite impacts, it is also important not to use them to scare people. Dramatic images and strong language are best avoided whenever possible, as this group of risks require sophisticated strategies that benefit from rational arguments. Throughout history we have seen too many examples when threats of danger have been damagingly used to undermine important values. The history of infinite impacts: The LA-602 document The understanding of infinite impacts is very recent compared with most of our institutions and laws. It is only 70 years ago that Edward Teller, one of the greatest physicists of his time, with his back-of-the-envelope calculations, produced results that differed drastically from all that had gone before. His calculations indicated that the explosion of a nuclear bomb – a creation of some of the brightest minds on the planet, including Teller himself – could result in a chain reaction so powerful that it would ignite the world’s atmosphere, thereby ending human life on Earth.16 Robert Oppenheimer, who led the Manhattan Project to develop the nuclear bomb, halted the project to see whether Teller’s calculations were correct.17 The resulting document, LA- 602: Ignition of the Atmosphere with Nuclear Bombs, concluded that Teller was wrong, But the sheer complexity drove them to end their assessment by writing that “further work on the subject [is] highly desirable”.18 The LA-602 document can be seen as the first scientific global risk report addressing a category of risks where the worst possible impact in all practical senses is infinite.19 Since the atomic bomb more challenges have emerged with potentially infinite impact. Allmost all of these new challenges are linked to the increased knowledge, economic and technical development that has brought so many benefits. For example, climate change is the result of the industrial revolution and development that was, and still is, based heavily on fossil fuel. The increased potential for global pandemics is the result of an integrated global economy where goods and services move quickly around the world, combined with rapid urbanisation and high population density. In parallel with the increased number of risks with possible infinite impact, our capacity to analyse and solve them has greatly increased too. Science and technology today provides us with knowledge and tools that can radically reduce the risks that historically have been behind major extinctions, such as pandemics and asteroids. Recent challenges like climate change, and emerging challenges like synthetic biology and nanotechnology, can to a large degree be addressed by smart use of new technologies, new lifestyles and institutional structures. It will be hard as it will require collaboration of a kind that we have not seen before. It will also require us to create systems that can deal with the problems before they occur. The fact that the same knowledge and tools can be both a problem and a solution is important to understand in order to avoid polarisation. Within a few decades, or even sooner, many of the tools that can help us solve the global challenges of today will come from fields likely to provide us with the most powerful instruments we have ever had – resulting in their own sets of challenges. Synthetic biology, nanotechnology and artificial intelligence (AI) are all rapidly evolving fields with great potential. They may help solve many of today’s main challenges or, if not guided in a benign direction, may result in catastrophic outcomes. The point of departure of this report is the fact that we now have the knowledge, economic resources and technological ability to reduce most of the greatest risks of our time. Conversely, the infinite impacts we face are almost all unintended results of human ingenuity. The reason we are in this situation is that we have made progress in many areas without addressing unintended low-probability high-impact consequences. Creating innovative and resilient systems rather than simply managing risk would let us focus more on opportunities. But the resilience needed require moving away from legacy systems is likely to be disruptive, so an open and transparent discussion is needed regarding the transformative solutions required. Figure 3: Probability density function with tail and threshold highlighted [FIGURE 3 OMITTED] 2.1 Report structure The first part of the report is an introduction where the global risks with potential infinite impact are introduced and defined. This part also includes the methodology for selecting these risks, and presents the twelve risks that meet this definition. Four goals of the report are also presented, under the headings “acknowledge”, “inspire”, “connect” and “deliver”. The second part is an overview of the twelve global risks and key events that illustrate some of the work around the world to address them. For each challenge five important factors that influence the probability or impact are also listed. The risks are divided into four different categories depending on their characteristics. “Current challenges” is the first category and includes the risks that currently threaten humanity due to our economic and technological development - extreme climate change, for example, which depends on how much greenhouse gas we emit. “Exogenic challenges” includes risks where the basic probability of an event is beyond human control, but where the probability and magnitude of the impact can be influenced - asteroid impacts, for example, where the asteroids’ paths are beyond human control but an impact can be moderated by either changing the direction of the asteroid or preparing for an impact. “Emerging challenges” includes areas where technological development and scientific assessment indicate that they could both be a very important contribution to human welfare and help reduce the risks associated with current challenges, but could also result in new infinite impacts.20 AI, nanotechnology and synthetic biology are examples. “Global policy challenge” is a different kind of risk. It is a probable threat arising from future global governance as it resorts to destructive policies, possibly in response to the other challenges listed above. The third part of the report discusses the relationship between the different risks. Action to reduce one risk can increase another, unless their possible links are understood. Many solutions are also able to address multiple risks, so there are significant benefits from understanding how one relates to others. Investigating these correlations could be a start, but correlation is a linear measure and non-linear techniques may be more helpful for assessing the aggregate risk. The fourth part is an overview, the first ever to our knowledge, of the uncertainties and probabilities of global risks with potentially infinite impacts. The numbers are only rough estimates and are meant to be a first step in a dialogue where methodologies are developed and estimates refined. The fifth part presents some of the most important underlying trends that influence the global challenges, which often build up slowly until they reach a threshold and very rapid changes ensue. The sixth and final part presents an overview of possible ways forward. 2.2 Goals Goal 1: Acknowledge That key stakeholders, influencing global challenges, acknowledge the existence of the category of risks that could result in infinite impact. They should also recognice that the list of risks that belong to this category should be revised as new technologies are developed and our knowledge increases. Regardless of the risks included, the category should be given special attention in all processes and decisions of relevance. The report also seeks to demonstrate to all key stakeholders that we have the capacity to reduce, or even eliminate, most of the risks in this category. Establish a category of risks with potentially infinite impact. Before anything significant can happen regarding global risks with potentially infinite impacts, their existence must be acknowledged. Rapid technological development and economic growth have delivered unprecedented material welfare to billions of people in a veritable tide of utopias.21 But we now face the possibility that even tools created with the best of intentions can have a darker side too, a side that may threaten human civilisation, and conceivably the continuation of human life. This is what all decision-makers need to recognise. Rather than succumbing to terror, we need to acknowledge that we can let the prospect inspire and drive us forward. Goal 2: Inspire That policy makers inspire action by explaining how the probabilities and impacts can be reduced and turned into opportunities. Concrete examples of initiatives should be communicated in different networks in order to create ripple effects, with the long-term goal that all key stakeholders should be inspired to turn these risks into opportunities for positive action. Show concrete action that is taking place today. This report seeks to show that it is not only possible to contribute to reducing these risks, but that it is perhaps the most important thing anyone can spend their time on. It does so by combining information about the risks with information about individuals and groups who has made a significant contribution by turning challenges into opportunities. By highlighting concrete examples the report hopes to inspire a new generation of leaders. Goal 3: Connect That leaders in different sectors connect with each other to encourage collaboration. A specific focus on financial and security policy where significant risks combine to demand action beyond the incremental is required. Support new meetings between interested stakeholders. The nature of these risks spans countries and continents; they require action by governments and politicians, but also by companies, academics, NGOs, and many other groups. The magnitude of the possible impacts requires not only leaders to act but above all new models for global cooperation and decision-making to ensure delivery. The need for political leadership is therefore crucial. Even with those risks where many groups are involved, such as climate change and pandemics, very few today address the possibility of infinite impact aspects. Even fewer groups address the links between the different risks. There is also a need to connect different levels of work, so that local, regional, national and international efforts can support each other when it comes to risks with potentially infinite impacts. Goal 4: Deliver That concrete strategies are developed that allow key stakeholders to identify, quantify and address global challenges as well as gather support for concrete steps towards a wellfunctioning global governance system. This would include tools and initiatives that can help identify, quantify and reduce risks with potentially infinite impacts. Identify and implement strategies and initiatives. Reports can acknowledge, inspire and connect, but only people can deliver actual results. The main focus of the report is to show that actual initiatives need to be taken that deliver actual results. Only when the probability of an infinite impact becomes acceptably low, very close to zero, and/or when the maximum impact is significantly reduced, should we talk about real progress. In order to deliver results it is important to remember that global governance to tackle these risks is the way we organise society in order to address our greatest challenges. It is not a question of establishing a “world government”, it is about the way we organise ourselves on all levels, from the local to the global. The report is a first step and should be seen as an invitation to all responsible parties that can affect the probability and impact of risks with potentially infinite impacts. But its success will ultimately be measured only on how it contributes to concrete results. 2.3 Global challenges and infinite impact This chapter first introduces the concept of infinite impact. It then describes the methodology used to identify challenges with an infinite impact. It then presents risks with potentially infinite impact that the methodology results in. 2.3.1 Definition of infinite impact The specific criterion for including a risk in this report is that well-sourced science shows the challenge can have the following consequences: 22 1. Infinite impact: When civilisation collapses to a state of great suffering and does not recover, or a situation where all human life ends. The existence of such threats is well attested by science.23 2. Infinite impact threshold – an impact that can trigger a chain of events that could result first in a civilisation collapse, and then later result in an infinite impact. Such thresholds are especially important to recognise in a complex and interconnected society where resilience is decreasing.24 A collapse of civilisation is defined as a drastic decrease in human population size and political/economic/social complexity, globally for an extended time.25 The above definition means the list of challenges is not static. When new challenges emerge, or current ones fade away, the list will change. An additional criterion for including risks in this report is “human influence”. Only risks where humans can influence either the probability, the impact, or both, are included. For most risks both impact and probability can be affected, for example with nuclear war, where the number/size of weapons influences the impact and tensions between countries affects the probability. Other risks, such as a supervolcano, are included as it is possible to affect the impact through various mitigation methods, even if we currently cannot affect the probability. Risks that are susceptible to human influence are indirectly linked, because efforts to address one of them may increase or decrease the likelihood of another. 2.3.2 Why use “infinite impact” as a concept? The concept of infinity was chosen as it reflects many of the challenges, especially in economic theory, to addressing these risks as well as the need to question much of our current way of thinking. The concept of a category of risks based on their extreme impact is meant to provide a tool to distinguish one particular kind of risk from others. The benefit of this new concept should be assessed based on two things. First, does the category exist, and second, is the concept helpful in addressing these risks? The report has found ample evidence that there are risks with an impact that can end human civilisation and even all human life. The report further concludes that a new category of risk is not only meaningful but also timely. We live in a society where global risks with potentially infinite impacts increase in both number and probability according to multiple studies. Looking ahead, many emerging technologies which will certainly provide beneficial results, might also result in an increased probability of infinite impacts.26 Over the last few years a greater understanding of low probability or unknown probability events has helped more people to understand the importance of looking beyond the most probable scenarios. Concepts like “black swans” and “perfect storms” are now part of mainstream policy and business language.27 Greater understanding of the technology and science of complex systems has also resulted in a new understanding of potentially disruptive events. Humans now have such an impact on the planet that the term “the anthropocene” is being used, even by mainstream media like The Economist.28 The term was introduced in the 90s by the Nobel Prize winner Paul Crutzen to describe how humans are now the dominant force changing the Earth’s ecosystems.29 The idea to establish a well defined category of risks that focus on risks with a potentially infinite impact that can be used as a practical tool by policy makers is partly inspired by Nick Bostrom’s philosophical work and his introduction of a risk taxonomy that includes an academic category called “existential risks”.30 Introducing a category with risks that have a potentially infinite impact is not meant to be a mathematical definition; infinity is a thorny mathematical concept and nothing in reality can be infinite.31 It is meant to illustrate a singularity, when humanity is threatened, when many of the tools used to approach most challenges today become problematic, meaningless, or even counterproductive. The concept of an infinite impact highlights a unique situation where humanity itself is threatened and the very idea of value and price collapses from a human perspective, as the price of the last humans also can be seen to be infinite. This is not to say that those traditional tools cannot still be useful, but with infinite impacts we need to add an additional set of analytical tools. Life Value The following estimates have been applied to the value of life in the US. The estimates are either for one year of additional life or for the statistical value of a single life. – $50,000 per year of quality life (international standard most private and government-run health insurance plans worldwide use to determine whether to cover a new medical procedure) – $129,000 per year of quality life (based on analysis of kidney dialysis procedures by Stefanos Zenios and colleagues at Stanford Graduate School of Business) – $7.4 million (Environmental Protection Agency) – $7.9 million (Food and Drug Administration) – $6 million (Transportation Department) – $28 million (Richard Posner based on the willingness to pay for avoiding a plane crash) Source: Wikipedia: Value of life http://en.wikipedia.org/wiki/Value\_of\_life US EPA: Frequently Asked Questions on Mortality Risk Valuation http://yosemite.epa.gov/EE%5Cepa%5Ceed.nsf/webpages/MortalityRiskValuation.html Posner, Richard A. Catastrophe: risk and response. Oxford University Press, 2004 Some of the risks, including nuclear war, climate change and pandemics, are often included in current risk overviews, but in many cases their possible infinite impacts are excluded. The impacts which are included are in most cases still very serious, but only the more probable parts of the probability distributions are included, and the last part of the long tail – where the infinite impact is found – is excluded.32 Most risk reports do not differentiate between challenges with a limited impact and those with a potential for infinite impact. This is dangerous, as it can mean resources are spent in ways that increase the probability of an infinite impact. Ethical aspects of infinite impact The basic ethical aspect of infinite impact is this: a very small group alive today can take decisions that will fundamentally affect all future generations. “All future generations” is not a concept that is often discussed, and for good reason. All through human history we have had no tools with a measurable global impact for more than a few generations. Only in the last few decades has our potential impact reached a level where all future generations can be affected, for the simple reason that we now have the technological capacity to end human civilisation. If we count human history from the time when we began to practice settled agriculture, that gives us about 12,000 years.33 If we make a moderate assumption that humanity will live for at least 50 million more years34 our 12,000-year history so far represents 1/4200, or 0.024%, of our potential history. So our generation has the option of risking everything and annulling 99.976% of our potential history. Comparing 0.024% with the days of a person living to 100 years from the day of conception, this would equal less than nine days and is the first stage of human embryogenesis, the germinal stage.35 Two additional arguments to treat potentially infinite impacts as a separate category are: 36 1. An approach to infinite impacts cannot be one of trial-and-error, because there is no opportunity to learn from errors. The reactive approach – see what happens, limit damage, and learn from experience – is unworkable. Instead society must be proactive. This requires foresight to foresee new types of threat and willingness to take decisive preventative action and to bear the costs (moral and economic) of such actions. 2. We cannot necessarily rely on the institutions, morality, social attitudes or national security policies that developed from our experience of other sorts of risk. Infinite impacts are in a different category. Institutions and individuals may find it hard to take these risks seriously simply because they lie outside our experience. Our collective fear-response will probably be ill-calibrated to the magnitude of threat. Economic aspects of infinite impact and discounting In today’s society a monetary value is sometimes ascribed to human life. Some experts use this method to estimate risk by assigning a monetary value to human extinction.37 We have to remember that the monetary values placed on a human life in most cases are not meant to suggest that we have actually assigned a specific value to a life. Assigning a value to a human life is a tool used in a society with a limited supply of resources or infrastructure (ambulances, perhaps) or skills. In such a society it is impossible to save every life, so some trade-off must be made.38 The US Environmental Protection Agency explains its use like this: “The EPA does not place a dollar value on individual lives. Rather, when conducting a benefit-cost analysis of new environmental policies, the Agency uses estimates of how much people are willing to pay for small reductions in their risks of dying from adverse health conditions that may be caused by environmental pollution.” 39 The fact that monetary values for human lives can help to define priorities when it comes to smaller risks does not mean that they are suitable for quite different uses. Applying a monetary value to the whole human race makes little sense to most people, and from an economic perspective it makes no sense. Money helps us to prioritise, but with no humans there would be no economy and no need for priorities. Ignoring, or discounting, future generations is actually the only way to avoid astronomical numbers for impacts that may seriously affect every generation to come. In Catastrophe: Risk and Response, Richard Posner provides a cost estimate, based on the assumption that a human life is worth $50,000, resulting in a $300 tn cost for the whole of humanity, assuming a population of six billion. He then doubles the population number to include the value of all future generations, ending up with $600 tn, while acknowledging that “without discounting, the present value of the benefits of risk-avoidance measures would often approach infinity for the type of catastrophic risk with which this book is concerned.” 40 Discounting for risks that include the possibility of an infinite impact differs from risk discounting for less serious impacts. For example the Stern Review41 prompted a discussion between its chief author, Nicholas Stern, and William Nordhaus,42 each of whom argued for different discount levels using different arguments. But neither discussed a possible infinite climate impact. An overview of the discussion by David Evans of Oxford Brookes University highlighted some of the differing assumptions.43 Two things make infinite impacts special from a discounting perspective. First, there is no way that future generations can compensate for the impact, as they will not exist. Second, the impact is something that is beyond an individual preference, as society will no longer exist. Discounting is undertaken to allocate resources in the most productive way. In cases that do not include infinite impacts, discounting “reflects the fact that there are many high-yield investments that would improve the quality of life for future generations. The discount rate should be set so that our investable funds are devoted to the most productive uses.” 44 When there is a potentially infinite impact, the focus is no longer on what investments have the best rate of return, it is about avoiding the ultimate end. While many economists shy away from infinite impacts, those exploring the potentially extreme impacts of global challenges often assume infinite numbers to make their point. Nordhaus for example writes that “the sum of undiscounted anxieties would be infinite (i.e. equal to 1 + 1 +1 + … = ∞). In this situation, most of us would dissolve in a sea of anxiety about all the things that could go wrong for distant generations from asteroids, wars, out-of-control robots, fat tails, smart dust and other disasters.” 45 It is interesting that Nordhaus himself provides very good graphs that show why the most important factor when determining actions is a possible threshold (see below Figure 4 and 5). Nordhaus was discussing climate change, but the role of thresholds is similar for most infinite impacts. The first figure is based on traditional economic approaches which assume that Nature has no thresholds; the second graph illustrates what happens with the curve when a threshold exists. As Nordhaus also notes, it is hard to establish thresholds, but if they are significant all other assumptions become secondary. The challenge that Nordhaus does not address, and which is important especially with climate change, is that thresholds become invisible in economic calculations if they occur far into the future, even if it is current actions that unbalance the system and eventually push it over the threshold.46 Note that these dramatic illustrations rest on assumptions that the thresholds are still relatively benign, not moving us beyond tipping points which result in an accelerated release of methane that could result in a temperature increase of more than 8 °C, possibly producing infinite impacts.47 Calculating illustrative numbers By including the welfare of future generations, something that is important when their very existence is threatened, economic discounting becomes difficult. In this chapter, some illustrative numbers are provided to indicate the order of magnitude of the values that calculations provide when traditional calculations also include future generations. These illustrative calculations are only illustrative as the timespans that must be used make all traditional assumptions questionable to say the least. Still, as an indicator for why infinite impact might be a good approximation they might help. As a species that can manipulate our environment it could be argued that the time the human race will be around, if we do not kill ourselves, can be estimated to be between 1-10 million years – the typical time period for the biological evolution of a successful species48 – and one billion years, the inhabitable time of Earth.49 [FIGURE 4 OMITTED] [FIGURE 5 OMITTED] If we assume – 50 million years for the future of humanity as our reference, – an average life expectancy of 100 years50, and – a global population of 6 billion people51 – all conservative estimate – , we have half a million generations ahead of us with a total of 3 quadrillion individuals. Assuming a value of $50,000 per life, the cost of losing them would then be $1.5 ×1020, or $150 quintillion. This is a very low estimate, and Posner suggests that maybe the cost of a life should be “written up $28 million” for catastrophic risks52. Posner’s calculations where only one future generation is included result in a cost of $336 quadrillion. If we include all future generations with the same value, $28 million, the result is a total cost of $86 sextillion, or $86 × 1021. This $86 sextillion is obviously a very rough number (using one billion years instead of 50 million would for example require us to multiply the results by 20), but again it is the magnitude that is interesting. As a reference there are about 1011 to 1012 stars in our galaxy, and perhaps something like the same number of galaxies. With this simple calculation you get 1022 to 1024, or 10 to 1,000 sextillion, stars in the universe to put the cost of infinite impacts when including future generations in perspective.53 These numbers can be multiplied many times if a more philosophical and technology-optimistic scenario is assumed for how many lives we should include in future generations. The following quote is from an article by Nick Bostrom in Global Policy Journal: “However, the relevant figure is not how many people could live on Earth but how many descendants we could have in total. One lower bound of the number of biological human life-years in the future accessible universe (based on current cosmological estimates) is 1034 years. Another estimate, which assumes that future minds will be mainly implemented in computational hardware instead of biological neuronal wetware, produces a lower bound of 1054 human-brain-emulation subjective life-years.” 54 Likewise the value of a life, $28 million, a value that is based on an assessment of how individuals chose when it comes to flying, can be seen as much too small. This value is based on how much we value our own lives on the margin, and it is reasonable to assume that the value would be higher than only a multiplication of our own value if we also considered the risk of losing our family, everyone we know, as well as everyone else on the planet. In the same way as the cost increases when a certain product is in short supply, the cost of the last humans could be assumed to be very high, if not infinite. Obviously, the very idea to put a price on the survival of humanity can be questioned for good reasons, but if we still want to use a number, $28 million per life should at least be considered as a significant underestimation. For those that are reluctant or unable to use infinity in calculations and are in need of a number for their formulas, $86 sextillion could be a good initial start for the cost of infinite impacts. But it is important to note that this number might be orders of magnitude smaller than an estimate which actually took into account a more correct estimation of the number of people that should be included in future generations as well as the price that should be assigned to the loss of the last humans. 2.3.3 Infinite impact threshold (IIT) As we address very complex systems, such as human civilisation and global ecosystems, a concept as important as infinite impact in this report is that of infinity impact threshold. This is the impact level that can trigger a chain of events that results in the end of human civilisation. The infinite impact threshold (IIT) concept represents the idea that long before an actual infinite impact is reached there is a tipping point where it (with some probability) is no longer possible to reverse events. So instead of focusing only on the ultimate impact it is important to estimate what level of impact the infinity threshold entails. The IIT is defined as an impact that can trigger a chain of events that could result first in a civilisation collapse, and then later result in an infinite impact. Such thresholds are especially important to recognise in a complex and interconnected society where resilience is decreasing. Social and ecological systems are complex, and in most complex systems there are thresholds where positive feedback loops become self-reinforcing. In a system where resilience is too low, feedback loops can result in a total system collapse. These thresholds are very difficult to estimate and in most cases it is possible only to estimate their order of magnitude. As David Orrell and Patrick McSharry wrote in A Systems Approach to Forecasting: “Complex systems have emergent properties, qualities that cannot be predicted in advance from knowledge of systems components alone”. According to complexity scientist Stephen Wolfram’s principle of computational irreducibility, the only way to predict the evolution of such a system is to run the system itself: “There is no simple set of equations that can look into its future.” 55 Orrell and McSharry also noted that “in orthodox economics, the reductionist approach means that the economy is seen as consisting of individual, independent agents who act to maximise their own utility. It assumes that prices are driven to a state of near-equilibrium by the ‘invisible hand’ of the economy. Deviations from this state are assumed to be random and independent, so the price fluctuations are often modelled using the normal distribution or other distributions with thin tails and finite variance.” The drawbacks of an approach using the normal distribution, or other distributions with thin tails and finite variance, become obvious when the unexpected happens as in the recent credit crunch, when existing models totally failed to capture the true risks of the economy. As an employee of Lehman Brothers put it on August 11, 2007: “Events that models predicted would happen only once in 10,000 years happened every day for three days.” 56 [FIGURE 6 OMITTED] The exact level for an infinite impact threshold should not be the focus, but rather the fact that such thresholds exists and that an order of magnitude should be estimated.57 During the process of writing the report, experts suggested that a relatively quick death of two billion people could be used as a tentative number until more research is available.58 With current trends undermining ecological and social resilience it should be noted that the threshold level is likely to become lower as time progress. 2.3.4 Global F-N curves and ALARP In the context of global risks with potentially infinite impact, the possibility of establishing global F-N curves is worth exploring. One of the most common and flexible frameworks used for risk criteria divides risks into three bands: 59 1. Upper: an unacceptable/ intolerable region, where risks are intolerable except in extraordinary circumstances and risk reduction measures are essential. 2. Middle: an ALARP (“as low as reasonably practicable”) region, where risk reduction measures are desirable but may not be implemented if their cost is disproportionate to the benefit achieved. 3. Lower: a broadly acceptable/ negligible region, where no further risk reduction measures are needed. The bands are expressed by F-N curves. When the frequency of events which cause at least N fatalities is plotted against the number N on log–log scales, the result is called an F-N curve.60 If the frequency scale is replaced by annual probability, then the resultant curve is called an f-N curve. The concept for the middle band when using F-N curves is ALARP. It is a term often used in the area of safety-critical and safety-involved systems.62 The ALARP principle is that the residual risk should be as low as reasonably practicable. The upper band, the unacceptable/ intolerable region, is usually the area above the ALARP area (see figure 8) By using F-N curves it is also possible to establish absolute impact levels that are never acceptable, regardless of probability (Figure 7. Based on an actual F-n Curve showing an absolute impact level that is defined as unacceptable). This has been done in some cases for local projects. The infinite threshold could be used to create an impact limit on global F-N curves used for global challenges in the future. Such an approach would help governments, companies and researchers when they develop new technical solutions and when investing in resilience. Instead of reducing risk, such an approach encourages the building of systems which cannot have negative impacts above a certain level. Pros – Clearly shows relationship between frequency and size of accident – Allows judgement on relative importance of different sizes of accident – Slope steeper than -1 provides explicit consideration of multiple fatality aversion and favours concepts with lower potential for large fatality events – Allows company to manage overall risk exposure from portfolio of all existing and future facilities Cons – Cumulative expression makes it difficult to interpret, especially by non-risk specialists – Can be awkard to derive – May be difficult to use if criterion is exceeded in one area but otherwise is well below – Much debate about criterion lines Figure 7: Example of F-n curve showing different levels of risk 61 Figure 9: Pros and cons of F-N curves 63 46 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 2.3 Global challenges and infinite impact practical guidance that can provide defined group of risks 2.3.5 A name for a clearly 10 100 1000 10000 10 10 10 10 10 10 10 10-2 -3 -4 -5 -6 -7 -8 -9 Number of Fatalities (N) Frequency (F) of Accidents with N or More Fatalities (Per Year) ALARP region Unacceptable Acceptable Today no established methodology exists that provides a constantly updated list of risks that threaten human civilisation, or even all human life. Given that such a category can help society to better understand and act to avoid such risks, and better understand the relation between these risks, it can be argued that a name for this category would be helpful.65 To name something that refers to the end of humanity is in itself a challenge, as the very idea is so far from our usual references and to many the intuitive feeling will be to dismiss any such thing. The concept used in this report is “infinity”. The reson for this is that many of the challenges relate to discussed. In one way the name is not very important so long as people understand the impacts and risks associated with it. Still, a name is symbolic and can either help or make it more difficult to get support to establish the new category. The work to establish a list of risks with infinite impact evolved from “existential risk”, the philosophical concept that inspired much of the work to establish a clearly defined group of risks. The reason for not using the concept “existential risk and impact” for this category, beside the fact that existential impact is also used in academic contexts to refer to a personal impact, is that the infinite category is a smaller subset of “existential risk” and this new category is meant to be used as a tool, not a scientific concept. Not only should the impacts in the category potentially result in the end of all human life, it should be possible to affect the probability and/or impact of that risk. There must also exist an agreed methodology, such as the one suggested in this report, that decides what risks belong and not belong on the list. Another concept that the category relates to is “global catastrophic risk” as it is one of the most used concepts among academics interested in infinite impacts. However it is vague enough to be used to refer to impacts from a few thousand deaths to the end of human civilisation. Already in use but not clearly defined, it includes both the academic concept existential risks and the category of risks with infinite impacts. macroeconomics and its challenges in relation to the kind of impacts that the risks in this report focus on. Further, the name clearly highlights the unique nature without any normative judgements. Still, infinity is an abstract concept and it might not be best communicate the unique group of risks that it covers to all stakeholders. In the same way as it can be hard to use singularity to describe a black hole, it can be difficult to use infinity to describe a certain risk. If people can accept that it is only from a specific perspective that the infinity concept is relevant it could be used beyond the areas of macroeconomics. Two other concepts that also have been considered during the process of writing this report are “xrisks” and “human risk of ruin”. Xrisk has the advantage, and disadvantage, of not really saying anything at all about the risk. The positive aspect is that the name can be associated with the general concept of extinction and the philosophical concept of existential risk as both have the letter x in them. The disadvantage is the x often represents the unknown and can therefore relate to any risk. There is nothing in the name that directly relates to the kind of impacts that the category covers, so it is easy to interpret the term as just unknown risks. Human risk of ruin has the advantage of having a direct link to a concept, risk of ruin, that relates to a very specific state where all is lost. Risk of ruin is a concept in use in gambling, insurance, and finance that can all give very important contributions to the work with this new category of risk. The resemblance to an existing concept that is well established could be both a strength and a liability. Below is an overview of the process when different names were Figure 8: Example of F-n curve showing an absolute impact level that is defined as unacceptable/ infinite. i.e no level of probability is acceptable above a certain level of impact, in this case 1000 dead 64 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 47 2.3 Global challenges and infinite impact 3. 2. 1. 9. Unacceptable risks in different combinations, e.g. unacceptable global risks – This is probably not appropriate for two main reasons. First, it is a normative statement and the category aims to be scientific; whether these risks are unacceptable or not is up to the citizens of the world to decide. Second, the idea of risk is that it is a combination of probability times impact. If a risk is unacceptable is therefore also usually related to how easy it is to avoid. Even if a risk is small, due to relatively low probability and relatively low impact, but is very easy to address, it can be seen as unacceptable, in the same way a large risk can be seen as acceptable if it would require significant resources to reduce. There will not be a perfect concept and the question is what concept can find the best balance between being easy to understand, acceptable where policy decisions needs to be made and also acceptable for all key groups that are relevant for work in these area. During the process to find a name for this category inspiration has been found in the process when new concepts have been introduced; from irrational numbers and genocide to sustainable development and the Human Development Index. So far “infinite risk” can be seen as the least bad concept in some areas and “xrisks” and “human risk of ruin” the least bad in others. The purpose of this report is to establish a methodology to identify a very specific group of risks as well as continue to a process where these risks will be addressed in a systematic and appropriate way. The issue of naming this group of risks will be left to others. The important is that the category gets the attention it deserves. The three concepts are very different. Global catastrophic risk is possibly the most used concept in contexts where infinite impacts are included, but it is without any clear definition. Existential risk is an academic concept used by a much smaller group and with particular focus on future technologies. The category in this report is a tool to help decision makers develop strategies that help reduce the probability that humanity will end when it can be avoided. The relation between the three concepts can be illustrated with three circles. The large circle (1) represents global catastrophic risks, the middle one (2) existential risks and the small circle (3) the list of twelve risks in this report, i.e. risks where there are peer reviewed academic studies that estimate the probability of an infinite impact and where there are known ways to reduce the risk. A list that could be called infinite risks, xrisks, or human risk of ruin. Other concepts that are related to infinite impacts that could potentially be used to describe the same category if the above suggestions are not seen as acceptable concepts are presented below, together with the main reason why these concepts were not chosen for this report. 1. Risk of ruin – is a concept in gambling, insurance and finance relating to the likelihood of losing all one’s capital or affecting one’s bankroll beyond the point of recovery. It is used to describe individual companies rather than systems.66 2. Extinction risk – is used in biology for any species that is threatened. The concept is also used in memory/cognition research. It is a very dramatic term, to be used with care. These factors make it probably unsuitable for use by stakeholders accustomed to traditional risk assessment. 3. Astronomical risk – is seldom used scientifically, but when it is used it is often used for asteroids and is probably best reserved for them.67 4. Apocalyptic risk – could have been suitable, as the original meaning is apocálypsis, from the Greek ἀπό and καλύπτω meaning ‘un-covering’. It is sometime used, but in a more general sense, to mean significant risks.68 But through history and today it is mainly used for a religious end of time scenario. Its strong links to unscientific doom-mongers make it probably unsuitable for a scientific concept. 5. End-of-the-world risk - belongs to the irrational doomsday narratives and so is probably unsuitable for scientific risk assessments. 6. Extreme risk – is vague enough to describe anything beyond the normal, so it is probably unsuitable for risk assessments of this magnitude. 7. Unique risk – is even vaguer, as every risk is unique in some way. Probably best avoided in risk assessments. 8. Collapse risk – is based on Jared Diamond’s thinking.69 There are many different kinds of collapse and only a few result in infinite impact. 48 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 2.3 Global challenges and infinite impact Estimations of impact Only literature where there is some estimation of impact that indicates the possibility of an infinite impact is included. Leading organisations’ priorities In order to increase the probability of covering all relevant risks an overview of leading organisations' work was conducted. This list was then compared with the initial list and subjected to the same filter regarding the possibility to affect the probability or impact. Possibility of addressing the risk Possibility of addressing the risk: From the risks gathered from literature and organisations, only those where the probability or impact can be affected by human actions are included. Expert review Qualitative assessment: Expert review in order to increase the probability of covering all relevant global risks. List of risks Result: List of risks with potentially infinite impacts. Relevant literature Identification of credible sources: search relevant literature in academic literature included in World of Knowledge and Google Scholar. 1 2 3 4 5 6 This chapter presents the methodology used to identify global risks with potentially infinite impact. Methodology overview In order to establish a list of global risks with potentially infinite impact a methodological triangulation was used, consisting of: – A quantitative assessment of relevant literature. – A strategic selection of relevant organisations and their priorities. – A qualitative assessment with the help of expert workshops. 2.4 Methodology 70 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 49 2.4 Methodology The scientific review of literature was led by Seth Baum, Executive Director of the Global Catastrophic Risk Institute72 and research scientist at the Center for Research on Environmental Decisions, Columbia University.73 The methodology for including global risks with a potentially infinite impact is based on a scientific review of key literature, with focus on peer-reviewed academic journals, using keyword search of both World of Knowledge74 and Google Scholar75 combined with existing literature overviews in the area of global challenges. This also included a snowball methodology where references in the leading studies and books were used to identify other scientific studies and books. In order to select words for a literature search to identify infinite impacts, a process was established to identify words in the scientific literature connected to global challenges with potentially infinite impacts. Some words generate a lot of misses, i.e. publications that use the term but are not the focus of this report. For example “existential risk” is used in business; “human extinction” is used in memory/cognition. Some search terms produced relatively few hits. For example “global catastrophic risk” is not used much. Other words are only used by people within a specific research community: few use “existential risk” in our sense unless they are using Nick Bostrom’s work. The term “global catastrophe” was identified as a phrase that referred almost exclusively to extremely negative impacts on humans, by a diversity of researchers, not just people in one research community. A list of 178 relevant books and reports was established based on what other studies have referred to, and/or which are seen as landmark studies by groups interviewed during the process. They were selected for a closer examination regarding the challenges they include.76 The full bibliography, even with its focus on publications of general interest, is still rather long. So it is helpful to have a shorter list focused on the highlights; the most important publications based on how often they are quoted, how wellspread the content (methodology, lists, etc.) is and how often key organisations use them. The publications included must meet at least one of the following criteria: – Historical significance. This includes being the first publication to introduce certain key concepts, or other early discussions of global challenges. Publications of historical significance are important for showing the intellectual history of global challenges. Understanding how the state of the art research got to where it is today can also help us understand where it might go in the future. – Influential in developing the field. This includes publications that are highly cited77 and those that have motivated significant additional research. They are not necessarily the first publications to introduce the concepts they discuss, but for whatever reason they will have proved important in advancing research. – State of the art. This includes publications developing new concepts at the forefront of global challenges research as well as those providing the best discussions of important established concepts. Reading these publications would bring a researcher up to speed with current research on global challenges. So they are important for the quality of their ideas. – Covers multiple global challenges (at least two). Publications that discuss a variety of global challenges are of particular importance because they aid in identifying and comparing the various challenges. This process is essential for research on global risks to identify boundaries and research priorities. In order to identify which global challenges are most commonly discussed, key surveys were identified and coded. First, a list of publications that survey at least three global challenges was compiled, and they were then scanned to find which challenges they discussed. The publications that survey many global challenges were identified from the full bibliography. Publications from both the academic and popular literature were considered. Emphasis was placed on publications of repute or other significance.78 To qualify as a survey of global challenges, the publication had to provide an explicit list of challenges or to be of sufficient length and breadth for it to discuss a variety of challenges. Many of the publications are books or book-length collections of articles published in book form or as special issues of scholarly journals. Some individual articles were also included because they discussed a significant breadth of challenges. A total of 40 global challenge survey publications were identified. For authors with multiple entries (Bostrom with three and WEF with ten) each challenge was counted only once to avoid bias. review of key literature 71 2.4.1 A scientific 50 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 2.4 Methodology 0 5 10 15 20 25 Climate Change Nuclear War Pandemic Biodiversity loss Asteroid / Comet / Meteor Volcano Genetic Engineering High Energy Physics Nanotech Resource Depletion Artificial Intelligence Chemical Pollution Ecological Catastrophe Biogeochem Government Failure Poverty System Failure Astronomic Explosion LULCC Biological Weapons Chemical Weapons Extraterrestrial Reject Procreation Computer Failure EM Pulse New Technology Ozone Depletion Dysgenics Ocean Acidification Interstellar Cloud Atmosphere Aerosols Phase Transition Simulation Unknown 21 18 17 15 14 14 13 13 13 13 11 11 11 8 8 8 8 7 7 5 5 5 5 4 4 4 4 3 3 2 1 1 1 1 In terms of authorship and audience, there are 17 academic publications, 9 popular publications, 1 government report, 3 publications written by academics for popular audiences. In terms of format, there are 15 books, 5 edited collections, 7 articles, 3 of miscellaneous format. Of the 40 publications identified, 22 were available at the time of coding. In addition, 10 Global Risks Reports from the World Economic Forum were coded and then gathered under one heading: “WEF Global Risk Report 2005-2014”. A list of 34 global challenges was developed based on the challenges mentioned in the publications. A spreadsheet containing the challenges and the publications was created to record mentions of specific challenges in each publication to be coded. Then each publication was scanned in its entirety for mentions of global challenges. Scanning by this method was necessary because many of the publications did not contain explicit lists of global challenges, and the ones that did often mentioned additional challenges separately from their lists. So it was not required that a global challenge be mentioned in a list for it to be counted – it only had to be mentioned somewhere in the publication as a challenge. Assessing whether a particular portion of text counts as a global challenge and which category it fits in sometimes requires some interpretation. This is inevitable for most types of textual analysis, or, more generally, for the coding of qualitative data. The need for interpretation in this coding was heightened by the fact that the publications often were not written with the purpose of surveying the breadth of global challenges, and even the publications that were intended as surveys did not use consistent definitions of global challenges. The coding presented here erred on the side of greater inclusivity: if a portion of text was in the vicinity of a global challenge, then it was coded as one. For example, some publications discussed risks associated with nuclear weapons in a general sense without specifically mentioning the possibility of large-scale nuclear war. These discussions were coded as mentions of nuclear war, even though they could also refer to single usages of nuclear weapons that would not rate as a global challenge. This more inclusive approach is warranted because many of the publications were not focused exclusively on global challenges. If they were focused on them, it is likely that they would have included these risks in their global challenge form (e.g., nuclear war), given that they were already discussing something related (e.g., nuclear weapons). Below are the results from the overview of the surveys. Figure 9: Number of times global challenges are included in surveys of global challenges Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 51 2.4 Methodology Climate Change Nuclear War Pandemic Biodiversity loss Asteroid / Comet / Meteor Volcano Genetic Engineering High Energy Physics Nanotech Resource Depletion Artificial Intelligence Chemical Pollution Ecological Catastrophe 21 18 17 15 14 14 13 13 13 13 11 11 11 0 25 20 15 10 5 dung beetle star trek zinc oxalate human extinction 0 200 400 600 800 1000 It should be noted that the literature that includes multiple global challenges with potentially infinite impact is very small, given the fact that it is about the survival of the human race. Experts in the field of global challenges, like Nick Bostrom, have urged policymakers and donors to focus more on the global challenges with infinite impacts and have used dramatic rhetoric to illustrate how little research is being done on them compared with other areas. However, it is important to note that many more studies exist that focus on individual global risks, but often without including low-probability high-impact outcomes.80 How much work actually exists on human extinction infinite impact is therefore difficult to assess. The list of risks found in the scientific literature was checked against a review of what challenges key organisations working on global challenges include in their material and on their webpages. This was done to ensure that no important risk was excluded from the list. The coding of key organisations paralleled the coding of key survey publications. Organisations were identified via the global catastrophic risk organisation directory published by the Global Catastrophic Risk Institute.82 They were selected from the directory if they worked on a variety of global challenges – at least three, and ideally more. The reason for focusing on those that work on multiple challenges is to understand which challenges they consider important and why. In contrast, organisations that focus on only one or two challenges may not Figure 10: The global challenges included ten times or more in surveys of global challenges on global challenges 81 organisations working 2.4.2 A review of Figure 11: Number of academic papers on various topics (listed in Scopus, August 2012) From the paper “Existential Risk Prevention as Global Priority” 79 52 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 2.4 Methodology Climate Change Nuclear War Pandemic Resource Depletion Biological Weapons Computer Failure Government Failure Nanotech Chemical Weapons Artificial Intelligence Genetic Engineering System Failure Biodiversity loss Ecological Failure Poverty Volcano Asteroid / Comet / Meteor Astronomic Explosion Biogeochem Chemical Pollution Extraterrestrial High Energy Physics New Technology Ozone Depletion Atmospheric Aerosols Dysgenics EM Pulse Interstellar Cloud LULCC Ocean Acidification Phase Transition Reject Procreation Simulation Unknown 13 13 12 9 8 7 7 7 6 5 4 4 2 2 2 2 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 4 8 12 2 6 10 14 be able to adjust their focus according to which challenges they consider the most important. The organisation coding used the same coding scheme developed for coding survey publications. References to specific global challenges were obtained from organisations’ websites. Many have web pages which list the topics they work on. Where possible, references to global challenges were pulled from these pages. Additional references to these challenges were identified by browsing other web pages, including recent publications. While it is possible that some of these organisations have worked on global challenges not mentioned on the web pages that were examined, overall the main challenges that they have worked on have probably been identified and coded. So the results should give a reasonably accurate picture of what global challenges these organisations are working on. Organisations working with global challenges were initially selected on the basis of the literature overview. A snowball sampling was conducted based on the list of organisations identified, according to whether they claimed to work on global challenges and/or their web page contained information about “existential risk”, “global catastrophic risk”,“human extinction” or “greatest global challenges”. Cross-references between organisations and input during the workshops were also used to identify organisations. An initial list of 180 organisations which work with global challenges was established. Based on the production of relevant literature, which other organisations referred to the organisation, and/or are seen as influential by groups interviewed during the process, a short-list of organisations were selected for a closer examination regarding the challenges they work with. Then those working with multiple challenges were selected, resulting in a list of 19 organisations.83 Below is the overview of the results from the overview of key organisations working with multiple global challenges. The organisations working on global challenges vary widely in: 1. What they count as a global challenge 2. How systematically they identify global challenges; and 3. Their emphasis on the most important global challenges For most organisations working with global challenges there are no explanations for the methodology used to select the challenges. Only a few thought leaders, like Tower Watson and their Extreme Risk Report 2013, have a framework for the challenges and estimates of possible impacts. Figure 12: Global challenges that key organisations work with Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 53 2.4 Methodology Climate Change Nuclear War Pandemic Resource Depletion Biological Weapons Computer Failure Government Failure Nanotech Chemical Weapons Artificial Intelligence Genetic Engeneering System Failure Atmospheric Aerosols 13 13 12 9 8 7 7 7 6 5 4 4 0 4 8 12 2 6 10 14 In most cases there is neither a definition of the impact, nor a definition of the probability. The report that focuses on global risk which is probably best known is the WEF Global Risk Report. The WEF’s risk work, with many other groups’, is probably best described as belonging to the category of risk perception rather than risk assessment, where experts are asked to estimate risks, but without any clear definition of probability or impact. The more serious organisations, like the WEF, also clearly define what they do as discussing perception of risk, not a scientific assessment of the actual risk. The WEF describes its perception methodology as follows: “This approach can highlight areas that are of most concern to different stakeholders, and potentially galvanise shared efforts to address them.” 85 The question which people are asked to answer is: “What occurrence causes significant negative impact for several countries and industries?” 86 The respondents are then asked to provide a number on two scales from 1-4, one for impact and another for likelihood (within 10 years).87 It is then up to the respondent to define what 1-4 means, so the major value of the report is to track the changes in perception over the years. Such perception approaches are obviously very interesting and, as the WEF states, can influence actual probability as the readers’ decisions will be influenced by how different challenges are perceived. Still, it is important to remember that the report does not provide an assessment of the actual probability (0-100%) or an assessment of the impact (and not the impact on human suffering, as many respondents likely define risk in monetary terms for their own company or country). An overview of WEF reports from the last ten years indicates that the challenges that likely could happen when applying a five year horizon, like the first signs of climate change, governmental failure and traditional pandemic, are identified. On the other hand, challenges which have very big impacts but lower probability, like extreme climate change, nanotechnology, major volcanoes, AI, and asteroids, tend to get less, or no, attention. An important question to explore is whether a focus on the smaller but still serious impacts of global challenges can result in an increased probability of infinite impacts. For example, there are reasons to believe that a focus on incremental adaptation instead of significant mitigation could be a problem for climate change as it could result in high-carbon lock-in.88 Other research indicates that focus on commercially relevant smaller pandemics could result in actions that make a major pandemic more likely. It is argued that this could happen, for example, by encouraging increased trade of goods while investing in equipment that scans for the type of pandemics that are known. Such a system can reduce the probability for known pandemics while at the same time resulting in an increased probability for new and more serious pandemics.89 Figure 13: The top 12 global challenges that key organisations work with 2.4.3 Workshops global risks 2.5 The list of Two workshops were arranged where the selection of challenges was discussed, one with risk experts in Oxford at the Future of Humanity Institute and the other in London with experts from the financial sector. See Appendix 2 for agenda and participants. In both workshops the list of global challenges was discussed to see if any additional challenges should be included, or if there were reasons to exclude some from the list. No challenge was excluded at the workshops, but one was added. Although little research exists yet that is able to verify the potential impacts, the participants agreed to include Global System Collapse as a risk with possible infinite impact. There was agreement that further research is needed to clarify exactly what parts of the economic and political system could collapse and result in a potentially infinite outcome. The conclusion was that enough research exists to include such a collapse on the list. Based on the risks identified in the literature review and in the review of organisations and applying the criteria for potentially infinite impact, these risks were identified: 1. Extreme Climate Change 2. Nuclear War 3. Global Pandemic 4. Ecological Catastrophe 5. Global System Collapse 6. Major Asteroid Impact 7. Supervolcano 8. Synthetic Biology 9. Nanotechnology 10. Artificial Intelligence (AI) 11. Unknown Consequences 12. Future Bad Global Governance This is an initial list. Additional risks will be added as new scientific studies become available, and some will be removed if steps are taken to reduce their probability90 and/or impact so that they no longer meet the criteria. Four categories of global challenges The challenges included in this report belong to four categories. The first, current challenges, includes those where decisions today can result directly in infinite impacts. They are included even if the time between action and impact might be decades, as with climate change. The second category is exogenous challenges, those where decisions do not – currently – influence probability, but can influence impact. The third category is emerging challenges, those where technology and science are not advanced enough to pose a severe threat today, but where the challenges will probably soon be able to have an infinite impact. The technologies included in emerging challenges, including synthetic biology, nanotechnology and artificial intelligence (AI), will be critical to finding solutions to infinite impacts. Including these technologies should not be seen as an attempt to arrest them. If anything, the development of sustainable solutions should be accelerated. But it is equally important to create guidelines and frameworks to avoid their misuse, whether intentional or accidental. The fourth category, future global policy challenges, is of a different kind. It includes challenges related to the consequences of an inferior or destructive global governance system. This is especially important as well-intended actions to reduce global challenges could lead to future global governance systems with destructive impact. The first category, current challenges, includes: 1. Extreme Climate Change 2. Nuclear War 3. Global Pandemic 4. Ecological Catastrophe 5. Global System Collapse The second category, exogenous challenges, covers: 6. Major Asteroid Impact 7. Supervolcano Those in the third category, emerging challenges, are: 8. Synthetic Biology 9. Nanotechnology 10. Artificial Intelligence (AI) 11. Unknown Consequences The fourth category, global policy challenges, is: 12. Future Bad Global Governance not included 2.5.1 Risks Many risks could severely damage humanity but have not been included in this report. They were excluded for one or more of three reasons: 1. Limited impact. Many challenges can have significant local negative effects, without approaching the “2 billion negatively affected” criterion - tsunamis, for example, and chemical pollution. 2. No effective countermeasures. The report focuses on promoting effective interventions and so ignores challenges where nothing useful can be done to prevent or mitigate the impact, as with nearby gamma-ray bursts. 3. Included in other challenges. Many challenges are already covered by others, or have a damage profile so similar that there seemed no need to have a separate category. Population growth, for one, is an underlying driver significant for climate change and eco-system catastrophe, but without direct large-scale impacts. The challenges mentioned in the reviewed literature and organisations which are not included in this report often refer to economic damage such as “fiscal crises” or “unemployment”. While such impacts could have far-reaching consequences they are obviously of another magnitude than those included here. Some of the risks that were suggested and/or which exist in books and reports about global risks were rejected according to the criteria above. They include: 91 1. Astronomical explosion/nearby gamma-ray burst or supernova.92 These seem to be events of extremely low probability and which are unlikely to be survivable. Milder versions of them (where the source is sufficiently far away) may be considered in a subsequent report. ͢ Not included due to: No effective countermeasures 2. False vacuum collapse. If our universe is in a false vacuum and it collapses at any point, the collapse would expand at the speed of light destroying all organised structures in the universe.93 This would not be survivable. ͢ Not included due to: No effective countermeasures 3. Chemical pollution. Increasingly, there is particular concern about three types of chemicals: those that persist in the environment and accumulate in the bodies of wildlife and people, endocrine disruptors that can interfere with hormones, and chemicals that cause cancer or damage DNA. ͢ Not included due to: Limited impact 4. Dangerous physics experiments creating black holes/strangelets including high energy physics. These risks are of low probability94 and have been subsumed under “Uncertain Risks”. ͢ Not included due to: Included in other challenges 5. Destructive solar flares. Though solar flares or coronal mass ejections could cause great economic damage to our technological civilisation,95 they would not lead directly to mass casualties unless the system lacks basic resilience. They have been subsumed in the Global System Collapse category. ͢ Not included due to: Limited impact/included in other challenges 6. Moral collapse of humanity. Humanity may develop along a path that we would currently find morally repellent. The consequences of this are not clear-cut, and depend on value judgements that would be contentious and unshared.96 Some of these risks (such as global totalitarianism or enduring poverty) were included in the Governance Disasters category. ͢ Not included due to: included in other challenges 7. Resource depletion/LULCC/ Biodiversity loss. It has often been argued that declining resources will cause increased conflict.97 Nevertheless such conflicts would not be sufficient in themselves to threaten humanity on a large scale, without a “ System Collapse” or “Governance Disasters”. ͢ Not included due to: included in other challenges 8. New technological experimental risks. It is possible and plausible that new unexpected technological risks will emerge due to experiments. However, until we know what such risks may be, they are subsumed in the “Uncertain Risks” category. ͢ Not included due to: included in other challenges 9. Genocides. Though immense tragedies within specific areas, past genocides have remained contained in space and time and haven’t spread across the globe.98 ͢ Not included due to: Limited impact 10. Natural disasters. Most natural disasters, like tsunamis and hurricanes, have no likelihood of causing the extent of casualties100 needed for consideration on this list, as they are geographically limited and follow relatively mild impact probability curves. ͢ Not included due to: Limited impact 11. Computer failure/Cyberwarfare. Though an area of great interest and research, cyberwarfare has never caused mass casualties and would be unlikely to do so directly. It may be the subject of a future report, but in this report it is considered to be a subset of warfare and general destabilising risks. ͢ Not included due to: Limited impact/Submersed in other challenges 12. Underlying trends, e.g. overpopulation. Though increased population will put strains on resources and can contribute to increased probability for other challenges included in this report (such as climate change and ecosystem catastrophe), plausible population levels will not cause any direct harm to humanity.101 Population growth is however an important trend that is significantly affecting several risks. ͢ Not included due to: Limited impact/Submersed in other challenges Note: Important underlying trends are discussed in chapter 5. 2.5 The rseulting list of global risks using this methodology the infinite threshold impact levels beyond 2.6 Relationship between General mitigation and resilience Total short term casualties Civilisation collapse General pre-risk collapse countermeasures Post-risk collapse countermeasures Post-collapse external threats and risks Post-collapse politics Maintaining technology base Long-term reconstruction probability Anthropic effect Extinction Pre-risk rebuilding enablers (tech stores...) Social and ecosystem resilience Long term impact Post-risk politics Complex systems are often stable only within certain boundaries. Outside these boundaries the system can collapse and rapidly change to a new stable state, or it can trigger a process where change continues for a long time until a new stable state is found. Sometimes it can take a very long time for a system to stabilise again. Looking at all the biotic crises over the past 530 million years, a research team from Berkeley found an average of 10 million years between an extinction and a subsequent flourishing of life.102 What makes things difficult is that once a system is unstable, a small disaster can have knock-on effects – the death of one Austrian nobleman can result in an ultimatum which draws in neighbours until Australians end up fighting Turks and the First World War is well under way, to be followed by communism, the Second World War and the Cold War. The challenge of understanding complex systems includes the fact that many of them have multiple attractors, including what are called “strange attractors”.103 Changes are close to linear as long as the system does not change very much, but once it is pushed out of balance it will get closer to other attractors, and when those become strong enough the system will tend to move towards chaos until a new balance is achieved around the new attractor.104 None of the risks in this report is likely to result directly in an infinite impact, and some cannot do so physically. All the risks however are big enough to reach a threshold where the social and ecological systems become so unstable that an infinite impact could ensue, as the graph below shows. This graph and its accompanying text explain, how an event that reaches a threshold level could cascade into even worse situations, via civilisation collapse105 to human extinction. The graph also seeks to illustrate the importance of ensuring ecological and social resilience, the two major insurance policies we have against a negative spiral after a major impact that takes us beyond the infinite threshold. 2.6 Relations between impact levels beyond the infinite threshold 1. Social and ecosystem resilience. Resilient systems are naturally resistant to collapse, though this often comes at the cost of efficiency.106 The more resilient the system, the more likely it is to be able to adapt to even large disasters. Improving resilience ahead of time can improve outcomes, even if the nature of the disaster isn’t known. 2. General pre-risk collapse countermeasures. This category consists of all those measures put into place ahead of time to prevent civilisation collapse. It could include, for instance, measures to ensure continuity of government or prevent breakup of countries (or to allow these breakups to happen with the minimum of disruption). At the same time it should be noted that these kinds of measures could also trigger the breakdown. 3. General mitigation and resilience. This category consists of all measures that can reduce the impact of risks and prevent them getting out of hand (excluding social and ecosystem measures, which are important and general enough to deserve their own category). 4. Pre-risk rebuilding enablers. On top of attempting to prevent collapses, measures can also be taken to enable rebuilding after a collapse.107 This could involve building stores of food, of technology, or crucial reconstruction tools.108 Alternatively, it could involve training of key individuals or institutions (such as the crews of nuclear submarines) to give them useful post-collapse skills. 5. Long-term impact. Some risks (such as climate change) have strong long-term impacts after years or even decades. Others (such as pandemics) are more likely to have only a short-term impact. This category includes only direct longterm impacts. 6. Post-risk politics. The political structures of the post-risk world (governmental systems, conflicts between and within political groupings, economic and political links between groups) will be important in determining if a large impact leads ultimately to civilisation collapse or if recovery is possible. 7. Post-risk collapse countermeasures. These are the countermeasures that the postrisk political structures are likely to implement to prevent a complete civilisation collapse. 8. Maintaining a technology base. Current society is complex, with part of the world’s excess production diverted into maintaining a population of scientists, engineers and other experts, capable of preserving knowledge of technological innovations and developing new ones. In the simpler post-collapse societies, with possibly much lower populations, it will be a challenge to maintain current technology and prevent crucial skills from being lost.109 9. Post-collapse politics. Just as post-risk politics are important for preventing a collapse, post-collapse politics will be important in allowing a recovery. The ultimate fate of humanity may be tied up with the preservation of such concepts as human rights, the scientific method and technological progress. 10. Post-collapse external threats and risks. Simply because a risk has triggered the collapse of human civilisation, that does not mean that other risks are no longer present. Humanity will have much less resilience to deal with further damage, so the probability of these risks is important to determine the ultimate fate of humanity. 11. Anthropic effects. We cannot observe a world incapable of supporting life, because we could not be alive to observe it. When estimating the likelihood of disasters and recovery it is very important to take this effect into consideration and to adjust probability estimates accordingly.110 12. Long-term reconstruction probability. A post-collapse world will differ significantly from a preindustrial revolution world. Easy access to coal and oil will no longer be possible. In contrast, much usable aluminium will have been extracted and processed and will be left lying on the surface for easy use. Thus it will be important to establish how technically possible it may be to have a second industrial revolution and further reconstruction up to current capabilities without creating the problems that the first industrial revolution resulted in. “You may choose to look the other way but you can never say again that you did not know.” William Wilberforce Challenges 3. Twelve Global 60 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3. Twelve Global Challenges Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences For the selection of events information from specialised bodies and scientific journals in the area of global risk was gathered.111 Using keywords related to the various risks, a global selection of events was sought, along with original sourcing in academic or official sources. The list of events was then ranked based on their risk relevance, i.e. their effect on the probability and/or the impact of the challenge. To finalise the list, a group of experts was consulted by email and a draft overview of the challenges was presented at a workshop at the Future of Humanity Institute (FHI) in Oxford, where additional input was provided on selection and content. Issue experts were then consulted before the final list of events was established. 112 Four categories were used to classify the different events: 1. Policy: Global or national policy initiatives that affect probability and/or impact 2. Event: The challenge is made real in some way that is relevant for probability and/or impact 3. Research: New knowledge about probability and/or impact 4. Initiative: A stakeholder/group addressing the challenge in concrete ways to reduce probability and impact Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 61 3. Twelve Global Challengesof risks Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences 3.1Current risks Climate Change 3.1.1 Extreme Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions, or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). Extreme climate change is used to distinguish from the impacts beyond the dangerous climate that a 2° C temperature rise is expected to result in.113 62 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 3.1.1.1 Expected impact disaggregation 3.1.1.2 Probability Many of the expected impacts of climate change are well known, including a warming climate, more severe storms and droughts, rising sea levels, ocean acidification, and damage to vulnerable ecosystems.114 As for all risks there are uncertainties in the estimates, and warming could be much more extreme than the middle estimates suggest. Models tend to underestimate uncertainty115 (especially where impact on humanity is concerned,116 where the effect also depends on modellers’ choices such as the discount rate117), so there is a probability118 that humanity could be looking at a 4°C119 or even 6°C120 warming in the coming decades. This could arise from positive feedback loops, such as the release of methane from permafrost121 or the dieback of the Amazon rainforests,122 that strengthen the warming effect. So far, efforts at curbing emissions have been only moderately successful and are still very far from what is needed.123 The impact of global warming, whether mild or severe, would be felt most strongly in poorer countries. Adaptation that can address significant warming is often very expensive,124 and many of the poorest countries are in the tropics and sub-tropics that would be hardest hit (they could become completely uninhabitable for the highest range of warming125). Mass deaths and famines, social collapse and mass migration are certainly possible in this scenario. Combined with shocks to the agriculture and biosphere-dependent industries of the more developed countries, this could lead to global conflict and possibly civilisation collapse – to the extent that many experts see climate change as a national security risk126. Further evidence of the risk comes from indications that past civilisation collapses have been driven by climate change.127 Extinction risk could develop from this if the remaining human groups were vulnerable to other shocks, such as pandemics, possibly exacerbated by the changed climate.128 There is some evidence of 6°C climate change causing mass extinction in the past,129 but a technological species such as ourselves might be more resilient to such a shock. A unique feature of the climate change challenge is what is called geo-engineering.130 Though this could - if it works - reduce many impacts at a relatively low cost, it would not do so evenly. Geo-engineering would possibly reduce the impacts of climate change in some countries, benefitting them while leaving others to suffer.131 This could lead to greater political instability. One of the most popular geo-engineering ideas – stratospheric sulphate aerosols – suffers from the weakness that it must be continuous. 132 If for any reason it stopped (such as a civilisation collapse), warming would resume at a significantly higher pace, reaching the point where it would have been without geo-engineering. The speed of this rebound would put extra pressure on the ecosystem and the world’s political system. So the biggest challenge is that geoengineering may backfire and simply make matters worse.134 Five important factors in estimating the probabilities and impacts of the challenge: 1. The uncertainties in climate sensitivity models, including the tail. 2. The likelihood - or not - of global coordination on controlling emissions. 3. The future uptake of low-carbon economies, including energy, mobility and food systems. 4. Whether technological innovations will improve or worsen the situation, and by how much. 5. The long-term climate impact caused by global warming. Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 63 3.1 Current risks CLIMATE CHANGE Climate research Pre-warming mitigation efforts Pre-warming collapse countermeasures Climate warfare Collapse of geoengineering projects New, polluting, uses for carbon products Low-carbon economies Geoengineering Technological innovations Research in emmision-reducing technologies Global coordination Economic transformations Research in mitigation and adaptation Moderate climate change Global poverty Extreme climate change Feedback loops Carbon emissions Climate change mitigation and adaptation Direct casualties Political instability in vulnerable nations Agriculture disruption Disruption to world politics and economy Ecosystem damage (e.g. ocean acidification) Post warming politics Long-term climate effects Forced migration Total short-term casualties Meta-uncertainty on how to predict the international political process Meta-uncertainty on the true uncertainty in climate change models Increased storms, flooding and natural disaters Civilization collapse Easily visible effects of climate change Extinction Uncertain events Key Meta-uncertainties Risk events Direct impacts Indirect impacts Current intervention areas Bad decisions Accidents Severe impacts GOVERNANCE DISASTERS Global povety Global instability New system of governance Smart sensors Global coordination Improvements to global governance Deliberate attempts to construct world dictatorship Technological innovations Enduring poverty Not achieving important ethical goals Climate change Lack of human flourishing Undesirable world system (e.g. global dictatorship) Global pollution Disruption to world politics and economy Total short-term casualties Collapse of world system Post-disaster politics General mitigation effort Long-term negative effects Civilisation collapse Extinction Failing to solve important problems Making things worse Uncertain events Key Meta-uncertainties Risk events Direct impacts Indirect impacts Current intervention areas Bad decisions Accidents Severe impacts Meta-uncertainty on tradeoffs between e.g. poverty, survival, freedom 64 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 1. Research which further refines our understanding of climate change and geo-engineering ideas will be essential in predicting change, preparing for it, and potentially reversing it. On the negative side, climate science research may allow the possibility of climate change tools being used for warfare. 2. Global poverty will affect both the vulnerability of many nations to the effects of climate change, and the likelihood of achieving global coordination earlier rather than later. 3. Pre-extreme warming mitigation efforts will affect the level of impact from climate change. 4. Pre-warming collapse countermeasures will affect the likelihood of civilisation collapse. 5. Research into mitigation and adaptation is necessary for effective implementation of either approach. 6. Research into emission-reducing technologies (such as alternative energies) will be important for transitioning to a low carbon economy. 7. Global coordination and cooperation will be key to funding mitigation/ adaptation research and development, and for the global control of carbon emissions or transitioning to a global low carbon economy. 8. Climate warfare is possible if geoengineering and climate modification methods can be harnessed by nations to harm others. 9. New, more polluting uses of carbon would, if they had a strong economic rationale, put upwards pressure on carbon emissions. 10. The direct casualties of limited global warming are likely to be few, as humans can adapt to many different temperatures and climates. The indirect effect can however be significant, e.g. migration, starvation, extreme weather. 11. Climate change is likely to cause extensive ecosystem damage, such as ocean acidification and pressure on many sensitive species that cannot easily adapt to temperature changes. 12. Agriculture will be disrupted by increased temperature. 13. The direct and indirect effects of climate change will have a great impact on the world’s political and economic systems, which will in turn determine the severity of the changes. 14. Many nations will be made politically vulnerable to the direct and indirect impacts of climate change, putting great pressure on their political systems and institutions. 15. Climate change will cause an increase in storms, floods, and other natural disasters. If political stability is maintained, most of the casualties are likely to result from these factors. 16. Forced migration from unstable or disrupted areas will put further pressure on more stable areas. 17. The long-term impact of climate change (including further carbon emissions and warming) will be important for determining the risk of collapse and subsequent rebuilding possibilities. 18. Attempts to mitigate and adapt to climate change will be important for reducing the severity of climate change’s impact. 19. The level of carbon emissions is the driver of climate change, and will be crucial in determining its ultimate impact. 20. Feedback loops will be important in determining whether carbon emissions are self-damping or self-forcing (i.e. whether an extra ton of CO2 emissions is likely to result in more or less than a ton in the atmosphere). 21. Transitioning to low carbon economies will be crucial for reducing emissions without disrupting the world’s political or economic systems. 22. Geo-engineering offers the possibility of decreasing carbon concentration in the atmosphere alongside, or instead of, emission reductions. But it may make climate warfare a possibility. 23. If geo-engineering projects collapse in the middle of implementation, this could lead to strong warming over a dangerously short period of time. 24. Technological innovations will be crucial for transitioning to low carbon economies or allowing geo-engineering. But they may also result in new, carbon-intensive innovations, which, if sufficiently profitable, could push emissions up. 25. Some level of changes to the standard economic system may be needed to transition to low carbon economies. 26. Easily visible impacts of climate change may be instrumental in pushing better global coordination on the issue. 27. The political systems in place as warming increases will determine how well the world copes with a hotter planet. 28. Climate models are extremely detailed and inevitably uncertain. But the real level of uncertainty includes uncertainties about the models themselves. 29. The course of international politics is extremely hard to predict, even for political scientists.135 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 65 3.1 Current risks during 2013 3.1.1.3 Main events 19-Apr-13: Launch of the report “Unburnable Carbon 2013: Wasted capital and stranded assets” 136 – Research To constrain the rise in global average temperature to less than 2°C above pre-industrial levels, a maximum of around 565 – 886 billion tonnes (Gt) of carbon dioxide could be emitted before 2050.137 The world’s proven fossil fuel reserves amount to 2,860 Gt of CO2, however, and are viewed as assets by companies and countries. Since it is likely that these assets cannot be realised, these entities are over-valued at current prices – arguably, a “carbon bubble.” The report provides evidence that serious risks are growing for highcarbon assets, and aims to help investors and regulators manage these risks more effectively and prepare for a global agreement on emissions reductions. It indirectly highlights part of the challenge of emissions reductions: they will mean the loss of highly valuable assets to corporations and governments. 02-May-13: CO2 at 400 PPM for the first time in > 800,000 years138 – Event The Mauna Loa carbon dioxide record, also known as the “Keeling Curve,” is the world’s longest unbroken record of atmospheric CO2 concentrations. It recently reached 400 ppm (parts per million) of CO2. Such concentrations have not been reached for at least 800,000 years,139 placing humanity in a historically unprecedented situation. Prior to the Industrial Revolution, natural climate variations caused atmospheric CO2 to vary between about 200 ppm during ice ages and 300 ppm during the warmer inter-glacial periods. The last time concentrations were as high as they are now seems to have been during the Mid-Pliocene, about 3 million years before the present when temperatures were 2-3°C warmer, and in which geological evidence and isotopes agree that sea level was at least 15 to 25 m above today’s levels with correspondingly smaller ice sheets and lower continental aridity.140 21-May-13: China agrees to impose carbon targets by 2016141 – Policy Since China is the world’s greatest emitter of CO2,142 any reduction steps it takes can have a substantial impact. It has announced a “National Low Carbon Day“,143 a “series of major promotional events to improve awareness and get the whole society to address climate change.” More practically, the Chinese government has agreed to impose carbon targets by 2016 - a ceiling on greenhouse gas emissions.144 Figure 14-15, Source: Scripps Institution of Oceanography, via http://blogs.scientificamerican.com/ observations/2013/05/09/400-ppm-carbon-dioxide-in-the-atmosphere-reaches-prehistoric-levels 66 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 22-May-13: Private Sector Initiative - database of actions on adaptation145 – Initiative Global warming is an externality146 – a consequence of business decisions made by entities that do not bear the full cost of what they decide – so the drive to mitigate its effects is more likely to come from governmental or supra-governmental organisations. Nevertheless, the private sector has been involved in mitigation attempts for a variety of reasons, from investment opportunities to public relations. The United Nations Framework Convention on Climate Change (UNFCCC) maintains a database of some of these attempts, ranging from Ericsson’s enabling access to climate services in Uganda, through BASF’s development of new technologies for food security, Allianz insurers rewarding sustainable business practices, all the way to Chiles de Nicaragua’s attempts to enable small agro-exporters to adapt to climate change – and many more. The potential opportunities for private companies are listed as: – New market opportunities and expansion; – Development of climate-friendly goods and services; – Potential cost savings; – Risk reduction measures, including physical operations; – Climate proofing the supply chain; – Enhanced corporate social responsibility. 27-Sep-13: IPCC report: “Climate Change 2013: The Physical Science Basis” 147 – Research The 5th IPCC report “considers new evidence of climate change based on many independent scientific analyses from observations of the climate system, palaeoclimate archives, theoretical studies of climate processes and simulations using climate models.” It concludes that: – Warming of the climate system is unequivocal, and since the 1950s many of the observed changes are unprecedented over decades to millennia. The atmosphere and oceans have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased. – Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system. It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. – Each of the last three decades has been successively warmer at the Earth’s surface than any preceding decade since 1850. – Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent. – The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia (high confidence). Over the period 1901 to 2010, global mean sea level rose by 0.19 [0.17 to 0.21] m. – The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years. Carbon dioxide concentrations have increased by 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land use change emissions. The report further predicted, amongst other points, that: – Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. – The oceans will continue to warm during the 21st century. Heat will penetrate from the surface to the deep ocean and affect ocean circulation. Further uptake of carbon by the oceans will increase ocean acidification. Global mean sea level will continue to rise during the 21st century. – It is very likely that Arctic sea ice cover will continue to shrink and become thinner. Global glacier volume will further decrease. – Most aspects of climate change will persist for many centuries even if emissions of CO2 are stopped. Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 67 3.1 Current risks 27-Sep-13: Launch of the Global Risk and Opportunity Indicator (GROI) 148 – Research Launched by the Global Challenge Foundation, this Indicator is a web tool for illustrating quantified risks, with the objective of increasing awareness about global risks and opportunities and helping guide the changes required in the global governance system. The site is still under construction; the Foundation’s aims are to achieve, by the end of 2014: 1. An interactive Global Risk & Opportunity Indicator that allows users to calculate the probability for any global warming, between one and ten degrees Celsius, at different greenhouse gas concentrations. The indicator will then be further developed to illustrate interdependencies with other global risks and highlight opportunities for minimising the risks. Subsequent development will allow users to change different underlying assumptions and see the corresponding change in risk. 2. Methodology and data to estimate probabilities for a number of climate impacts at different temperature levels, e.g., sea level rise, droughts, flooding and heat waves, as well as to explore the risk of runaway global warming. 3. Methodology and data to estimate the probability of existential climate threats, i.e., to estimate the risk that climate change impacts pose a significant threat to human civilisation – defined as a serious negative impact on at least two billion people. 23-Nov-13: Limited progress at Warsaw COP 19 climate negotiations 149 – Policy The global environment can be considered a global public good (i.e. non-excludable and non-rivalrous).150 Economic theory claims that such goods will be undersupplied by the market.151 Hence the importance of trans-national negotiations to address climate change. Despite the importance of the subject, the main achievement of the Warsaw negotiations was to keep talks on track for more negotiations in 2015.152 Though there was general agreement on the necessity of cutting carbon emissions, the dispute was over how to share the burden of doing so. In this instance, the debate was between more- and less-developed countries, with the latter demanding compensation from the former to help them cope with the burden of reducing emissions. That particular dispute was papered over,153 but similar ones will be likely in future due to the range of different actors and their divergent agendas.154 03-Dec-13 Abrupt Impacts of Climate Change: Anticipating Surprises155 – Research Climate change has been developing gradually, at least on the human scale156 (though very rapidly on a geological timescale157). This may not continue, however: this paper looks at the potential for abrupt changes in physical, biological, and human systems, in response to steady climate change. It highlights two abrupt changes that are already under way: the rapid decline in sea ice158 and the extinction pressure on species.159 On the other hand, some widely discussed abrupt changes – the rapid shutdown of the Atlantic Meridional Overturning Circulation160 and the rapid release of methane from either thawing permafrost161 or methane hydrates162 – are shown to be unlikely to occur this century. The report argues that large uncertainties about the likelihood of some potential abrupt changes163 highlight the need for expanded research and monitoring, and propose an abrupt change early warning system. The aim would be to foresee abrupt change before it occurs, and reduce the potential consequences. 68 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 69 3.1 Current risks Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences 3.1 Current risks 3.1.2 Nuclear War After their use in Hiroshima and Nagasaki nuclear weapons have never been used in a conflict, but because they are extremely powerful and could cause destruction throughout the world, the possibility of nuclear war has had a great effect on international politics. 164 70 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 3.1.2.1 Expected impact disaggregation 3.1.2.2 Probability The likelihood of a full-scale nuclear war between the USA and Russia has probably decreased in recent decades due to some improvements in relations between these two countries and reductions in the size of their arsenals. Still, the potential for deliberate or accidental165 nuclear conflict has not been removed, with some estimates putting the risk of nuclear war in the next century or so at around 10%166 – it may have been mostly down to luck that such a war did not happen in the last half century167. A nuclear war could have a range of different impacts. At the lowest end is the most obvious and immediate impact: destruction and death in major cities across the world, due to the explosions themselves and the radioactive fallout. But even if the entire populations of Europe, Russia and the USA were directly wiped out in a nuclear war – an outcome that some studies have shown to be physically impossible168, given population dispersal and the number of missiles in existence169 – that would not raise the war to the first level of impact, which requires > 2 billion affected.170 A larger impact would depend on whether or not the war triggered what is often called a nuclear winter or something similar.171 The term refers to the creation of a pall of smoke high in the stratosphere that would plunge temperatures below freezing around the globe and possibly also destroy most of the ozone layer.172 The detonations would need to start firestorms in the targeted cities, which could lift the soot up into the stratosphere.173 There are some uncertainties about both the climate models and the likelihood of devastating firestorms,174 but the risks are severe and recent models175 have confirmed the earlier176 analysis. Even a smaller nuclear conflict (between India and Pakistan, for instance) could trigger a smaller nuclear winter which would place billions in danger.177 The disintegration of the global food supply would make mass starvation and state collapse likely. As the world balance of power would be dramatically shifted and previous ideological positions called into question, large-scale war would be likely. This could lead to a civilisation collapse. Extinction risk is only possible if the aftermath of the nuclear war fragments and diminishes human society to the point where recovery becomes impossible178 before humanity succumbs179 to other risks, such as pandemics.180 Five important factors in estimating the probabilities and impacts of the challenge: 1. How relations between current and future nuclear powers develop. 2. The probability of accidental war. 3. Whether disarmament efforts will succeed in reducing the number of nuclear warheads. 4. The likelihood of a nuclear winter. 5. The long-term effects of a nuclear war on climate, infrastructure and technology. Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 71 3.1 Current risks NUCLEAR WAR US-Russia relations Relations between future major nuclear powers Number of future major nuclear powers Meta-certainty of changes in the military technology Meta-certainty of political predictions Disarmament efforts Proliferation: desire for nuclear weapons Proliferation: building nuclear weapons Number of future small nuclear powers Relations between future nuclear powers Relations between current nuclear powers Nuclear attack Nuclear attack Full-scale Nuclear War Disruption to world politics and economy War casualties Firestorm risks Firestorm risks Nuclear Winter Small Nuclear Winter Post-war politics Pre-war casualty countermeasures (bunkers, food...) Long-term impact Extinction Civisation collapse Total short term casualties War casualties Nuclear accidents or misunderstandings Small-scale Nuclear War Nuclear terrorism Nuclear security Uncertain events Key Meta-uncertainties Risk events Direct impacts Indirect impacts Current intervention areas Bad decisions Accidents Severe impacts GOVERNANCE DISASTERS Global povety Global instability New system of governance Smart sensors Global coordination Improvements to global governance Deliberate attempts to construct world dictatorship Technological innovations Enduring poverty Not achieving important ethical goals Climate change Lack of human flourishing Undesirable world system (e.g. global dictatorship) Global pollution Disruption to world politics and economy Total short-term casualties Collapse of world system Post-disaster politics General mitigation effort Long-term negative effects Civilisation collapse Extinction Failing to solve important problems Making things worse Uncertain events Key Meta-uncertainties Risk events Direct impacts Indirect impacts Current intervention areas Bad decisions Accidents Severe impacts Meta-uncertainty on tradeoffs between e.g. poverty, survival, freedom 72 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 1. The success or failure of disarmament will determine the number of nuclear warheads available for a future nuclear conflict. 2. The first step of proliferation is countries desiring to possess nuclear weapons. Various political interventions may reduce or increase this desire. 3. The second step of proliferation is countries building nuclear weapons. Various mechanisms, agreements and inspections may be relevant 4. Nuclear terrorism may be the trigger of a larger nuclear conflict, especially if the detonation is misinterpreted as a traditional attack. 5. The security of nuclear weapons and materials affects both the probability of nuclear terrorism and the control likelihood of nuclear accidents. 6. The relations between future nuclear powers will be the major determinant of whether a nuclear war breaks out. 7. The relations between current nuclear powers will be a major determinant of the relations between future nuclear powers. 8. The relations between future major nuclear powers will be the major component of determining whether a major nuclear war breaks out. 9. Relations between the USA and Russia (the only current major nuclear powers) will be a major determinant of the relations between future major nuclear powers. 10. Pre-war countermeasures (such as nuclear bunkers and food stores) can help mitigate the casualties of a smaller nuclear conflict. 11. A small-scale nuclear war could start with an attack by one or more nuclear powers. 12. A full-scale nuclear war could start with an attack by one or more major nuclear powers. 13. Aside from attacks, the other way a nuclear war could start would be through accidental firings or misinterpretations of other incidents. 14. Firestorms caused by burning cities are one of the main ways a nuclear conflict could cause major climate disruption, and hence high casualties. 15. The direct war casualties from a nuclear conflict are likely to be small compared with the potential climate effects. 16. A nuclear winter is the way in which a nuclear conflict could have the most damaging effects on the world. 17. Even a smaller nuclear conflict could trigger a smaller nuclear winter that could have major disruptive effects on agriculture and hence human survival. 18. Any war will have a disruptive impact on the world’s politics and economy. A nuclear conflict – possibly accompanied by a nuclear winter – even more so. 19. The long term impact of nuclear winter, infrastructure disruption, and possibly radiation, will determine the likelihood of collapse and rebuilding. 20. Since a nuclear power must be one of the parties to a nuclear war, the number of the former affects the probability of the latter. 21. Since a major nuclear power must be one of the parties to a major nuclear war, the number of the former affects the probability of the latter. 22. Post-war politics will be determined by the war, the disruption it caused, and the number of casualties it inflicted. 23. Unlike other risks, nuclear weapons are targeted by humans, so may take out important parts of the world’s infrastructure (and conventional weapons used in a conflict may have the same effect). 24. Unlike other risks, nuclear weapons are targeted by humans, so may take out important parts of the world’s technology and research base (and conventional weapons used in a conflict may have the same effect). 25. Maintaining a technology base will be complicated by the possible targeting of infrastructure and the technology base during a conflict. 26. The further development of military technology is hard to predict. The current balance of power under MAD (mutually assured destruction) is based on certain assumptions about the effectiveness of nuclear weapons, such as second strike capability. If this were removed (such as by effective submarine detection, or anti-ballistic missile shields), the effect on the balance of power is hard to predict. 27. The course of international politics is extremely hard to predict, even for political scientists.181 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 73 3.1 Current risks during 2013 3.1.2.3 Main events 12-Feb-13: North Korea carries out third, largest nuclear test 182 – Event On 12 February 2013, North Korea carried out its third nuclear test. The test was condemned across the world, 183 and led to increased sanctions184 against the already isolated nation.185 North Korea is the only nation to have withdrawn from the Nuclear NonProliferation Treaty,186 and is the only country to have conducted nuclear tests in the 21st century, starting in 2006, 187 as well as developing a ballistic missile capability.188 It has also been involved in the export of weapons technology, undermining the Treaty.189 Diplomatic attempts to deal with North Korea (especially on the part of the United States) have generally been inconsistent and unsuccessful.190 Though the situation remains a potential flashpoint for conventional and nuclear conflict, and its collapse could have disastrous consequences191 (including the possibility of “loose nukes” becoming available to various groups), it should be noted that the “North Korean problem” has existed in one form or another since the end of the Korean War in 1953, without erupting into open conflict.192 04-Mar-13: Conference: Humanitarian Impact of Nuclear Weapons 193 – Policy On 4 and 5 March 2013, the Norwegian Minister of Foreign Affairs, Espen Barth Eide, hosted an international conference on the humanitarian impact of nuclear weapons. The conference heard presentations on the effects of nuclear weapons detonations. Three key points emerged: – It is unlikely that any state or international body could address the immediate humanitarian emergency caused by a nuclear weapon detonation in an adequate manner and provide sufficient assistance to those affected. Moreover, it might not be possible to establish such capacities at all. – The historical experience from the use and testing of nuclear weapons has demonstrated their devastating immediate and long-term effects. While political circumstances have changed, the destructive potential of nuclear weapons remains. – The effects of a nuclear weapon detonation, irrespective of cause, will not be limited by national borders, and will affect states and people to significant degrees, regionally as well as globally. A number of states wished to explore these issues further, and Mexico said it would host a follow-up conference.194Figure 16, Source: Wikimedia Commons, http://en.wikipedia.org/wiki/ File:Worldwide\_nuclear\_testing.svg CC-BY-SA license. Worldwide nuclear testing, 1945-2013 74 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 16-May-13: Revealed: The USSR and US Came Closer to Nuclear War Than Was Thought 195 – Research Documents recently released under a FOIA (US Freedom Of Information Act) request show that the risk of nuclear conflict between the superpowers was higher than realised at the time. The large-scale 1983 NATO nuclear exercises Able Archer 83” spurred “a high level of Soviet military activity, with new deployments of weapons and strike forces.” This unprecedented Soviet reaction in turn created a series of introspective US intelligence analyses and counter-analyses, debating whether US intelligence had actually understood Soviet actions, perceptions, and fears – and acknowledging the danger of nuclear “miscalculation” if it had not.196 This is but one of the many nuclear accidents197 and incidents that peppered the Cold War and its aftermath, and which have been revealed only subsequently. We know now that there were at least three occasions – the Cuban missile crisis in 1962,198 the Petrov incident in 1983199 and the Norwegian rocket incident in 1995200 – where a full-scale nuclear war was only narrowly averted.201 Further information on these incidents, and on how they were interpreted and misinterpreted202 by the great powers, will be important to estimate the probability of nuclear conflict in the coming decades. On a more positive note, efforts are being made to reduce the probability of inadvertent or accidental nuclear conflicts.203 24-Jun-13: Report: “Analysing and Reducing the Risks of Inadvertent Nuclear War Between the United States and Russia” 204 – Research Though the end of the Cold War has reduced the likelihood of deliberate nuclear war, its impact on the risk of accidental nuclear war is much smaller. The arsenals remain on “launch on warning”,205 meaning that there is a possibility for a “retaliatory” strike before an attack is confirmed. The most likely cause of such an accident is either a false warning (of which there have been many, with causes ranging from weather phenomena to a faulty computer chip, wild animal activity, and controlroom training tapes loaded at the wrong time)206 or a misinterpreted terrorist attack.207 The report attempted a rigorous estimate of the numerical probability of nuclear war. Such numerical rigour is rare, with the exception of Hellman’s estimates.208 This report applied risk analysis methods using fault trees and mathematical modelling to assess the relative risks of multiple inadvertent nuclear war scenarios previously identified in the literature. Then it combined the fault tree-based risk models with parameter estimates sourced from the academic literature, characterising uncertainties in the form of probability distributions, with propagation of uncertainties in the fault tree using Monte Carlo simulation methods. Finally, it also performed sensitivity analyses to identify dominant risks under various assumptions. This kind of highly disaggregated analysis is most likely to elicit the best performance and estimates from experts.209 Their conclusion was that (under the more pessimistic assumption), there was a mean 2% risk of accidental nuclear war a year (a high risk when compounded over several decades), with the risk from false alarm being orders of magnitude higher than that from terrorist attacks. The analysis suggests that the most important inadvertent nuclear war risk factor is the short launch decision times,210 inherent in the “launch on warning” posture. Some ways of improving this were suggested, for instance by moving each country’s strategic submarines away from the other’s coasts. Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 75 3.1 Current risks 03-Sep-13: Report of the UN General Assembly working group on “Taking Forward Multilateral Nuclear Disarmament Negotiations” 211 – Policy The working group had extensive exchanges of view from different participants, and reviewed existing disarmament commitments and proposals, including international law. The issues surrounding disarmament and treaties were analysed in depth, and several proposals were put forward, with an eye to the complete elimination of nuclear weapons. A key recognition was, however, that “participants recognised the absence of concrete outcomes of multilateral nuclear disarmament negotiations within the United Nations framework for more than a decade”. Indeed, though the Nuclear Non-Proliferation Treaty212 (NPT) is a multilateral treaty closely connected with the United Nations, and though it committed the nuclear powers to reduce their arsenals, all the major nuclear arms reduction deals have been bilateral treaties between the US and the USSR/Russia. These include the INF treaty213, START I214, SORT215, and New START216, which have significantly reduced the world’s stock of nuclear weapons. It has also been argued that the NPT has been undermined by a number of bilateral deals made by NPT signatories, most notably the United States.217 This further serves to emphasise the weakness of international institutions where nuclear arms control is concerned. 15-Nov-13: International Physicians for the Prevention of Nuclear War report: “Nuclear Famine: Two Billion People at Risk?” 218 – Research This report is one of a series of reports and publications in recent years about the potential impacts of nuclear conflicts.219 It looked at the likely consequences of a “limited” nuclear war, such as between India and Pakistan. While previous papers had estimated that up to a billion people might be at risk in such a conflict,220 this report increased the estimate to two billion. The main source of this increase is decreased agricultural production in the United States221 and in China.222 A key component of these estimates was the severe agricultural impact of the relatively mild temperature reduction in 1816, the “year without a summer” 223, due mainly to the “volcanic winter” caused by the eruption of Mount Tambora. The report highlights some significant areas of uncertainty, such as whether a small nuclear conflict and its consequences would lead to further conflicts across the world, and doubts whether markets, governments and other organisations could mitigate the negative impacts. The report is a reminder that even small-scale nuclear conflict could have severe consequences. 24-Nov-13: Nuclear deal with Iran may reduce risk of proliferation 224 – Policy In November, Iran struck a deal with the so called “P5+1” (the five permanent members of the security council, plus Germany). The deal, if it holds, would allow Iran to continue some uranium enrichment, but it would have to submit to inspections to ensure it wasn’t developing a nuclear weapons programme (the deal would also result in eased sanctions in return). There have been longrunning fears than Iran may have been attempting to construct a nuclear weapon225, resulting in sanctions being imposed on it.226 This event illustrates the surprising success of the Non-Proliferation Treaty,227 which came into force in 1970. At the time it was proposed there were fears of very rapid proliferation of nuclear weapons.228 And though 40 countries or more currently have the knowhow to build nuclear weapons,229 only nine countries are currently known to possess them: the five security council members, India, Pakistan, and North Korea, plus Israel.230 76 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 77 3.1 Current risks Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences 3.1 Current risks Catastrophe 3.1.3 Ecological Ecological collapse refers to a situation where an ecosystem suffers a drastic, possibly permanent, reduction in carrying capacity for all organisms, often resulting in mass extinction. Usually an ecological collapse is precipitated by a disastrous event occurring on a short time scale. 231 78 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 3.1.3.1 Expected impact disaggregation 3.1.3.2 Probability Humans are part of the global ecosystem and so fundamentally depend on it for our welfare. Species extinction is proceeding at a greatly increased rate compared with historic data232, and attempts to quantify a safe ecological operating space place humanity well outside it.233 Furthermore, there may be signs of a “sudden” biosphere collapse, possibly within a few generations.234 Many of the problems of ecological degradation interact to multiply the damage and (unlike previous, localised collapses) the whole world is potentially at risk, 235 with severe challenges to countering this risk through global policy.236 If animals are seen to have intrinsic value, 237 or if human quality of life is dependent on a functioning ecosystem, 238 the current situation already represents a large loss. Whether such a loss will extend to human lives depends on technological and political factors - technological, because it seems plausible that some human lifestyles could be sustained in a relatively ecosystem-independent way, at relatively low costs.239 Whether this can be implemented on a large scale in practice, especially during a collapse, will be a political challenge and whether it is something we want is an ethical question. There is currently more than enough food for everyone on the planet to ensure the nutrition needed, 240 but its distribution is extremely uneven and malnutrition persists. Thus ecological collapse need not have a strong absolute effect in order to result in strong localised, or global, effects. Even a partial collapse could lead to wars, mass migrations, and social instability. It is conceivable that such a scenario, if drawn out and exacerbated by poor decision-making, could eventually lead to mass deaths and even the collapse of civilisation. Extinction risk is possible only if the aftermath of collapse fragments and diminishes human society so far that recovery becomes impossible241 before humanity succumbs to other risks (such as climate change or pandemics). After a post-civilisation collapse, human society could still be suffering from the effects of ecological collapse, and depending on what form it took, this could make the recovery of human civilisation more challenging than in some of the other scenarios presented here. Five important factors in estimating the probabilities and impacts of the challenge: 1. The extent to which humans are dependent on the ecosystem. 2. Whether there will be effective political measures taken to protect the ecosystem on a large scale. 3. The likelihood of the emergence of sustainable economies. 4. The positive and negative impacts on the eco systems of both wealth and poverty. 5. The long-term effects of an ecological collapse on ecosystems. Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 79 3.1 Current risks ECOLOGICAL CATASTROPHE Long-term ecological effects Post-eco-collapse climate change Moral tragedy from ecosystem loss Quality of life loss from ecosystem loss Ecological collapse Economic costs Disruption to politics and economy Threat to food supply Loss of biodiversity Rebuilding the ecosystem Vulnerabilities to flood and other disasters Sustainable or non-sustainable economies Post-eco-collapse politics Pollution Preservation efforts Pre-eco-collapse climate change New, environmentally damaging industries Meta-uncertainty on the true dependence of humanity on the ecosystem Total short-term casualties Civilisation collapse Extinction Pre-eco-collapse mitigation efforts Human survivability in “closed” systems Global poverty Global coordination Sustainability research Technological innovations Uncertain events Key Meta-uncertainties Risk events Direct impacts Indirect impacts Current intervention areas Bad decisions Accidents Severe impacts GOVERNANCE DISASTERS Global povety Global instability New system of governance Smart sensors Global coordination Improvements to global governance Deliberate attempts to construct world dictatorship Technological innovations Enduring poverty Not achieving important ethical goals Climate change Lack of human flourishing Undesirable world system (e.g. global dictatorship) Global pollution Disruption to world politics and economy Total short-term casualties Collapse of world system Post-disaster politics General mitigation effort Long-term negative effects Civilisation collapse Extinction Failing to solve important problems Making things worse Uncertain events Key Meta-uncertainties Risk events Direct impacts Indirect impacts Current intervention areas Bad decisions Accidents Severe impacts Meta-uncertainty on tradeoffs between e.g. poverty, survival, freedom 80 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 1. Global coordination and cooperation will be important to any attempt to control ecological damage on a large scale and prevent “races to the bottom”. 2. Poverty is often seen as exacerbating ecological damage through unsustainable practices, while richer countries introduce environmental regulations – but richer nations exploit many resources (such as fossil fuels) in non-sustainable and damaging ways. 3. Transitioning to sustainable economies, or sustainable economic trajectories, could control ecological damage. 4. Research into sustainability could allow the construction of sustainable economies or environments at costs that people are willing to bear. 5. Climate change exacerbates the pressure on the ecological system by changing weather patterns and increasing natural disasters in ways ecosystems find hard to adapt to. 6. Global pollution is a visible source of ecological damage, one that global agreements have had moderate success at tackling. 7. Truly global preservation efforts may be needed for some threatened ecosystems that stretch beyond natural boundaries (e.g. in the seas and oceans). 8. Beyond general all-purpose mitigation efforts, addressing this threat could include the preservation of ecosystems, species or genetic codes, to allow a subsequent rebuilding. 9. New, profitable, but environmentally damaging industries could put extra strain on the ecosystem. 10. According to some systems of value, the loss of certain animals and ecosystems constitutes a moral tragedy in and of itself. 11. Humans derive much pleasure and many benefits from various parts of the ecosystem, and losing this would result in a loss to human quality of life. 12. Ongoing and continuous biodiversity loss is a clear consequence of ecological collapse. 13. Ecological damage can put the human food system in danger, triggering famines. 14. Ecological damage increases vulnerability to floods and other natural disasters. 15. Disruptions to the world’s political and economic systems could trigger further conflicts or instabilities, causing more casualties and impairing effective response. 16. Since a lot of the world’s carbon is locked up in trees, ecological collapse could exacerbate climate change. 17. The ecosystem is of great economic benefit to humanity, so its loss would have large economic costs. 18. Ecological damage is likely to be long-term: the effects will last for many generations. 19. Technological innovations may result in more sustainable economies, or in more environmentally damaging products. 20. It may be possible to ensure human survival in semi- “closed” systems (solar power, hydroponic food, distilled water), with minimal dependency on the external ecosystem. 21. Over the long term, it may become possible and necessary to go about rebuilding the ecosystem and healing its damage. 22. Political decisions will be the most likely factors to exacerbate or mitigate an ecological disaster. 23. It is unclear how dependent humans truly are on the ecosystem, and how much damage they could inflict without threatening their own survival. Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 81 3.1 Current risks during 2013 3.1.3.3 Main events 22-Jan-13: Current extinctions probably the result of past actions; many future extinctions to come 242 – Research An estimated 40% of world trade is based on biological products or processes such as agriculture, forestry, fisheries and plant-derived pharmaceuticals, and biodiversity comprises an invaluable pool for innovations.243 And yet this biodiversity is being lost at an alarming rate – the rate of extinctions for plants and animals is 100 to 1,000 times higher than their pre-human levels.244 A variety of methods have been suggested to halt or slow this loss, ranging from putting an explicit value245 on biodiversity and ecosystem services (human benefits from a multitude of resources and processes that are supplied by ecosystems), 246 to performing triage on the most valuable species.247 This research paper suggests, however, that there is a lag of several decades between human pressure on the ecosystem and ultimate species extinction. This suggests that many extinctions will continue in decades to come, irrespective of current conservation efforts. 05-Apr-13: Ocean data added to Microsoft Eye on Earth project – Initiative In order to safeguard ecological resources, it is important to track and quantify them. This has traditionally been the role of governments or non-governmental organisations.248 Recently, however, private organisations have started developing tools to enable companies and individuals to track ecological damage and make decisions in consequence. One such tool was Eye on Earth, developed by Microsoft in alliance with the European Environment Agency and Esri.249 It was launched with three services – WaterWatch, AirWatch and NoiseWatch – keeping track of the levels of different pollutants, using official sources and inputs from citizens.250 This was subsequently expanded to include other environmentally sensitive pieces of information, such as the states of coral reefs and invasive alien species. It was primarily land-based, so the oceans were missing from this visualisation tool. This lack has been partially overcome with the inclusion of data from the MyOcean 2 project251 (partly funded by the European Commission). The data cover sea surface temperature, salinity and currents for the Mediterranean Sea and the Black Sea. 30-May-13: Improvement in managed fisheries in Europe 252 – Research Human action has been shown to be able to mitigate some ecosystem damage. Overfishing is expected by standard economic theory: the sea’s resources are a (global) common, where the rational behaviour of individual fishermen must lead to dilapidation of the resource.253 Unlike on land, where nature reserves or parks can be established, there are no easy ways of establishing property rights in the sea254 (thus privatising that “common”). A typical example of this behaviour is the collapse of the Grand Banks fisheries off Canada’s Atlantic coast in the 1990s, where cod biomass fell by over 95% from its peak and has currently not recovered.255 It is therefore significant that the European Union has been partly successful in its attempts to control over-fishing through legislation. For instance, despite the fact that North Sea cod remains vulnerable, there has been a recent increase in stock size and a decrease in fish mortality. This may point to the potential for further ecological improvements through well-chosen policy interventions. 82 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks Figure 18: Increase in the number of species assessed for the IUCN Red List of Threatened SpeciesTM (2000–2013.2). Source: http://www.iucnredlist.org/about/summary-statistics 02-Jul-13: About 21,000 Species Face Extinction, says International Union for Conservation of Nature (IUCN) 256 – Event In 2013 the IUCN added an additional 4,807 species to its Red List of Threatened Species. This brings the total to about 21,000. Some have argued that we are entering a new geological era in Earth’s history: the Anthropocene257, when human actions are one of the major impactors on the planet’s biosphere. The graph shows a fairly steady growth in the (estimated) number of threatened species. This steadiness may be illusory, as the biosphere shows signs that it may be approaching a planetary-scale tipping point, where it may shift abruptly and irreversibly from one state to another. As a result, the biological resources humans presently take for granted may be subject to rapid and unpredictable transformations within a few human generations.258 This could be seen as a great tragedy beyond purely human concerns, if animals (and animal welfare) are seen to have intrinsic value.259 Figure 17: Collapse of Atlantic cod stocks (East Coast of Newfoundland), 1992 Source: http://en.wikipedia.org/wiki/File:Surexploitation\_morue\_surp%C3%AAcheEn.jpg) Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 83 3.1 Current risks Extreme Climate Change Ecological Nanotechnology Nuclear War Catastrophe Global System Collapse Major Asteroid Impact Global Pandemic Future Bad Global Governance Super-volcano Synthetic Biology Artificial Intelligence Unknown Consequences 3.1 Current risks Pandemic 3.1.4 Global A pandemic (from Greek πᾶν, pan, “all”, and δῆμος demos, “people”) is an epidemic of infectious disease that has spread through human populations across a large region; for instance several continents, or even worldwide. Here only worldwide events are included. A widespread endemic disease that is stable in terms of how many people become sick from it is not a pandemic. 260 84 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 3.1.4.1 Expected impact disaggregation 3.1.4.2 Probability Influenza subtypes266 Infectious diseases have been one of the greatest causes of mortality in history. Unlike many other global challenges pandemics have happened recently, as we can see where reasonably good data exist. Plotting historic epidemic fatalities on a log scale reveals that these tend to follow a power law with a small exponent: many plagues have been found to follow a power law with exponent 0.26.261 These kinds of power laws are heavy-tailed262 to a significant degree.263 In consequence most of the fatalities are accounted for by the top few events.264 If this law holds for future pandemics as well,265 then the majority of people who will die from epidemics will likely die from the single largest pandemic. Most epidemic fatalities follow a power law, with some extreme events – such as the Black Death and Spanish Flu – being even more deadly.267 There are other grounds for suspecting that such a highimpact epidemic will have a greater probability than usually assumed. All the features of an extremely devastating disease already exist in nature: essentially incurable (Ebola268), nearly always fatal (rabies269), extremely infectious (common cold270), and long incubation periods (HIV271). If a pathogen were to emerge that somehow combined these features (and influenza has demonstrated antigenic shift, the ability to combine features from different viruses272), its death toll would be extreme. Many relevant features of the world have changed considerably, making past comparisons problematic. The modern world has better sanitation and medical research, as well as national and supra-national institutions dedicated to combating diseases. Private insurers are also interested in modelling pandemic risks.273 Set against this is the fact that modern transport and dense human population allow infections to spread much more rapidly274, and there is the potential for urban slums to serve as breeding grounds for disease.275 Unlike events such as nuclear wars, pandemics would not damage the world’s infrastructure, and initial survivors would likely be resistant to the infection. And there would probably be survivors, if only in isolated locations. Hence the risk of a civilisation collapse would come from the ripple effect of the fatalities and the policy responses. These would include political and agricultural disruption as well as economic dislocation and damage to the world’s trade network (including the food trade). Extinction risk is only possible if the aftermath of the epidemic fragments and diminishes human society to the extent that recovery becomes impossible277 before humanity succumbs to other risks (such as climate change or further pandemics). Five important factors in estimating the probabilities and impacts of the challenge: 1. What the true probability distribution for pandemics is, especially at the tail. 2. The capacity of modern international health systems to deal with an extreme pandemic. 3. How fast medical research can proceed in an emergency. 4. How mobility of goods and people, as well as population density, will affect pandemic transmission. 5. Whether humans can develop novel and effective anti-pandemic solutions. Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 85 3.1 Current risks GOVERNANCE DISASTERS Global povety Global instability New system of governance Smart sensors Global coordination Improvements to global governance Deliberate attempts to construct world dictatorship Technological innovations Enduring poverty Not achieving important ethical goals Climate change Lack of human flourishing Undesirable world system (e.g. global dictatorship) Global pollution Disruption to world politics and economy Total short-term casualties Collapse of world system Post-disaster politics General mitigation effort Long-term negative effects Civilisation collapse Extinction Failing to solve important problems Making things worse Uncertain events Key Meta-uncertainties Risk events Direct impacts Indirect impacts Current intervention areas Bad decisions Accidents Severe impacts Meta-uncertainty on tradeoffs between e.g. poverty, survival, freedom GLOBAL PANDEMIC Contact with reservoir species Global poverty Small pandemic scares Density of population Medical research Bio-terrorism Global coordination Impact of increased movement of goods and people Antibiotics resistance Impact of sanitation or lack thereof Accidental release from lab Healthcare in individual countries Pandemic combining different deadly features Deadly pandemic Pandemic leaping the species barrier Impact of monoculture food supply Smart sensors Post-pandemic politics Disruption to world politics and economy Long-term fate of pandemic virus/ bacteria/parasite Impact on meat production and food supply Pandemic transmission Direct casualties Effectiveness of countermeasures Total short-term casualties Pre-pandemic medical contingency plans Civilisation collapse Meta-uncertainty of how the changed world Extinction has affected pandemic probabilities Meta-uncertainty of what probability distributions pandemics follow Uncertain events Key Meta-uncertainties Risk events Direct impacts Indirect impacts Current intervention areas Bad decisions Accidents Severe impacts 86 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks 1. Extensive medical research will be key to preventing and combatting large scale pandemics. The drawbacks are the possibility of accidental release of dangerous pathogens from laboratories and of bioterrorism. 2. As so much is known about pandemic risks compared with other risks, there are more possibilities for specific prepandemic contingency plans. 3. The effectiveness of healthcare systems will be important, especially in less developed nations where the pandemic may overwhelm the system, and then transmit from there to other nations. 4. Global coordination in detection, analysis and treatment are vital for stopping a pandemic in its early stages, and for implementing measures such as quarantines and more advanced countermeasures. 5. Poverty will affect the quality of national healthcare systems, population density and sanitation quality, the movement of local goods and people, and the effectiveness of the political response. 6. Bioterrorists may unleash a pathogen held in storage, such as smallpox. 7. Laboratory security at the top labs is insufficient for the danger at hand, and accidental release is a nonnegligible possibility. 8. Pandemics are one of the risks where there is a possibility for a very large number of direct casualties, depending on the severity of the pathogen. 9. Mass casualties and finger-pointing could destabilise the world political and economic systems. 10. If the pathogen is transmissible to farm animals, this could affect the world food supply. 11. It is unlikely the pathogen would be a recurrent, long-term risk, but variants of it could continue to affect people and animals for many years, dependent on its transmissibility and life cycle. 12. Small pandemic scares could improve global coordination on the issue. 13. Increased population density causes increased transmissibility of the pathogen, especially in urban slums. 14. Some pathogens, such as bird flu, depend on regular contact between humans and “reservoir species” in order to evolve into periodically dangerous strains. 15. If antibiotic resistance develops, humanity could see the resurgence of bacteria-based pandemics. 16. The increased movement of people and products increases the speed and spread of pandemic transmission. 17. Sanitation or its lack will strongly affect the spread of certain pathogens in key areas. 18. The efficiency of global reaction to a new pandemic will be strongly determined by the speed of research on the pathogen during the pandemic. 19. A great risk will arise if a pathogen combines the different dangerous features of current viruses or bacteria. 20. The improvements to surveillance and sensing technologies (including indirect detection via web queries or social media) open the possibility of smarter interventions (such as microquarantines) and faster understanding of the pathogen’s transmissibility. 21. Post-pandemic politics will be important for preventing a civilisation collapse or enabling reconstruction. 22. Many pathogens incubate in species close to humans, before leaping the species barrier. 23. Monoculture food systems make it easier to transmit any pathogen infecting human food animals. 24. The mode of transmission of the pathogen will be critical to its ultimate reach and impact. 25. Various countermeasures are available in terms of detection, virus analysis, treatment, and quarantining. Future research, technological and political developments may open up new methods of fighting the pathogen. 26. Many of the current factors determining pathogen transmission are unprecedented, such as movements of goods and people, the quality of healthcare systems, and the existence of a centralised political response. This means that data from past pandemics will not be as reliable for computing probability distributions. 27. The pandemic risk lies in the “tails” – the extreme events – and these tails must be estimated from few data points, making them tricky and uncertain. Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 87 3.1 Current risks during 2013 3.1.4.3 Main events 10-Jun-13: Pandemic Influenza Risk Management: WHO Interim Guidance 278 – Policy This is an updated document that replaces the 2009 Pandemic Influenza Preparedness and Response: a WHO guidance document.279 It updates its recommendations based on lessons from the influenza A(H1N1) 2009 pandemic (swine flu),280 the adoption by the Sixty-fourth World Health Assembly of the Pandemic Influenza Preparedness Framework281 (for the sharing of influenza viruses and access to vaccines and other benefits), and the States Parties’ obligations on capacity strengthening contained in the International Health Regulations of 2005.282 Of significance was the Report of the Review Committee on the Functioning of the International Health Regulations (2005) on the A(H1N1) 2009 pandemic,283 which concluded: “We were lucky this time, but as the report concludes, the world is ill-prepared to respond to a severe influenza pandemic or to any similarly global, sustained and threatening public-health emergency.” This is reinforced by the fact that the 2009 pandemic is alleged to have infected 24% of the population.284 The main lesson the WHO drew from that epidemic was that member states generally had communication issues (between ministries of health and decision,makers, and with the public), and were prepared for a pandemic of high severity and appeared unable to adapt their national and subnational responses adequately to a more moderate event. The guidance paper indicates simultaneously the weaknesses of pandemic preparations, the improvements in these preparations, and the continued role of the WHO as global directing and coordinating authority. 24-Jul-13: Bacteria become resistant to some of the last remaining antibiotics 285 – Event Bacterial infections, such as the Black Death, 286 syphilis, 287 and tuberculosis, 288 have been responsible for millions of deaths, over the thousands of years they have co-existed with humanity. Though these diseases have not been eradicated – overall, a third of the world is currently infected with the tuberculosis bacillus289 – they have been controlled since the introduction of antibiotics, and prognostics have improved tremendously. But recently a rising number of bacteria have developed antibiotic resistance, due mainly to antibiotic over-prescription290 and use in livestock feed.291 This Nature report highlights the worrying way in which Enterobacteriaceae (bacteria with a 50% mortality rate) have become resistant to carbapenems, one of the last remaining antibiotics that had been effective against them. 09-Aug-13: Epihack: Digital disease surveillance hack-a-thon 292 – Initiative Beyond the formal, top-down initiatives to deal with pandemics, there are openings for bottom-up, innovative ideas. Epihack attempted to generate just such ideas, through three days of designing and hacking in Cambodia. Descriptions of the winning projects were given: – CoPanFlu: This project included home visits to collect blood samples from 807 homes and weekly follow-up phone calls to document the occurrence of infectious respiratory symptoms. These visits and phone calls caused disturbance to the participants. The new system uses SMS for users to report symptoms. Chart and map visualisation of the data (with full case details) and a fieldwork tracking tool were developed to help the research team analyse and monitor data. – DoctorMe: In addition to all of the popular features of DoctorMe (free health information for the general public), the tool now features a weekly survey for users. The survey will ask participants to select whether they are experiencing any symptoms from a list. 88 Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 3.1 Current risks – ILI Surveillance, Bureau of Epidemiology Thailand: The old system was web-based and had no visual element. The new mobile application and website provides a map visualisation for the reported cases of influenza-like illness (ILI) in Thailand. The map shows hospital ILI cases with colour-coded pins to indicate the level of ILI and allows for simple analysis of the situation. – Mae Tao Clinic: The electronic records for this healthcare clinic were very basic. During EpiHack, the data was moved to the cloud and is now open-source. A data visualisation dashboard was created to allow for map visualisation of diagnoses. The staff at Mae Tao Clinic can now easily view and analyse the data to spot trends and send alerts. They plan to pilot this programme at their clinic and, if successful, to replicate it with other clinics. – Verboice: The technology platform of Verboice is so user-friendly it doesn’t require technical developers to develop the systems. At EpiHack, project managers were able to design and create systems to address needs in their work completely on their own. In just eight hours, four project managers each completed their own voicebased participatory surveillance systems to monitor One Health in Kenya and Tanzania; early warning generation in South Sudan; animal health in Laos; unexploded ordnance in Laos; child trafficking in Cambodia. The project owners of these new systems will now take them back to their countries and develop implementation and sustainability plans. 22-Sep-13: Research hints at possibility for universal flu vaccine 293 – Research The Spanish flu outbreak was the deadliest short pandemic in history, infecting about a third of the world population (≈ 500 million people) and killing 50-100 million people.294 There have been numerous flu pandemics in the last few centuries, with three others having around a million casualties (the 1889-1890 Russian Flu,295 the 1957-1958 Asian Flu, and the 1968-1969 Hong Kong Flu296 outbreaks). The most recent pandemic was that in 2009, which killed 150,000-500,000 people.297 Thus any move towards a universal flu vaccine would be of great importance to combating such recurring pandemics. This paper, analysing the role of T cells in combating influenza, suggests a way that such a vaccine could be feasible. 28-Nov-13: Difficulties in containing the accidental laboratory escape of potential pandemic influenza viruses 298 – Research Biosafety laboratories experiment with some of the deadliest of the world’s pathogens, and occasionally create new ones.299 Their number is increasing globally, and their safety record is far from perfect, with several pathogen leaks reported300 and others suspected301 (the last smallpox fatality was due to a virus that escaped a lab302, after eradication of the virus in the wild). The rate of pathogen escape has been estimated at 0.3% per laboratory, per year303 – a very high probability, given the 44 BSL-4304 labs and several thousands of BSL-3 labs. There have already been three known escapes from BSL-4 labs since 1990.305 This report uses an agent-based model to analyse whether the accidental laboratory release of pandemic flu viruses could be contained, and concludes that controllability of escape events is not guaranteed. 3-Dec-13: Global pandemic tops poll of insurance industry risks 306 – Initiative Academics and governmental307/ supra-governmental308 organisations have long worried about the risks of pandemics. But such organisations attract certain types of people with specific outlooks, who can be subject to further biases because of their profession and the social milieu surrounding it.309 Insurers come from a different background, focusing on practical profitability in the business world. It is therefore instructive that they too see pandemics as among the major threats in the world today. This also implies that combating pandemics is of use not only from a humanitarian but also from an economic standpoint. Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks 89 3.1 Current risks System Collapse 3.1.5 Global Global system collapse is defined here as either an economic or societal collapse on the global scale. There is no precise definition of a system collapse. The term has been used to describe a broad range of bad economic conditions, ranging from a severe, prolonged depression with high bankruptcy rates and high unemployment, to a breakdown in normal commerce caused by hyperinflation, or even an economically-caused sharp increase in the death rate and perhaps even a decline in population. 310 Often economic collapse is accompanied by social chaos, civil unrest and sometimes a breakdown of law and order. Societal collapse usually refers to the fall or disintegration of human societies, often along with their life support systems. It broadly includes both quite abrupt societal failures typified by collapses, and more extended gradual declines of superpowers. Here only the former is included. 3.1.5.1 Expected impact The world economic and political system is made up of many actors with many objectives and many links between them. Such intricate, interconnected systems are subject to unexpected system-wide failures due to the structure of the network311 – even if each component of the network is reliable. This gives rise to systemic risk: systemic risk occurs when parts that individually may function well become vulnerable when connected as a system to a self-reinforcing joint risk that can spread from part to part (contagion), potentially affecting the entire system and possibly spilling over to related outside systems.312 Such effects have been observed in such diverse areas as ecology,313 finance314 and critical infrastructure315 (such as power grids). They are characterised by the possibility that a small internal or external disruption could cause a highly non-linear effect,316 including a cascading failure that infects the whole system,317 as in the 2008-2009 financial crisis. The possibility of collapse becomes more acute when several independent networks depend on each other, as is increasingly the case (water supply, transport, fuel and power stations are strongly coupled, for instance).318 This dependence links social and technological systems as well.319 This trend is likely to be intensified by continuing globalisation,320 while global governance and regulatory mechanisms seem inadequate to address the issue.321 This is possibly because the tension between resilience and efficiency322 can even exacerbate the problem.323 Many triggers could start such a failure cascade, such as the infrastructure damage wrought by a coronal mass ejection,324 an ongoing cyber conflict, or a milder form of some of the risks presented in the rest of the paper. Indeed the main risk factor with global systems collapse is as something which may exacerbate some of the other risks in this paper, or as a trigger. But a simple global systems collapse still poses risks on its own. T

he productivity of modern societies is largely dependent on the careful matching of different types of capital325 (social, technological, natural...) with each other. If this matching is disrupted, this could trigger a “social collapse” far out of proportion to the initial disruption.326 States and institutions have collapsed in the past for seemingly minor systemic reasons.327 And institutional collapses can create knock-on effects, such as the descent of formerly prosperous states to much more impoverished and destabilising entities.328 Such processes could trigger damage on a large scale if they weaken global political and economic systems to such an extent that secondary effects (such as conflict or starvation) could cause great death and suffering. 3.1.5.2 Probability disaggregation Five important factors in estimating the probabilities of various impacts: 1. Whether global system collapse will trigger subsequent collapses or fragility in other areas. 2. What the true trade-off is between efficiency and resilience. 3. Whether effective regulation and resilience can be developed. 4. Whether an external disruption will trigger a collapse. 5. Whether an internal event will trigger a collapse. 1. Increased global coordination and cooperation may allow effective regulatory responses, but it also causes the integration of many different aspects of today’s world, likely increasing systemic risk. 2. Systemic risk is only gradually becoming understood, and further research is needed, especially when it comes to actually reducing systemic risk. 3. Since systemic risk is risk in the entire system, rather than in any individual component of it, only institutions with overall views and effects can tackle it. But regulating systemic risk is a new and uncertain task. 4. Building resilience – the ability of system components to survive shocks – should reduce systemic risk. 5. Fragile systems are often built because they are more efficient than robust systems, and hence more profitable. 6. General mitigation efforts should involve features that are disconnected from the standard system, and thus should remain able to continue being of use if the main system collapses 7. A system collapse could spread to other areas, infecting previously untouched systems (as the subprime mortgage crisis affected the world financial system, economy, and ultimately its political system). 8. The system collapse may lead to increased fragility in areas that it does not directly damage, making them vulnerable to subsequent shocks. 9. A collapse that spread to government institutions would undermine the possibilities of combating the collapse. 10. A natural ecosystem collapse could be a cause or consequence of a collapse in humanity’s institutions. 11. Economic collapse is an obvious and visible way in which system collapse could cause a lot of damage. 12. In order to cause mass casualties, a system collapse would need to cause major disruptions to the world’s political and economic system. 13. If the current world system collapses, there is a risk of casualties through loss of trade, poverty, wars and increased fragility. 14. It is not obvious that the world’s institutions and systems can be put together again after a collapse; they may be stuck in a suboptimal equilibrium. 15. Power grids are often analysed as possible candidates for system collapse, and they are becoming more integrated. 16. The world’s financial systems have already caused a system collapse, and they are still growing more integrated. 17. The world’s economies are also getting integrated, spreading recessions across national boundaries. 18. The world’s political and legal systems are becoming more closely integrated as well. Any risk has not been extensively researched yet, and there remain strong obstacles (mainly at the nation state level) slowing down this form of integration. 19. The politics of the post-system collapse world will be important in formulating an effective response instead of an indifferent or counterproductive one. 20. System collapses can be triggered internally by very small events, without an apparent cause. 21. External disruptions can trigger the collapse of an already fragile system. 22. The trade-off between efficiency and resilience is a key source of fragility in a world economy built around maximising efficiency. 23. Climate change, mass movements of animals and agricultural mono-cultures are interlinking ecosystems with each other and with human institutions. 24. There is a lot of uncertainty about systemic risk, especially in the interactions between different fragilities that would not be sufficient to cause a collapse on their own.

#### It’s faster—our blackouts happen before 2050—that’s Muresan—BUT theirs take 200 years.

Lewis 15—(Senior Lecturer in Aerospace Engineering at the University of Southampton, Member of the UK Space Agency delegation to the Inter-Agency Space Debris Coordination Committee and Member of the UK delegation to the United Nations Committee on the Peaceful Uses of Outer Space). Hugh Lewis. 2015. “Space Debris, Kessler Syndrome, and The Unreasonable Expectation of Certainty”, ROOM The Space Journal, Issue #3(5), October, <https://room.eu.com/article/Space_debris_Kessler_Syndrome_and_the_unreasonable_expectation_of_certainty>

There is now widespread awareness of the space debris problem amongst policymakers, scientists, engineers and the public. Thanks to pivotal work by J.C. Liou and Nicholas Johnson in 2006 we now understand that the continued growth of the debris population is likely in the future even if all launch activity is halted. The reason for this sustained growth, and for the concern of many satellite operators who are forced to act to protect their assets, are collisions that are expected to occur between objects – satellites and rocket stages – already in orbit. In spite of several commentators warning that these collisions are just the start of a collision cascade that will render access to low Earth orbit all but impossible – a process commonly referred to as the ‘Kessler Syndrome’ after the debris scientist Donald Kessler – the reality is not likely to be on the scale of these predictions or the events depicted in the film Gravity. Indeed, results presented by the Inter-Agency Space Debris Coordination Committee (IADC) at the Sixth European Conference on Space Debris show an expected increase in the debris population of only 30% after 200 years with continued launch activity. Collisions are still predicted to occur, but this is far from the catastrophic scenario feared by some. Constraining the population increase to a modest level can be achieved, the IADC suggested, through widespread and good compliance with existing space debris mitigation guidelines, especially those relating to passivation (whereby all sources of stored energy on a satellite are depleted at the end of its mission) and post-mission disposal, such as de-orbiting the satellite or re-orbiting it to a graveyard orbit. Nevertheless, the anticipated growth of the debris population in spite of these robust efforts merits the investigation of additional measures to address the debris threat, according to the IADC.

#### It's slow and in 140 years.

Drmola & Hubík 18 Mgr. Jakub Drmola, PhD, Political Sceince Professor at Masaryk University. Tomáš Hubík, Computer Science PhD Candidate at Charles University in Prague, Systems Dynamics UiB at the University of Bergen. [Kessler Syndrome: System Dynamics Model, Space Policy, 44–45, 29–39, ScienceDirect]//BPS

It must be stressed that the model was not designed with such long outlooks in mind, and many of the assumptions will certainly not hold over the next 200 years (such as static launch rate growth, size, and structure of the satellites, their lifetime, evasion rates, lack of mitigation, and many others). But in the overwhelmingly unlikely case that these assumptions stay true, the simulated outcome seems to suggest a collapse of sorts around the year 2163. However, it does not look like a suddenly triggered chain reaction leading to widespread fragmentation of the entire LEO but rather like a gradually reached point at which LEO is so full of debris, and the rate of active satellite fragmentation is so high (almost one every day) that the launches cannot keep up anymore. This is consistent with the findings reported by LaFleur and Finkelman, who found the debris system to be unconditionally stable [18], [19], [27].

#### Kessler agrees.

Burns Interviewing Kessler 13 Corrinne Burns, interviewing Donald Kessler, who made up the concept. [Space junk apocalypse: just like Gravity? 11-15-2013, https://www.theguardian.com/science/blog/2013/nov/15/space-junk-apocalypse-gravity]//BPS

Now? Are we in trouble? Not yet. Kessler syndrome isn't an acute phenomenon, as depicted in the movie – it's a slow, decades-long process. "It'll happen throughout the next 100 years – we have time to deal with it," Kessler says. "The time between collisions will become shorter – it's around 10 years at the moment. In 20 years' time, the time between collisions could be reduced to five years." Fortunately, communications satellites are, in the main, situated high up in geosynchronous orbit (GEO), whereas the risk of collisions lies mainly in the much lower, and more crowded, low Earth orbit (LEO). But that doesn't mean we can relax. "We've got to get a handle on it – we need to prevent the cascade process from speeding up." And the only way to do that is, he says, to begin actively removing junk from space. Charlotte Bewick agrees. She's a mission concepts engineer with the German space technology company OHB System, with special expertise in space junk – specifically, how we can capture it and bring it back to Earth. While agreeing with Kessler that the movie scenario is exaggerated, she remains concerned. "Fragments of junk can naturally re-enter the atmosphere [and so be removed from orbit]. But we're at the stage where the rate of creation of new debris fragments is higher than the rate of natural removal. The orbits most at risk harbour important space assets – satellites for weather forecasting, oil spill and bush fire detection, and polar ice monitoring." Bewick highlights the case of Envisat, a defunct 8,000kg spacecraft circling Earth in an orbit that is very popular with space agencies and, hence, pretty crowded. "If Envisat collides with a piece of debris or a micrometeorite, the fragments could render the whole orbital region unusable." So can we get the junk down, I asked Massimiliano Vasile, part of the Mechanical & Aerospace Department at the University of Strathclyde and co-ordinator of the Stardust network. He told me defunct satellites in the high GEO region have, for some time, been shifted to higher "graveyard orbits" to keep them out of the way. But that's not an option for items in low Earth orbit. For this, he tells me, researchers are looking seriously into active debris removal – in-orbit capture techniques like harpooning, netting and tethering, the use of contactless systems like ion-beams or lasers, and even onboard robotics to position the junk away from high-risk orbital regions. As for middle Earth orbit – well, ideas are welcome, he says. We're in no immediate danger from Kessler syndrome – but it's not a problem that's going away. Despite Gravity's artistic license, Donald Kessler is pleased to see the phenomenon represented on the big screen. "It is very improbable that events would play out as they did in the film," he says. "But if it raises awareness, then that's great."

#### It’ll take decades

Donald J. Kessler 10, Retired Senior Scientist for Orbital Debris Research at NASA/JSC, Nicholas L. Johnson, Chief Scientist for Orbital Debris Research, Orbital Debris Program Office, NASA Johnson Space Center, and J.-C. Liou, Lead Scientist for In-Situ Measurements, Orbital Debris Program Office, and Mark Matney, Lead Scientist for Modeling, Orbital Debris Program Office, NASA Johnson Space Center, “The Kessler Syndrome: Implications to Future Space Operations”, 33rd Annual AAS Guidance and Control Conference, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.394.6767&rep=rep1&type=pdf2/10/2010,

INTRODUCTION

Since the beginning of the space program through the 1970’s, it was generally believed that NORAD was tracking all man-made objects in Earth orbit and that the catalogued objects represented the major collision threat to other operational spacecraft. In 1978, Kessler and Cour-Palais published the paper Collision Frequency of Artificial Satellites: The Creation of a Debris Belt.1 The paper concluded that if the past growth rate in the catalogued population continued, around the year 2000 a more hazardous population of small debris would be generated as a result of fragments from random collisions between cataloged objects. This new source of debris would quickly produce a hazard that exceeds the hazard from natural meteoroids, and over a longer period of time the growth in small debris would become exponential, even if a zero net input rate in the catalogue is maintained. Shortly after the publication, John Gabbard from NORAD (known for his “Gabbard Plot”), introduced the term “Kessler Syndrome” to describe the future collisional cascading described in the paper. Over the years, the term has developed definitions from the press that are not necessarily consistent with the paper or Mr. Gabbard’s intent.

A segment of the Japanese animated TV series Planetes,2 set in the year 2075, is an example of a popular definition of the Kessler Syndrome that includes both factual and exaggerated components. While an episode appropriately defines the Kessler Syndrome as the cascading of fragments from collisions breaking up other intact objects at an increasing rate, it goes on to say that, once initiated, “…. billions of other pieces [would be generated] in a very short time [and] the Earth would be surrounded by debris …. completely cut off from space.” In general, collisional cascading is a slow process, but very much depends on the population density and size of the objects in orbit. Current population densities would require decades to produce a significant change in the small debris environment, and much longer to approach a condition where the Earth might be “completely cut off from space”. However, it is conceivable that some ill-planned rapid expansion in the use of low Earth orbit could produce a much more rapid increase in small debris as a result of collisional cascading.

#### Modelling proves

Lawrence M. Wein 9, Jeffrey S. Skoll Professor of Management Science at Stanford University and Senior Fellow at Stanford’s Center for International Security and Cooperation, former DEC Leaders for Manufacturing Professor of Management Science at MIT, and Andrew M. Bradley, PhD-Institute for Computational and Mathematical Engineering at Stanford University, Space Debris: Assessing Risk and Responsibility, Advances in Space Research 43 (2009) 1372–1390

More importantly, while our numerical results mimic earlier results (Liou and Johnson, 2005; Walker and Martin, 2004) that stressed the importance of postmission deorbiting, we do not necessarily agree with the claim that the only way to prevent future problems is to remove existing large intacts from space (Liou and Johnson, 2006, 2008). The divergence between our views and those in Liou and Johnson (2006, 2008) is perhaps due to the different performance metrics used. The root causes for alarm in Liou and Johnson (2006, 2008) appear to be the growth rate of fragments and the small increase in the rate of catastrophic collisions over the next 200 years (Liou and Johnson, 2008, Fig. 2). However, the great majority of catastrophic collisions in the SOI do not involve operational spacecraft, and are hazardous only in the sense that the fragments generated from such a collision could subsequently damage or destroy operational spacecraft. Therefore, we introduced the notion of the lifetime risk of an operational spacecraft as the primary performance metric. Our model predicts that the lifetime risk is <5x10^-4 [less than .0005%] over the next two centuries, and always stays <10^-3 [less than .001%] than if there is very high (>98%) spacecraft deorbiting compliance. These risks appear to be low relative to the immense cost and considerable technological uncertainty involved in removing large objects from space, are dwarfed by the ~20% historical mission-impacting (but not necessarily mission-ending) failure rate of spacecraft (Frost and Sullivan, 2004), and could be overestimated if improved traffic management techniques lower future collision risks (Johnson, 2004). Hence, the need to bring large objects down from space does not appear to be as clear cut as suggested in Liou and Johnson (2006, 2008). Nonetheless, our model does not incorporate the possibility of intentional catastrophic collisions (ASAT tests, space wars) that could conceivably occur in the future. In addition, Fig. 5 considers only catastrophic collisions, whereas noncatastrophic intact-fragment collisions could easily disable an operational spacecraft. If the operational lifetime risk is modified to include noncatastrophic collisions with fragments >= 10cm, then the sustainable risk rises by ~50%: it increases from 2.19x10^-2 [.0219%] to 3.09x10^-2 in the base case, and increases from 4.91x10^-4 [.000491%] to 7.94x10^-4 in the full compliance case. Moreover, if fragments >= 1 cm (rather than >= 10 cm) are harmful to spacecraft (Johnson, 2004), then we (as well as other researchers) could be underestimating the risk.

In summary, in the absence of the removal of large objects from space, the sustainable lifetime risks in Figs. 3–5 do not appear to be obviously above or below a tolerable level. Even if these risks are deemed acceptable, it is prudent to invest in research and development for space remediation technologies, which is a topic of current study (Proposal for forming an IAA study group, 2000). However, given the optimality of full deorbit compliance from a societal, sustainable perspective, and the sensitivity of sustainable lifetime risk to postmission deorbit compliance, the primary focus for policymakers should be on increasing compliance, which leads us to a discussion of economic instruments that could be used to address this issue.

#### 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.

### 1NC – Adv 2

#### No Terrorist groups have ever shown motive in space terrorism, they stick to easy, less sophisticated, conventional, and traceable methods of conflict – 1AC cross-ex proves they haven’t shown motive

#### No Cyberterrorism threat

Mueller 22 — (John Mueller, Political Scientist at Ohio State University and a Senior Fellow at the Cato Institute. His most recent book is The Stupidity of War: American Foreign Policy and the Case for Complacency., “The Cyber-Delusion“, Foreign Affairs, 3-22-2022, Available Online at https://www.foreignaffairs.com/articles/russia-fsu/2022-03-22/cyber-delusion, accessed 4-21-2022, HKR-AR)

To date, however, **no terrorist group has launched a successful cyberattack**. And even if it becomes possible for hackers to shed blood, shootings and bombings are likely to accomplish the same goal far more reliably. Still, cyber has undoubtedly proved to be a relatively convenient method for terrorist groups to recruit and communicate. Rather than creating a paradigm shift, however, this technique has simply replaced or embellished older methods. Even comparatively savvy groups such as the Islamic State (also known as ISIS) tend to comically fail when using the Internet to stir up violence and instruct potential sympathizers. In one case, an ISIS handler connected his eager American charge to a prospective collaborator who happened to be an FBI operative.

For the most part, any virtual terrorist army in the United States has, as terrorism expert Brian Jenkins puts it, remained exactly that: virtual. “Talking about jihad, boasting of what one will do, and offering diabolical schemes egging each other on is usually as far as it goes,” he noted. Indeed, the foolish willingness of would-be terrorists to describe their aspirations and often-childish fantasies on the Internet has often helped police seeking to track them down.

#### Propellants are used for a wide variety of things apart from constellations

OPC ND— (Orbital Propulsion Centre, “Space Propulsion Systems for Satellites and Spacecraft“, Available Online at https://www.space-propulsion.com/spacecraft-propulsion/propulsion-systems/index.html, accessed 1-27-2022, HKR-AR)

For over half a century, we have been producing propulsion systems for a diverse range of international satellites and spacecraft. We specialise in monopropellant, bipropellant and electric ion propulsion and supply from component parts and subsystem modules, through to complete propulsion systems and beyond - with a complete range of propulsion support services from delivery, integration & test, and propellant loading, through to launch campaign support, post launch and in-orbit operations.

Applications

Typical applications of our propulsion system include:

Orbital satellites and spacecraft.

Interplanetary spacecraft and probes.

Control of re-entry vehicles.

Automated resupply missions to the International Space Station.

Ascent roll control and stabilisation of light to heavy launch vehicles .

### 1NC – Adv 3

#### Public

#### No extinction—humans would adapt.

Robert Walker 16, mathematician, 12-14-2016, “Why Resilient Humans Would Survive Giant Asteroid Impact - Even With Over 90% Of Species Extinct,” https://www.science20.com/robert\_inventor/why\_resilient\_humans\_would\_survive\_giant\_asteroid\_impact\_even\_with\_over\_90\_of\_species\_extinct-187383

If you look at some of the past extinction events, you might think that humans could go extinct very easily. The worst of all of those was the Permian–Triassic extinction event during which 96% of marine species and 70% of land species went extinct according to one estimate. So based on those figures you might well think that there is a 70% chance that humans would go extinct as a result of whatever causes those extinctions. However, even after the extinction of the dinosaurs, birds, dawn sequoia, river turtles, small mammals and many other plants and creatures survived. Many species would go extinct after a gamma ray burst or a large asteroid impact, but humans are great survivors. We were at risk in the past before we developed tools and clothing. But with clothes, tools, boats, etc, we are an extremely adaptable species, able to survive anywhere from the Kalahari desert to the Arctic, with only stone age technology. We had already colonized most of the world by the end of the neolithic period. Overview of Pre-modern human migration - there is debate and controversy about the details, but generally agreed that humans were already present world-wide by the end of the neolithic period (which ends around 2000 BC), or shortly after. So, as long as we retain at least stone age technology, there isn't much that could make us extinct. Even if we have to go back to beachcombing and surviving on shellfish, which was a staple of early human diet in cold places such as Canada and Scotland where I live, one way or another some humans would survive. Conchero al sur de Puerto Desead - a shell midden in Argentina. For long periods of time ancient humans survived on shellfish, for so long that they built up these huge shell middens in many parts of the world. See Shell Midden We are omnivores able to survive on: Shellfish Insects Fish and other marine life Nuts Fruit Roots Seeds and cereals Birds, Animals Reptiles. So long as any of those survive the extinction event, anywhere in the world and so long as humans retain at least stone age level of understanding of technology - then there would be many survivors and we would not go extinct, even if more than 90% of species went extinct. The dinosaurs weren't a patch on us as far as survival goes. Without any technology, turtles, crocodiles, alligators, small mammals, flying dinosaurs (the birds), dawn redwood trees, pine trees, many lifeforms survived the dinosaur extinction impact. We aren't vulnerable like the early hominids. So long as We retain the ability to make clothes and simple tools and to make boats to cross rivers and seas to find new sources of food There is something edible somewhere on Earth that we can find in our travels, and cultivate or just eat in situ as hunter gatherers Then we could survive anywhere where there is such food, from the Arctic to the hottest of deserts, along the sea shores, or in tropical rainforests. So, for sure, some of us would survive a giant impact like that.