### 1NC – T

#### Interpretation: appropriation involves permanent, exclusive use of land and resource extraction. The aff must defend that appropriation of outer space by private entities is unjust.

Stephen Gorove, Stephen Gorove (1917-2001) was a space law education pioneer. He served as a professor of space law and director of space studies and policy, from 1991-1998, at the University of Mississippi., 1969 " Interpreting Article II of the Outer Space Treaty" Fordham Law Review, https://ir.lawnet.fordham.edu/cgi/viewcontent.cgi?article=1966&context=flr

With respect to the concept of appropriation the basic question is **what constitutes "appropriation,"** as used in the Treaty, especially in contradistinction to casual or temporary use. The term "appropriation" is used most frequently to denote the taking of property for one's own or exclusive use with a sense of permanence. Under such interpretation the establishment of a permanent settlement or the carrying out of commercial activities by nationals of a country on a celestial body may constitute national appropriation if the activities take place under the supreme authority (sovereignty) of the state. Short of this, if the state wields no exclusive authority or jurisdiction in relation to the area in question, the answer would seem to be in the negative, unless, the nationals also use their individual appropriations as cover-ups for their state's activities.5 In this connection, it should be emphasized that the word "appropriation" indicates a taking which involves something more than just a casual use. Thus a temporary occupation of a landing site or other area, just like the **temporary or nonexclusive use of property, would not constitute appropriation**. By the same token, any use involving consumption or **taking with intention of keeping for one's own exclusive use would amount to appropriation.**

#### Violation – application of PTD to space isn’t permanent, it’s context dependent and depends on cost benefit analysis

**WEF n.d.** -- (“Public Trust Doctrine.” Water Education Foundation, The Water Education Foundation is a nonprofit organization whose goal is to provide unbiased, balanced information on water issues in California and the Southwestern United States. The Foundation's mission, since its founding in 1977, has been "to create a better understanding of water resources and foster public understanding and resolution of water resource issues through facilitation, education and outreach,” <https://www.watereducation.org/aquapedia/public-trust-doctrine>, HKR-AS)

Rooted in Roman law, the public trust doctrine recognizes the public right to many natural resources including “the air, running water, the sea and its shore.”

The public trust doctrine requires the sovereign, or state, to hold in trust designated resources for the benefit of the people. Traditionally, the public trust applied to commerce and fishing in navigable waters, but its uses were expanded in California in 1971 to include fish, wildlife, habitat and recreation.

At that time, the California Supreme Court in Marks v. Whitney broadened the definition of public trust because “public trust uses are sufficiently flexible to **encompass changing public needs**.” This definition would be first applied in a legal case in the 1980s (see below). [See also California water rights.]

Mono Lake Case

In California, public trust was most notably invoked in a landmark case involving water use at Mono Lake.

In a landmark case filed to protect the Mono Lake Basin from 40 years of water diversions by the city of Los Angeles, California’s Supreme Court ruled in 1983 that reasonable and beneficial uses of water **must be interpreted in accordance with public trust needs**. This was the first case in California where the public trust doctrine was applied.

Significantly, the Mono Lake decision held that the state retains jurisdiction over these rights and may reconsider the impact on public trust, which in addition to the traditional commerce, navigation and fishing, includes wildlife habitat. The necessity of protecting the public trust was to be determined by balancing the value and cost of instream water needs against the benefits and costs of diversions. [Purchase the Layperson’s Guide to Water Rights to learn more about public trust.]

#### Vote neg –

#### Ground – allowing affs to not defend permanent appropriation kills negative ground – we can’t read the innovation DA, since they can say innovative appropriation efforts are allowed, we can’t read asteroid mining or disads to specific types of appropriation since they can defend an exemption for that, etc

#### T is a voting issue that should be evaluated through competing interps – it tells the negative what to prepare for and reasonability invites judge intervention

### 1NC – CP

#### States should declare that public guardianship obligations created by the non-ownership doctrine necessitate a reduction in private actor appropriation of Outer Space.

#### The public trust doctrine is inseparable from an anthropocentric politics of human chauvinism – further application can only strengthen exploitative relationships to nature – guardianship asserts the doctrine of non-ownership, which solves better and competes

Adler 05, Dean College of Law at Utah (Robert, The Law at the Water's Edge: Limits to ""Ownership"" of Aquatic Ecosystems, in Wet Growth: Should Water Law Control Land Use?, pg. 244)

I argue instead that the idea of a public “trust” should be replaced by one of public “guardianship.” In a classic trust, legal and equitable title are held by different persons, and the person with legal title has “equitable duties to deal with the property for the benefit of another person.” The trust duty is fiduciary and typically requires the trustee to maximize the income or other economic value of the trust assets for the beneficiary. This principle implies that if the trustee believes that a particular asset is better used for another purpose, or that certain trust values are more valuable than others from the perspective of the beneficiary, the trustee can manage the trust assets accordingly or even eliminate the resource entirely. Viewed again according to the underlying theory or property ownership, that landowners will make decisions that maximize the welfare value of the holding, public trust ownership solves some, but not all, of the market failure problems of private ownership. Under the expanded version of the public trust doctrine as interpreted by some courts, the trustee is now supposed to ensure that all common public values, including noncommodified environmental values that benefit the public in some way, are considered fully and appropriately and weighed against values that might benefit a subset of society or even an individual landowner disproportionately. If private market participants exert undue influence on the government’s decision process in the exercise of its trust, however, those decisions may not necessarily maximize overall welfare. Give the deference usually enjoyed by trustees absent clear violations of the trust duty, many courts are not likely to interfere with those judgements. Even absent such biasing of the trustee’s decision, a trustee may simply, in the exercise of its fiduciary judgement, determine that the commercial value of a particular piece of trust property is more valuable to the beneficiary than its environmental value, a decision more likely to be reviewed by courts from a procedural, rather than a substantive, perspective. Moreover, to the extent that trust resources provide ecosystem or other values or benefits that transcend the welfare of human societies, the public trust doctrine, - and trust law in general - is not even designed to incorporate those values. In fact, a public trustee arguably would violate its fiduciary duty to the public beneficiary if it considered environmental values at the expense of the immediate (current generation) public beneficiaries. One solution to that dilemma would be to consider the beneficiaries to include future as well as current generations of humans, but the inherently anthropocentric focus of the trust duty remains. Thus, while some courts have upheld government regulation and even prohibition of private development of land at the water's edge, under interpretations of the public trust doctrine and police power that affirm environmental stewardship duties; others have applied the doctrine as one that merely ensures that the trustee makes rational decisions after properly considering all trust values. 174 Other courts have ap­plied the doctrine to sanction the very economic development activities at the water's edge that cause such extensive aquatic ecosystem harm, such as the use of trust property for transportation systems, public utilities, oil production, and urban and commercial expansion. So long as the law considers aquatic species and other components of aquatic eco­systems to be "trust assets" to be managed entirely for the benefit of human economic and other welfare, aquatic ecosystems will remain vulnerable to continued impairment. A potentially more satisfying model, as discussed in the next section, is suggested by the evolution of wildlife law from one in which wildlife was similarly viewed as being "owned" by the state in trust for the people in common to one of "non­ownership." The non-ownership doctrine implies a corollary principle that the government is a guardian, rather than a trustee, of the resource and must exercise its legal responsibilities accordingly.

#### Implementation of public trust doctrine protection will be arbitrary and capricious ensuring ecological harm. The counterplans application of non-ownership solves

Adler 05, Dean College of Law at Utah (Robert, The Law at the Water's Edge: Limits to ""Ownership"" of Aquatic Ecosystems, in Wet Growth: Should Water Law Control Land Use?, pg. 244)

There are several other ways in which the non-ownership doctrine as applied to aquatic ecosystem resources and values differs from the existing public trust doctrine and is likely to be a superior tool to protect those resources and values. First, while some courts have endeavored to "unshackle" the public trust doctrine from its historic limits, the doctrine is, for the most part, constrained by those artificial geographic boundaries, and litigants seeking to enforce the public trust face a significant burden to overcome those presumed boundaries. The non-ownership doctrine and its implied government guardianship is defined not by artificial geographic limits but by actual determinations of the degree to which aquatic ecosystem values and services exist. Second, as explained above, the nature of the guardianship duty is a more logical model for government control of resources that cannot be owned and suggests that those resources must be protected and cannot be conveyed either for private economic gain or for public economic gain at the expense of ecological harms. Third, and most importantly, relative to the public trust doctrine the burden of proof should be flipped. Rather than requiring the government to prove that it owns or otherwise controls a resource under the public trust doctrine in order to justify protection, a landowner presumptively has no rights to impair ecosystem components, values, or services in a significant way, meaning the burden of proof is on the landowner to demonstrate ownership rights, and not vice versa. Like the public trust doctrine, of course, the "non-ownership" doctrine could suffer the fate of other efforts to develop rules of resource protection through a state-by-state and case-by-case approach, with the possibility of the same type of doctrinal fragmentation among states. For several reasons, however, the legal doctrine of "non-ownership" could avoid this common-law odyssey. First, the non-ownership doctrine was pronounced by the Court in Hughes as a matter of federal law in the context of a constitutional ruling. If the Court were to apply that same doctrine in the context of a constitutional takings challenge, it could achieve national status without the need for an uncertain crosscountry journey. While the public trust doctrine often is attributed to the Court's rulings in cases like Illinois Central and Shively v. Bowlby, in fact it had its origins in earlier state cases, and the Court has ruled that the geographic reach and other aspects of the public trust doctrine are a matter of state law. It was this perhaps unfortunate conclusion that has relegated the public trust doctrine to such an uncertain fate. Second, with due respect to the tremendous innovation and influence of the modern rejuvenation of the public trust doctrine, in addition to the inherent limitations discussed above, its application to a larger geography and a broader scope of trust resources relies heavily on a somewhat subjective, amorphous set of judgments about what advances public trust values and how those values should be balanced against other resources and values, both public and private. To be sure, application of the "non-ownership" doctrine will require sometimes difficult case by case judgments, as do virtually all efforts to protect ecological resources, whether judicial or regulatory in method. The core governing principle of non-ownership, however, is amenable to a far greater degree of uniformity. As a matter of law, once it is recognized that private-property rights do not include the right to destroy or degrade aquatic ecosystem resources, the role of government as guardian of those resources, whether through judicial or regulatory action, is less open to the type of discretion that characterizes the public trust doctrine. Under the guardianship principle, the government's role is to protect, not to choose from among a large number of potentially competing uses.

#### The counterplan and the plan are mutually exclusive – application of the public trust doctrine establishes ownership while the counterplan is explicitly non-ownership. Severance permutations should be rejected because they eliminate all counterplan net benefits and disprove desirability of the plan

Adler 05, Dean College of Law at Utah (Robert, The Law at the Water's Edge: Limits to ""Ownership"" of Aquatic Ecosystems, in Wet Growth: Should Water Law Control Land Use?, pg. 244)

4. "Non-Ownership" of Wildlife: Consequences and Implications Several legal implications flow from the realization that states do not own wildlife populations but can regulate their use under inherent police power authority. First, and most obviously, if the sovereign cannot "own" wildlife species or populations (as opposed to individual members of a species when lawfully captured or killed under relevant federal and state laws and regulations), a fortiori neither do private landowners. This corollary, of course, is entirely consistent with the traditional "capture" doctrine in wildlife law, but for different and more fundamental reasons. Under traditional principles, individuals cannot own wildlife until it is reduced to physical possession, and hence control, through lawful kill or capture. Under the non-ownership doctrine as announced in Hughes and its predecessors, wildlife in its natural state is inherently incapable of ownership. Indeed, such ownership would then be inconsistent with the state's more appropriate status as a legal guardian of wildlife resources. If the state "owned" wildlife in the sense that one can own a mineral, presumably it would have the power to deplete it entirely if it determines that it is in the state's (and society's) best economic or other interests to do so. 207 If it only has the authority to regulate and protect the resource "as between a State and its inhabitants," it does so more in the position of a legal guardian rather than as a trustee "owner" with the rights normally attendant thereto. The guardianship analogy is still imperfect, but it is superior to the public trust notion with respect to the nonhuman values inherent in wildlife and other ecosystem resources and to the extent that those natural objects are viewed as having rights of their own. As a matter of property law, a "trustee ... has title to trust property; a guardian of property does not have title to the property, but has only certain powers and duties to deal therewith for the benefit of the ward, the ward having title to the property. "208 The state as guardian cannot confer on private individuals, through its system of property law or otherwise, an ownership interest in what it is guarding. Nor can it simply dispose of that "property." ln contrast, dispositions of trust property are restricted.

#### 1] Their interp artificially insulates them from competition- kills cost-benefit analysis- innovative research needs to be tested against the 1ar to check expertise gap- their assessment of the plan relative to a germane opportunity cost is arbitrarily confined

#### 2] Promotes offense unique to the plan- best policy option and most real-world- tests the desirability of the plan versus other options- when faced with two bad options, rational decision-makers reject both- condo is key- debaters are risk-averse b/c they like to stick to comfortable strategies to win. Lower barriers to entry w/ condo encourage more innovative arguments, which is key to argument generation and education . Nonsense 1NC ptions are inevitable – throw in worse DA’s topicality

Counter-interp: the neg may read agent Cps

Counter-interp: The neg can read an agent counterplan if the aff specs a mechanism of implementation.

Solves their offense — means we get the reciprocal ability to test the necessity of the plan, creates more in depth debate but avoids debates at the margins when it’s not core to the 1AC.

Have a high bar on agent cps bad in this round — this boils down to boo hoo we don’t want to defend 50% of the aff cards from scrutiny.

Our offense -

1. Neg flex – aff gets plan and advantage choice, first and last word, infinite prep, and lit bias on this topic – agent CPs are a key neg generic to check these advantages, especially on this topic where the resolution has no actor and the aff can pick any mechanism they want

2. Advocacy Skills- Forcing the aff to defend their agent encourages the development of better researched and planned policies and is vital to being a competent advocate – outweighs since it’s the only portable skill from debate

### 1NC

#### States should pass legislation to increase the scope of the Public Trust Doctrine to reduce private actor appropriation of Outer Space

#### Roberts**, Kavanaugh, Barrett** balancing now

Stahl 21 [Jeremy, Senior Editor for Slate, “If John Roberts Really Wants to Save the Court, He Should Retire” https://slate.com/news-and-politics/2021/12/john-roberts-retirement-abortion-supreme-court.html]

Second, retirement would clearly alleviate many of the questions the court faces about its legitimacy that Roberts now says he’s very concerned about. If Roberts retires now, for instance, he gives weight to the argument his Democratic-appointed colleague Stephen Breyer has used to resist calls for his own retirement—that the court is actually not a hopelessly broken and partisan institution and that justices strategically resigning when a preferred president is in the White House is what really damages the court’s legitimacy. If Roberts retires when a Democrat can replace him, it proves Breyer’s point that the system still works! Further, Roberts going now would basically amount to an offer of restitution for the Supreme Court seat that was stolen by Mitch McConnell when the Senate refused to hold a hearing on Barack Obama nominee Merrick Garland for nearly a year at the end of his presidency and then seated Amy Coney Barrett with weeks remaining in Donald Trump’s tenure.

To be clear: At this point, the biggest point of contention around the court’s legitimacy is that stolen seat. In one fell swoop, Roberts could negate that argument almost entirely. As such, his retirement would tamp down any lingering calls for court reform, which are weak now but could gain strength as the court further lurches to the right.

Third, this is likely the best method Roberts has of pushing the court in the face-saving direction he actually wants it to go, where it gradually but significantly moves the constitutional law to the right, only without overturning the entire apple cart all at once. If Roberts is replaced by a fourth progressive jurist, Justices Kavanaugh and Coney Barrett might feel some pressure to pivot to finding any sort of middle ground on major issues with tactically moderate progressives, such as Elena Kagan. After all, they will be on the court a long time and they have to know that 73-year-old Clarence Thomas and 71-year-old Samuel Alito can’t live forever. If Kavanaugh and Barrett find that there’s a potential for the balance of the court to shift in the next ten years, they might be persuaded to play a little nicer with Kagan, lest the court possibly swing drastically leftward when Thomas and Alito are no longer on the job.

This is all a long shot, I will say, but it’s more likely to work than whatever it is Roberts is doing now to convince his junior colleagues not to join Thomas and Alito in a mission to watch the world burn. Tactically speaking, the ballast of a fourth progressive justice will do a lot more to pull the court back from the brink of total illegitimacy than any admonishing minority opinions Roberts might join his three progressive colleagues in offering.

Finally, the one thing that Roberts appears truly concerned with other than the court’s legitimacy (and demolishing voting rights, which he’s already achieved), is his own legacy. How will history judge him if he retires early to restore the court’s balance and legitimacy? One thing is sure, he will go down in certain conservative circles as a Benedict Arnold–level villain. But he’s already achieved that status to a great extent and I don’t think Donald Trump could be any meaner to him than he already has been. Meanwhile, should he retire, Roberts will almost certainly go down in history as a noble hero who sacrificed his own position to save the legitimacy of the court and maybe even the “constitutional system.” Further, the gesture will likely be largely symbolic, as the five remaining conservative justices will continue to pull the court and the country further and further in the rightward direction that Roberts actually prefers, perhaps radically so.

#### SCOTUS will avoid sweeping ruling in West Virginia v. EPA – a broad ruling wrecks climate response and turns the case

Farah 11-1 [Niina H. Farah, E&E News legal reporter, 11-1-2021 https://www.eenews.net/articles/what-the-supreme-courts-move-means-for-epa-climate-rules/]

The Supreme Court may be poised to put new guardrails on the Biden administration’s climate agenda after justices agreed last week to consider the extent of EPA’s authority to regulate carbon emissions.

The court sent shock waves through the legal world when it agreed Friday to consider a consolidated challenge from Republican-led states and coal companies. The challenge stemmed from a federal court ruling that struck down a Trump-era regulation gutting EPA’s climate rule for power plants (E&E News PM, Oct. 29).

When the justices issue their ruling in the EPA case, which is expected by next summer, the decision could provide the first indication of how the court’s new 6-3 conservative majority will approach questions of the federal government’s role in curbing global climate change.

“This is likely to result in one of the most significant environmental rulings the court has ever reached,” said Robert Percival, director of the Environmental Law Program at the University of Maryland’s law school.

The court’s decision could place new limits on how expansively EPA can interpret its authority to use the Clean Air Act to address climate change.

Friday’s order coincided with the beginning of global climate negotiations at the 26th Conference of the Parties, or COP, in Glasgow, Scotland. It also comes as Congress is negotiating a Democratic spending package that would pump more than $500 billion into addressing climate change. The Biden administration’s goal is to cut U.S. greenhouse gas emissions in half by 2030 and put the electricity sector on a path to zeroing out carbon emissions by 2035.

West Virginia Attorney General Patrick Morrisey (R) praised the justices’ decision to review the ruling earlier this year by the U.S. Court of Appeals for the District of Columbia Circuit, which scrapped the Trump administration’s Affordable Clean Energy rule and handed the Biden team a clean slate to draft a new regulation for coal-fired power plant emissions (Greenwire, Jan. 19).

“This is a tremendous victory for West Virginia and our nation. We are extremely grateful for the Supreme Court’s willingness to hear our case," Morrisey said in a statement Friday.

"This shows the Court realizes the seriousness of this case and shares our concern that the D.C. Circuit granted EPA too much authority," he continued. "Given the insurmountable costs of President Biden’s proposals, our team is eager to present West Virginia’s case as to why the Supreme Court should define the reach of EPA’s authority once and for all."

White House national climate adviser Gina McCarthy said yesterday that the administration believes the high court will uphold EPA’s ability to regulate carbon emissions across the electricity sector.

"The courts have repeatedly upheld the EPA’s authority to regulate dangerous power plant pollution," she told reporters on a call. She noted that the appeals court had struck down the Trump-era rule that would have weakened power plant regulations.

McCarthy said the White House is confident that the Supreme Court will rule in a way that affirms that “EPA has not just the right but the authority and responsibility to keep our families and communities safe from pollution."

Critics of the Supreme Court decision to hear the case said that in most instances, federal courts wait for an agency to enact a rule before they weigh in on a legal controversy around the agency’s power to regulate.

"In that sense, this seems like a power grab. But we don’t know yet," said Bethany Davis Noll, executive director of the State Energy & Environmental Impact Center at New York University School of Law.

Instead of reinstating the Obama-era Clean Power Plan — which interpreted the "best system of emission reduction" to include emissions trading or shifting generation to renewable energy — EPA under Biden opted to start from scratch. The power sector has already surpassed the 2015 Clean Power Plan’s emissions reductions target a decade early.

The agency under Biden has yet to publish a draft proposal, and observers says it may now choose to wait for the Supreme Court’s decision before writing a new carbon rule.

EPA did not respond to a request for comment on the Supreme Court’s order but agency Administrator Michael Regan defended the agency’s authority Friday on Twitter.

"Power plant carbon pollution hurts families and communities, and threatens businesses and workers," he tweeted. "The Courts have repeatedly upheld EPA’s authority to regulate dangerous power plant carbon pollution."

Agency powers

Several observers said the Supreme Court’s eventual ruling in the case could be limited to power plants, while others predicted a bigger blow to emissions regulation for other sectors.

"The issue just gets dumped back in Congress’ lap," said Jeff Holmstead, a partner at the law and lobbying firm Bracewell LLP, of the possible consequences of the court’s limiting EPA’s power.

"Any kind of meaningful regulatory program could be well off the table," he said.

A more concerning — but less likely — possibility would be if the high court used the case to more broadly undermine the regulatory authority of federal agencies.

"It’s possible that what the court is seeking to review here is Section 111(d) itself," said Michael Burger, executive director of Columbia Law School’s Sabin Center for Climate Change Law.

He referred to the part of the Clean Air Act that EPA used to regulate carbon emissions from existing power plants under former presidents Obama and Trump.

"If that’s the case, the broadest threat here is not just about climate change, or about EPA’s authority, but it’s about the power of the court to review congressional authorizations of agency action," he said.

In a worst-case scenario, the high court could give itself authority to tell Congress "in almost any instance" that it has to be more specific about delegating authority to agencies, Burger added.

In their petitions to the Supreme Court, the coal companies and states targeting EPA’s power to regulate raised concerns about whether Congress had clearly given the agency the authority to address utility emissions on a broad, systemwide basis.

The challengers also asked the justices to weigh in on whether Congress could lawfully allow EPA to act on emissions under Section 111(d) of the Clean Air Act under the non-delegation doctrine, which says that lawmakers cannot hand off their legislative authority to executive agencies. The Supreme Court’s conservative wing has expressed interest in reviving the long-dormant legal doctrine.

That argument could threaten not only Biden’s rule proposals, but also existing regulations.

#### **Only the court can expand PTD – all past expansions prove – at worst, its normal means**

Rollins 21 [Brigit, staff writer for The National Agricultural Law Center and environmental lawyer, “The Public Domain: Basics of the Public Trust Doctrine” https://nationalaglawcenter.org/the-public-domain-basics-of-the-public-trust-doctrine/]

One of the main underpinnings of environmental law in the United States is the Public Trust Doctrine (“PTD”). The doctrine, which is found primarily in state common law, requires states to manage certain natural resources for the benefit of the public. While the PTD has traditionally been used to manage water resources, recent lawsuits have sought to expand the doctrine to include natural resources that have been impacted by climate change.

What Is the PTD?

The United States’ PTD is commonly viewed as having roots in Roman civil law. In the sixth century, Roman law texts that “by the law of nature these things are common to all mankind: the air, running water, the sea, and consequently the shores of the sea.” This has been interpreted to mean that air, water, and beaches were common property which would be owned by no one and instead belonged to people as a whole. That idea was reaffirmed in the Magna Carta and eventually incorporated into English common law. However, when this concept was assumed into English common law it was altered slightly by assigning ownership of common property to the king to keep as a trustee for the benefit of the people. When the United States was developing its legal system, it adopted the English common law, in some cases refining certain aspects of the law as the country developed. When courts began to consider the PTD, they reasoned that ownership of water and underlying lands had transferred to citizens of states when the state gained statehood, ultimately interpreting the PTD much closer to the original Roman concept.

The first Supreme Court case to address the PTD, Martin v. Waddell, 41 U.S. 367 (1842), affirmed the doctrine and held that the public maintained a common right to fish in navigable and tidal water because those waters and their underlying lands were kept in trust by the state for the common use of the people. In this case, the Supreme Court established the basic concept of the PTD in the United – that resources subject to the PTD are entrusted to the care of government to be managed in trust for the benefit of the public. Traditionally, the PTD was applied to navigable waters, submerged lands beneath navigable waters, and tidelands. Those resources were managed to protect the public’s right to engage in commerce, navigation, and fishing.

The Supreme Court revisited the PTD again in both Illinois Central R. Co. v. Illinois, 146 U.S. 387 (1892), and Greer v. Connecticut, 161 U.S. 519 (1896). In Illinois Central R. Co., the Court considered the responsibility of the states as trustees under the PTD. First, the Court reaffirmed that states held navigable waters and the lands beneath them in trust for the benefit of the public, but went on to note that states may allow private entities to use trust resources, and to obtain property rights in those resources. However, even though states may allow private entities to use and acquire rights to trust resources, the PTD still required that as trustees the states must ensure that the underlying purposes of the public trust are fulfilled.

In Greer, the Supreme Court expanded the PTD to include wildlife. Specifically, the Court concluded that states held all the wildlife within their borders in public trust, and could therefore regulate the management and harvest of wildlife. Although the application of Greer has evolved, the general idea that wildlife can be managed according to the PTD remains. Prior to this case, the PTD had primarily been viewed as applying to waterways and the lands beneath them. Greer showed that the doctrine had the potential to be more expansive.

#### Their plan would be perceived as pro-regulatory, anti-free market

Dreier 16 [Casey Dreier, Chief Advocate & Senior Space Policy Adviser for The Planetary Society, April 13, 2016. “Does Presidential Intervention Undermine Consensus for NASA?” https://www.planetary.org/blogs/casey-dreier/2016/0413-does-a-strong-president-help-or-hurt-consensus-on-NASA.html]

To see how this happens, I recommend reading the book “[Beyond Ideology](http://smile.amazon.com/Beyond-Ideology-Politics-Principles-Partisanship/dp/0226470768/ref=smi_www_rco2_go_smi_g2243582042?_encoding=UTF8&*Version*=1&*entries*=0&ie=UTF8)” by Frances Lee. The author’s larger premise is that issues having no intrinsic relation to stated party ideology have become increasingly polarized in recent years. This is a function of the two party nature of our political system. If your party coalition wins, the other one loses. It’s [It is] zero-sum. Your party can win in one of two ways: you can make a better pitch to voters by demonstrating the superiority of your agenda; or you can undermine and stymie the agenda of the opposition party, making them unpopular with voters, and pick up the seats that they lose. Since you’re the only other political party, you gain in either scenario. I’m not sure if you’ve noticed, but the “undermine and stymie” approach has been popular for quite some time now in the U.S. Congress. Given this situation, the President and their policies naturally become the symbolic target of the opposition party. Anything promoted by the President effectively induces opposition by association. Lee demonstrates the magnitude of this induced polarization on various types of issues. For highly polarized issues like the role of government in the economy, or social issues, the impact is minimal—the opposition has already been clearly defined and generally falls into clearly defined ideologies of the Republican and Democratic parties. But for issues that do not fit readily into a predefined political ideology—like space—the induced polarization by the President can be significant. In fact, Lee showed that space, science, and technology issues incur the greatest increase in partisanship based on their inclusion in the Presidential agenda. One need only look to at the responses by political operatives of the opposing party to the strong human spaceflight proposals by [Barack Obama in 2010](http://www.shelby.senate.gov/public/index.cfm/mobile/newsreleases?ID=25F3AD2E-802A-23AD-4960-F512B9E205D2), [George W. Bush in 2004](http://www.nbcnews.com/id/3950099/ns/technology_and_science-space/t/bush-sets-new-course-moon-beyond/#.Vw3UMRMrKHo), and [George H.W. Bush in 1989](http://www.nytimes.com/1989/07/21/us/president-calls-for-mars-mission-and-a-moon-base.html) to see this reflected in recent history. This isn’t to say that Presidents can’t have a significant impact on the space program. Clearly they can. But the broad consensus needed for stability after their departure from office may be undermined by the very priority they gave it during their tenure. It what amounts to a mixed blessing for NASA, the U.S. space program does have an unusually strong bipartisan group of politicians who support the program due to NASA centers in a variety of states throughout the union. Berger notes this throughout his article, and it does, in a way, act as force that is resistant to change for good and bad. This mitigates somewhat the pure polarization seen on other science and technology issues. But for a Journey to Mars—a major effort that would, at best, require stability and significant funding over many Presidential administrations—that may not be enough. Perhaps the solution is for the next President to maintain a light touch on space. May

be they should speak softly through the budget process, and avoid the Kennedyesque speeches and declarations to Congress that induce the types of partisanship we so dearly need to avoid.

#### The plan causes institutional balancing – SCOTUS couple’s the plan’s expansion of agency enforcement with an equal and opposite ruling in West Virginia constraining agencies

HLR 11 – Harvard Law Review, “ADVISORY OPINIONS AND THE INFLUENCE OF THE SUPREME COURT OVER AMERICAN POLICYMAKING”, June, 124 Harv. L. Rev. 2064, Lexis

In assessing the Court's power relative to the elected branches, it is first necessary to be clear about what motivates the Supreme Court. When exercising judicial review, the Court seeks to vindicate its constitutional vision by striking down legislation repugnant to that vision. This is true whether one believes that the Court seeks in good faith to divine the true meaning of the Constitution and impose it on the elected branches, attempts to interpret the Constitution faithfully but subconsciously imports its own policy views, or disingenuously strives to implement its policy preferences in the guise of neutral interpretation. For the purposes of the present argument it is irrelevant which view or combination of views is most accurate, and the phrase "constitutional vision" will stand for any and all of these. Yet as suggested above, the Court is not unconstrained when it seeks to effect its constitutional vision through judicial review: if it strays too far from the political mainstream, n55 it will face consequences that undermine its constitutional [\*2076] vision even more than would the upholding of a disfavored statute. n56 The upshot is that the Court operates under conditions of scarcity and must economize on its political capital to go as far in implementing its constitutional vision as political realities allow, which sometimes means upholding (or declining to review) government actions that contravene that vision. n57 And, as a distinct matter, most [\*2077] Justices have displayed a desire to conserve the Court's political capital and maintain its institutional prestige as much as possible even where the Court was not immediately threatened with any hard political constraints. n58 This conservatism is especially understandable given that the Justices are generally not political experts and lack the sophisticated public relations apparatuses of the elected branches, and that the elected branches have substantial capacity to shift public opinion about the Court if they so choose; these factors make it rational for the Court to be parsimonious with its political capital in order to avoid blind overreaching.

[FOOTNOTE]

n57. Thus, the Court's decisionmaking process in a judicial review case incorporates its internal preferences and its view of external constraints as follows: R = B / C, where B equals the benefits to the Court's constitutional vision of invalidating a given piece of legislation, C stands for the cost the Justices expect to incur in terms of political capital, and R gives the trade-off rate between costs and benefits in any given case, such that the Court will expend its political capital in those cases where R is highest, so long as R > 1.

A reasonable objection to the model elaborated in this Part is that although the Court is politically constrained, this "bank account" model in which the Court has finite political capital to "spend" by striking down popular government actions is unrealistic: the Court can also increase its prestige - its institutional capital - by exercising judicial review, which has been the effect of Marbury and Brown, two decisions without which the Court would be much weaker now. Nonetheless, most countermajoritarian decisions do seem to cost the Court rather than increase its capital (Marbury was a refusal to make the countermajoritarian decision, see Friedman, supra note 53, at 60-62, and Brown jeopardized rather than solidified the Court's power over the years immediately following the decision, see Klarman, supra note 53, at 312-43). This is especially true in the short run, while the decision remains countermajoritarian, and it is the short run that counts for the current Justices: the fact that Brown is today sacrosanct did not help the Court when Southern resistance threatened that decision's efficacy in the years immediately after its announcement. Cf. Daryl J. Levinson, Parchment and Politics: The Positive Puzzle of Constitutional Commitment, 124 Harv. L. Rev. 657, 743 (2011) ("Evidently, the Court can build up a savings account of approval that it can then spend down by issuing unpopular decisions without losing public support."). The necessary implication of Levinson's statement is that the "savings account" - and thus the Court's countermajoritarian capacity - is finite. At any rate, the Court's position is no different from that of any other political actor: though the presidency as an institution, for instance, would certainly lose influence as a result of a string of weak, unassertive presidents, and might gain it through the acts of a strong leader, any given President at any given time is undoubtedly limited by political constraints.

#### Biden delegation key to every impact – especially key to end COVID, solve climate change, manage nuclear waste, and regulate Juul

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Joe Biden promised us an FDR-sized presidency—starting with bold action to halt the spread of COVID-19, end the worst economic downturn in decades, and stop the climate crisis. Biden could use regulation and executive action to move quickly to decarbonize the economy, cancel student loan debt, and raise wages. But a Biden administration has an even bigger problem than two long-shot special elections in Georgia: the new 6–3 conservative majority on the Supreme Court may soon burn down the federal government’s regulatory powers.

At least five conservative justices have signaled that they are eager to revive the “non-delegation doctrine,” the constitutional principle that Congress can’t give (“delegate”) too much lawmaking power to the executive branch. On paper, the rule requires Congress, when delegating power to an agency, to articulate an “intelligible principle” (like air pollution regulation needed “to protect public health”) to guide the agency’s exercise of that power. But in practice, the nondelegation doctrine is effectively dead. The court has only struck down two statutes on nondelegation grounds—and none since 1935.

Today, most of the government’s work is done through the “administrative state,” the administrative agencies and offices, like the Environmental Protection Agency, the Department of Labor, and the Department of Education, which issue regulations and enforce laws. Congress doesn’t have the capacity to pass laws that nimbly address complex, technical, and ever-changing problems like air pollution, COVID-19 exposure in workplaces, drug testing, and the disposal of nuclear waste. So Congress tasks agencies staffed with scientists and other specialists to craft regulations that directly address those problems. This division of responsibility—Congress legislates policy goals and agencies implement them effectively—is the foundation of functional government.

Take, for example, the Clean Air Act. In 1963, Congress ordered the EPA to regulate air quality standards “at a level that is requisite to protect public health.” Based on that authority, the EPA routinely issues lifesaving regulations limiting lead in the air, air pollutants coming from chemical plants, and, critically, greenhouse gasses. Biden can use the CAA to start tackling the climate crisis on Day One. The dormant nondelegation doctrine is the foundation of thousands of regulations across dozens of agencies, allowing agencies to make technical decisions about, say, hospital reimbursement rates to administer Medicare or wage and hour rules that protect workers from exploitation.

But last year, in a case called Gundy v. United States, four conservative justices announced that they wanted to bring the nondelegation doctrine back to life. Gundy arose out of a national sex offender registry law that explicitly applied to everyone convicted after the law took effect but delegated authority to the Department of Justice to determine when and how it applied to people convicted before the law took effect. Herman Gundy, who was convicted before the registry law took effect, argued that the law violated the nondelegation doctrine. The court upheld the law. But in a dissent joined by Chief Justice John Roberts and Justice Clarence Thomas, Justice Neil Gorsuch wrote that the court should revive the dormant nondelegation doctrine.\* Gorsuch’s dissent argued that Congress may only delegate policymaking power to agencies under three narrow circumstances: to “fill up the details” of a legislative scheme; for executive fact-finding to determine the application of a rule; and to assign nonlegislative responsibilities to the executive and judicial branches. Justice Samuel Alito wrote separately to say he’d like to “reconsider” the nondelegation doctrine—just not in a case about sex offenders’ rights.

Justice Brett Kavanaugh wasn’t on the court in time to hear Gundy. But last fall, in a separate opinion, he signaled his support for Gorsuch’s new, revived nondelegation doctrine. That makes five votes for resurrecting the nondelegation doctrine and taking a hatchet to landmark labor, environmental, and consumer protection law—even without Justice Amy Coney Barrett, who, administrative law experts warn, shares the conservative justices’ hostility to the administrative state.

As Justice Elena Kagan pointed out in Gundy if the conservative justices bring back the nondelegation doctrine, “most of Government is unconstitutional.” Exactly how much government would be unconstitutional, though, isn’t clear. What does Gorsuch mean when he writes that Congress may give agencies the power to “fill up the details” of a legislative scheme? What does Kavanaugh’s test—that Congress may not delegate “major policy questions” to agencies—actually forbid in practice? Would Biden’s EPA be permitted to issue regulations about greenhouse gasses or new, dangerous chemicals leaking into our public waters? Congress relies on OSHA experts to set workplace safety standards that are “reasonably necessary or appropriate to provide safe or healthful employment.” Does that “delegate” too much power to OSHA to act fast to issue COVID-19 safety standards for transportation, grocery stores, and meatpacking workers, as Joe Biden has promised to do? What about the EEOC’s power to interpret anti-discrimination to address workplace dress codes that discriminate against Black women’s natural hair? What about the FDA’s authority under the Family Smoking Prevention and Tobacco Control Act to subject “any” tobacco products to federal regulations—is “tobacco products” narrow enough under Gorsuch and Kavanaugh’s tests? Or would an FDA decision to regulate Juul just like cigarettes be a “major policy question” outside agencies’ powers?

The uncertainty alone could give special interests like fossil fuel companies and Juul grounds to sue to stop, or at least hold up, lifesaving regulations issued by the Biden administration. They’re already trying—just last year, e-cigarette company “Big Time Vapes” argued that the FDA’s power to regulate “any” tobacco product violated the nondelegation doctrine. The U.S. Court of Appeals for the 5th Circuit rejected that challenge. But in its opinion, the 5th Circuit hinted that similar challenges could soon be successful, as the Supreme Court “might well decide—perhaps soon—to reexamine or revive the nondelegation doctrine.” And if that happens, all bets are off.

Such a decision would not only threaten existing regulations. It endangers every piece of future progressive legislation, too. Big, transformative legislative packages, like a Green New Deal or “Medicare for All,” would require a million and one technical decisions that Congress is poorly positioned to make. Biden and Congress can pass legislation phasing the United States toward 100 percent clean energy by 2030—but someone will have to actually sweat the details about which engines can be included in which cars.

Government doesn’t work without the administrative state. But that’s sort of the point. The conservative justices have long been hostile to regulation and executive action. And now they may finally have the votes to bring virtually any regulation to a halt. At least five justices are ready to drop a 1,000-pound anvil on any Biden administration rule that displeases them.

### 1NC - DA

#### Expanding PTD shatters the entire legal-regulatory balance

Huffman 15 [James L. Huffman is Dean Emeritus of Lewis & Clark Law School and a Visiting Fellow at the Hoover Institution. He holds degrees from Montana State University (BS), The Fletcher School of Tufts University (MA) and the University of Chicago (JD). "WHY LIBERATING THE PUBLIC TRUST DOCTRINE IS BAD FOR THE PUBLIC." https://law.lclark.edu/live/files/19611-45-2huffman]

Since the beginning of the modern environmental movement in the 1960s, environmental advocates have been in search of ways to circumvent the twin obstacles of political compromise and vested property rights. In a 1970 article, Professor Joseph Sax suggested that the common law public trust doctrine might provide an avenue for judicial intervention in the name of claimed public rights in a wide array of natural resources. Because the traditional doctrine was narrowly limited in terms of both public rights and affected resources, Sax published a second article ten years later, calling for courts to liberate the public trust doctrine from its historical parameters. While a few judges responded with generally limited extensions of the doctrine, Sax’s plea has been ignored by most courts—but not by academics. A flood of law review articles have resorted to shoddy history, retrospective theorizing about the origins and purposes of the doctrine, appeals to higher law and moral imperatives, and confusion of the idea of public trust in representative government with the public rights protected by the public trust doctrine in efforts to persuade courts to liberate the doctrine. Implicit, if not explicit, in all of these arguments is the claim that the common law origins of American law and the American judicial system vest courts with authority to amend old law and make new law. At risk in this vast and imaginative effort to liberate the public trust doctrine from its common law confines are the constitutional separation of powers, the rule of law, due process and secure property rights, and the economic prosperity on which environmental protection ultimately depends.

#### Expanding PTD beyond precedent allows for unchecked judicial activism across the law – the plan applies it everywhere on earth, which ensures circumvention, authoritarianism, and shocks global rule of law

Huffman 15 [James L. Huffman is Dean Emeritus of Lewis & Clark Law School and a Visiting Fellow at the Hoover Institution. He holds degrees from Montana State University (BS), The Fletcher School of Tufts University (MA) and the University of Chicago (JD). "WHY LIBERATING THE PUBLIC TRUST DOCTRINE IS BAD FOR THE PUBLIC." https://law.lclark.edu/live/files/19611-45-2huffman]

Modern progressives, like their early twentieth century predecessors, tend to be skeptical of democratic policymaking. They prefer to rely on experts, scientific management and expeditious executive action to implement policies they know to be right and good. Democracy, the separation of powers, constitutional rights, and the rule of law all get in the way. It was early frustration with these traditional American principles that led Professor Sax to call for liberating the public trust doctrine from its historical shackles. He recognized that if courts could be persuaded to expand and extend the doctrine, environmentalists could revolutionize American property law while claiming the mantle of the rule of law. Courts would rule for environmentalist claims not because it was the right thing to do but because the law required it.

That barely a handful of courts have even acknowledged Sax’s invitation to liberate the public trust doctrine underscores that most judges, most of the time, do their best to interpret and apply the law as those affected by the law would reasonably expect them to. Most judges understand that people rely on those expectations in their interactions with others and in the risks they assume and to which they expose others. If it were otherwise, people would soon lose confidence in the courts as objective arbiters of disputes.

This does not mean that the law is stuck in the past. The common law has always evolved. But it has evolved in a way that respects rather than undermines expectations. One of the great strengths of the common law method is in “serving the rule of law by adapting legal rules to the demonstrated needs and wishes of those who rely on law to bring at least a degree of certainty to their day-to-day lives.”226

Perhaps the best indication of widespread commitment to the rule of law is that judges seduced into lawmaking of the kind urged by public trust liberationists, like the liberationists themselves, invariably appeal to precedent in seeking to justify their rulings. This does not mean that the lawmaking judges shy away from explaining the policy benefits of their decisions, but one would be hard pressed to find a case in which a court acknowledges that its new rule has no basis in preexisting law. Rather, lawmaking judges follow the path advocated by Judge Richard Posner in his commentary on the Supreme Court’s decision in Bush v. Gore.227 Posner explains that what he calls pragmatic judges should cover their lawmaking tracks by providing “legal-type judgment” as justification.228

Anyone who believes in the rule of law as a necessary principle of government in every free society should be troubled by this ends-driven, whatever-it-takes approach to judging in particular, and government in general. Even accepting, for the sake of argument, that we face a global environmental crisis as Professor Wood and many others assert,229 experience demonstrates that compromising the rule of law will harm rather than help efforts to meet any serious challenge. Saving a failing planet will require innovative thinking and creativity of the highest sort. History demonstrates that individual liberty and the rule of law are essential to such innovation and problem solving. Absent the rule of law, many a nation has failed to solve much lesser challenges.230

#### Rule of law solves war

Feldman ‘8 [Noah; September 28; Professor of Law at Harvard University School of Law; New York Times, “When Judges Make Foreign Policy,” lexis]

Why We Need More Law, More Than Ever

So what do we need the Constitution to do for us now? The answer, I think, is that the Constitution must be read to help us remember that while the war on terror continues, we are also still in the midst of a period of rapid globalization. An enduring lesson of the Bush years is the extreme difficulty and cost of doing things by ourselves. We need to build and rebuild alliances — and law has historically been one of our best tools for doing so. In our present precarious situation, it would be a terrible mistake to abandon our historic position of leadership in the global spread of the rule of law.

Our leadership matters for reasons both universal and national. Seen from the perspective of the world, the fragmentation of power after the cold war creates new dangers of disorder that need to be mitigated by the sense of regularity and predictability that only the rule of law can provide. Terrorists need to be deterred. Failed states need to be brought under the umbrella of international organizations so they can govern themselves. And economic interdependence demands coordination, so that the collapse of one does not become the collapse of all.

From a national perspective, our interest is less in the inherent value of advancing individual rights than in claiming that our allies are obligated to help us by virtue of legal commitments they have made. The Bush administration’s lawyers often insisted that law was a tool of the weak, and that therefore as a strong nation we had no need to engage it. But this notion of “lawfare” as a threat to the United States is based on a misunderstanding of the very essence of how law operates.

Law comes into being and is sustained not because the weak demand it but because it is a tool of the powerful — as it has been for the United States since World War II at least. The reason those with power prefer law to brute force is that it regularizes and legitimates the exercise of authority. It is easier and cheaper to get the compliance of weaker people or states by promising them rules and a fair hearing than by threatening them constantly with force. After all, if those wielding power really objected to the rule of law, they could abolish it, the way dictators and juntas have often done the world over.

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#### SOP decline causes global nuke war

Dr. G. John Ikenberry 15, PhD in Political Science from the University of Chicago, Albert G. Milbank Professor of Politics and International Affairs at Princeton University in the Department of Politics and the Princeton School of Public and International Affairs, “Getting Hegemony Right”, in Korean Attitudes Toward the United States: Changing Dynamics, Ed. Steinberg, p. 17-18

A critical ingredient in stabilizing international relations in a world of radical power disparities is the character of America itself. The United States is indeed a global hegemon, but because of its democratic institutions and political traditions it is--or can be--a relatively benign one. Joseph Nye's arguments on "soft power" of course come to mind here, and there is much to his point. But, in fact, there are other, more significant aspects of the American way in foreign policy that protect the United States from the consequences of its own greatness.

When other major states consider whether to work with the United States or resist it, the fact that it is an open, stable democracy matters. The outside world can see American policymaking at work and can even find opportunities to enter the process and help shape how the overall order operates. Paris, London, Berlin, Moscow, Tokyo and even Beijing--in each of these capitals officials can readily find reasons to conclude that an engagement policy toward the United States will be more effective than balancing against U.S. power.

America in large part stumbled into this open, institutionalized order in the 1940s, as it sought to rebuild the postwar world and to counter Soviet communism. In the late 1940s, in a pre-echo of today's situation, the United States was the world's dominant state--constituting 45 percent of world GNP, leading in military power, technology, finance and industry, and brimming with natural resources. But America nonetheless found itself building world order around stable and binding partnerships. Its calling card was its offer of Cold War security protection. But the intensity of political and economic cooperation between the United States and its partners went well beyond what was necessary to counter the Soviet threat. As the historian Geir Lundestad has observed, the expanding American political order in the half century after World War II was in important respects an "empire by invitation." The remarkable global reach of American postwar hegemony has been at least in part driven by the efforts of European and Asian governments to harness U.S. power, render that power more predictable, and use it to overcome their own regional insecurities. The result has been a vast system of America-centered economic and security partnerships.

Even though the United States looks like a wayward power to many around the world today, it nonetheless has an unusual ability to co-opt and reassure. Three elements matter most in making U.S. power more stable, engaged and restrained. First, America's mature political institutions organized around the rule of law have made it a relatively predictable and cooperative hegemon. The pluralistic and regularized way in which U.S. foreign and security policy is made reduces surprises and allows other states to build long-term, mutually beneficial relations. The governmental separation of powers creates a shared decision-making system that opens up the process and reduces the ability of any one leader to make abrupt or aggressive moves toward other states. An active press and competitive party system also provide a service to outside states by generating information about U.S. policy and determining its seriousness of purpose. The messiness of a democracy can, indeed, frustrate American diplomats and confuse foreign observers. But over the long term, democratic institutions produce more consistent and credible policies--policies that do not reflect the capricious and idiosyncratic whims of an autocrat.

### 1NC – Case

#### China uses space coop to bolster perception of credible leadership – that causes nuclear war and conventional conflict in the SCS

Fisher 15 Richard D. Fisher 2-8-2015 “China’s Military Ambitions in Space and America’s Response” <http://www.uscc.gov/sites/default/files/Fisher_Testimony_2.18.15.pdf> (President of Pacific Strategies, Inc)//Elmer

As with the former Soviet Union, China’s pursuit of regional and then global military power is not rooted in an existential threat, but in the CCP’s fears for its power position. This requires a CCP-led “rejuvenation” of China, entailing mobilization for greater power, ever more control over its own people, and then increasing control over others. Another result is China’s choice to be hostile to Western rules or concepts that may constrain China’s power. This justifies an essential Chinese rejection of American or Western conceptions of transparency and restraint, or verifiable weapons control in space which might constrain its power. This mirrors the CCP/PLA’s repeated refusal of U.S. requests to consider real nuclear weapons transparency and control, transparency over its nuclear and missile exports, and --from many of its neighbors and Washington -- fair settlement of territorial disputes which threaten war. The latter, especially in the South China Sea, is instructive. As it has gained military power in the South China Sea, China has sought to change the strategic environment and dictate new rules to increase its security at the expense of others. Once it gains commanding strength and position in space, will China do the same? For the United States, cooperation with China in space may yield some benefits, but it likely will have little impact on the direction and severity of terrestrial conflicts which will dominate relations with China. One can see the value of meeting with Chinese space officials, especially higher CCP and PLA leaders, to advance concerns over their actions in space and to promote transparency. But at this juncture, before China has achieved levels of “space dominance”, it is crucial to link any real cooperation with China to its behavior in space and elsewhere which threatens U.S. security. Furthermore, allowing China increasing access to U.S. space technology, space corporations, or government institutions at this time presents two risks. First it could encourage China to advance an illusion of cooperation with the U.S. and the West while differences on Earth become sharper. This could become useful for Beijing to deflect criticism on other issues, or even to obtain leverage over U.S. options and actions. Second, as has been proven repeatedly, China will exploit any new access for espionage gains to strengthen its own space and military sectors. 2 China’s increasing space power, however, like its growing economic and political power, cannot be “contained.” Russia appears ready to greatly expand space and military cooperation with China as part of a larger strategic alignment, while the European Space Agency is edging toward greater cooperation with China. These attractions may only increase if China has the only LEO manned space station in the mid-2020s. Already a top commercial space service and technology provider, China will use its gathering space diplomacy tools to aid its pursuit of economic, political and military influence in critical regions like Africa and Latin America. The challenge for the United States is to maintain the means to compete with China in space both in military and non-military endeavors. China’s potential for developing new space combat systems means the U.S. must be able to rapidly develop appropriate deterrent capabilities. There should also be a more developed U.S. capability to rapidly repopulate satellite systems taken down by PLA attacks, and there should be more terrestrial or airborne systems to compensate for lost navigation, communication and surveillance satellites. In addition, as the PLA moves substantially out to deep space, the Moon, or to the Lagrangian Points, it will be necessary for the U.S. to consider a compensating presence that is affordable, attractive to a coalition of democracies, and helps to deter China from seeking strategic advantage. Strategic priorities would suggest that a presence on or near the Moon is of greater importance than going to Mars. A multinational government-private presence on the Moon is one option, as is the likely less expensive option of a far cis-lunar presence to further develop manned deep space capabilities. As was the case with the former Soviet Union, relative peace on Earth or in space will not truly be possible until China evolves beyond its Leninist dictatorship. In its final years, the Soviet Union was on the cusp of deploying multiple space combat systems despite years of U.S.-Soviet space diplomacy. Real space cooperation between Russia the West became possible only after the fall of the Soviet Union, and may again become threatened by Russia’s slide into authoritarian aggression. Substantive cooperation with China in space offers no assurance that China will change its threatening behaviors on Earth or in space, but does create opportunities for China to exploit U.S. and Western space technology to gain potential military advantages.

#### Nuclear War

and the strategic preferences of others increase as well.

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

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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. The 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.

#### Reverse causal—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.

#### No debris cascades

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

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

What is Kessler Syndrome?

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

It is a dark picture.

Is Kessler Syndrome likely to happen?

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

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

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

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

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

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

How bad could Kessler Syndrome in High LEO be?

Let’s imagine a worst case scenario.

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

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

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

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

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

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

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

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

#### It takes centuries and adaptation solves

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

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

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

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

#### No miscalc or escalation

James Pavur 19, Professor of Computer Science Department of Computer Science at Oxford University and Ivan Martinovic, DPhil Researcher Cybersecurity Centre for Doctoral Training at Oxford University, “The Cyber-ASAT: On the Impact of Cyber Weapons in Outer Space”, 2019 11th International Conference on Cyber Conflict: Silent Battle T. Minárik, S. Alatalu, S. Biondi, M. Signoretti, I. Tolga, G. Visky (Eds.), <https://ccdcoe.org/uploads/2019/06/Art_12_The-Cyber-ASAT.pdf>

A. Limited Accessibility Space is difficult. Over 60 years have passed since the first Sputnik launch and only nine countries (ten including the EU) have orbital launch capabilities. Moreover, a launch programme alone does not guarantee the resources and precision required to operate a meaningful ASAT capability. Given this, one possible reason why space wars have not broken out is simply because only the US has ever had the ability to fight one [21, p. 402], [22, pp. 419–420]. Although launch technology may become cheaper and easier, it is unclear to what extent these advances will be distributed among presently non-spacefaring nations. Limited access to orbit necessarily reduces the scenarios which could plausibly escalate to ASAT usage. Only major conflicts between the handful of states with ‘space club’ membership could be considered possible flashpoints. Even then, the fragility of an attacker’s own space assets creates de-escalatory pressures due to the deterrent effect of retaliation. Since the earliest days of the space race, dominant powers have recognized this dynamic and demonstrated an inclination towards de-escalatory space strategies [23]. B. Attributable Norms There also exists a long-standing normative framework favouring the peaceful use of space. The effectiveness of this regime, centred around the Outer Space Treaty (OST), is highly contentious and many have pointed out its serious legal and political shortcomings [24]–[26]. Nevertheless, this status quo framework has somehow supported over six decades of relative peace in orbit. Over these six decades, norms have become deeply ingrained into the way states describe and perceive space weaponization. This de facto codification was dramatically demonstrated in 2005 when the US found itself on the short end of a 160-1 UN vote after opposing a non-binding resolution on space weaponization. Although states have occasionally pushed the boundaries of these norms, this has typically occurred through incremental legal re-interpretation rather than outright opposition [27]. Even the most notable incidents, such as the 2007-2008 US and Chinese ASAT demonstrations, were couched in rhetoric from both the norm violators and defenders, depicting space as a peaceful global commons [27, p. 56]. Altogether, this suggests that states perceive real costs to breaking this normative tradition and may even moderate their behaviours accordingly. One further factor supporting this norms regime is the high degree of attributability surrounding ASAT weapons. For kinetic ASAT technology, plausible deniability and stealth are essentially impossible. The literally explosive act of launching a rocket cannot evade detection and, if used offensively, retaliation. This imposes high diplomatic costs on ASAT usage and testing, particularly during peacetime. C. Environmental Interdependence A third stabilizing force relates to the orbital debris consequences of ASATs. China’s 2007 ASAT demonstration was the largest debris-generating event in history, as the targeted satellite dissipated into thousands of dangerous debris particles [28, p. 4]. Since debris particles are indiscriminate and unpredictable, they often threaten the attacker’s own space assets [22, p. 420]. This is compounded by Kessler syndrome, a phenomenon whereby orbital debris ‘breeds’ as large pieces of debris collide and disintegrate. As space debris remains in orbit for hundreds of years, the cascade effect of an ASAT attack can constrain the attacker’s long-term use of space [29, pp. 295– 296]. Any state with kinetic ASAT capabilities will likely also operate satellites of its own, and they are necessarily exposed to this collateral damage threat. Space debris thus acts as a strong strategic deterrent to ASAT usage.

#### Gottschalk a] public b] describing current financial harms of debris c]

#### No Russia war

* Apocalyptic fears overblown
* Moscow believes NATO is strong enough
* Allies are increasing spending
* Putin is focused on domestic concerns
* He wants to expand ties
* At worst, conflict not militarized

Trenin 18 [Dmitri Trenin is director of the Carnegie Moscow Center. Fears of World War III are overblown. July 20, 2018. https://www.politico.eu/article/donald-trump-vladimir-putin-nato-crimea-fears-of-world-war-iii-are-overblown/]

Europeans fretted about the end of NATO. But seen from Moscow, the military alliance still appears to be very much alive. Trump's harsh words to his allies on spending haven't changed that. Russia is all too aware that the alliance is focused on its eastern flank, and not only rhetorically. Since it rediscovered Russia as a threat in 2014, there have been new deployments, a higher degree of mobility, and more military exercises along the Russian border, from the Barents to the Black Seas. Hardly a boon for Russia.

It was clear at last week's NATO summit that allies agree on the need to upgrade the bloc’s military efforts. Germany, Italy, France, the U.S. — they all agree members’ defense spending should go up. Whether by 2 percent of GDP as agreed in Wales, or by 4 percent as now demanded by Trump, is, of course, important. However, with Russia’s GDP often likened to that of Spain, or the state of New York, either figure is considered significant in Moscow, given that the money will be spent with Russia in mind.

NATO allies also worry about Trump’s comment this week that it is problematic for the U.S. to come to the defense of smaller NATO allies such as Montenegro. But let’s not forget that at the height of the Cold War it was never 100 percent certain what the U.S. would do in case of an attack on West Germany. Former Chancellor Helmut Schmidt would not have asked for U.S. medium-range missiles in Europe in the 1970s had he had full confidence in NATO's largest member. Nor is NATO enlargement off the table completely. Macedonia has just crossed a major hurdle in its push for membership.

Predictions that Trump would recognize Crimea at the Helsinki meeting were also overblown. There was never any question of the U.S. accepting Crimea’s status as part of Russia, or Washington leaning on Kiev to fulfill its side of the Minsk II accords. In Helsinki, Trump and Putin simply acknowledged the issue, and moved on. The U.S. continues to support both Ukraine and Georgia in their conflicts with Russia and to promote their eventual membership in NATO, which most in the West privately regard as increasingly dangerous.

NATO is still very much exerting pressure on Russia. It's considered more of an annoyance than an immediate threat in Moscow, but also keeps the country in permanent "war mode" vis-à-vis the U.S. Because Moscow is focused on Washington, this means Europeans usually get a pass.

As for Russia’s own intentions, two things are clear. There is no interest in Moscow in attacking the Baltic states or Poland. These countries are as safe now as they were before 2014. Suggestions otherwise simply point to the deep wounds in both nations' psyche, which will not be healed for many decades.

Should Ukraine's leaders decide to repeat Mikheil Saakashvili’s mistake in 2008 and launch a major offensive to retake Donbas — however unlikely — the Russian response could indeed be devastating and lead to Ukraine's loss of sovereignty, as Putin recently stated. But does this mean Russia will move on Ukraine unprovoked? Most certainly not.

Putin's main concerns are largely domestic. He has an ambitious program that logically calls for more economic ties with the West. To move forward, he is looking to ease tensions with the EU and the U.S. What Putin wanted to get out of Helsinki was mainly to start a dialogue with Washington.

Those hopes are now visibly going up in smoke. It is safe to bet that Russia will continue to face the same opposition from a coalition of U.S. and EU interests.

The first détente in the hybrid war between Russia and the West was indeed nipped in the bud by Trump's behavior and the vehemence of his domestic critics. So be it.

Moscow will not capitulate, and will indeed push back. But it's not likely to take the form of an aggressive, overt military attack. Fears of new wars are far from accurate.

#### 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.