## 1

#### **[a] Interp - The letter “A” is an indefinite article that modifies “democracy” – the resolution must be proven true in all instances, not one particular instance**

CCC Capital Community College [a nonprofit 501 c-3 organization that supports scholarships, faculty development, and curriculum innovation], “Articles, Determiners, and Quantifiers”, http://grammar.ccc.commnet.edu/grammar/determiners/determiners.htm#articles AG

The three articles — a, an, the — are a kind of adjective. The is called the definite article because it usually precedes a specific or previously mentioned noun; a and an are called indefinite articles because they are used to refer to something in a less specific manner (an unspecified count noun). These words are also listed among the noun markers or determiners because they are almost invariably followed by a noun (or something else acting as a noun). caution CAUTION! Even after you learn all the principles behind the use of these articles, you will find an abundance of situations where choosing the correct article or choosing whether to use one or not will prove chancy. Icy highways are dangerous. The icy highways are dangerous. And both are correct. The is used with specific nouns. The is required when the noun it refers to represents something that is one of a kind: The moon circles the earth. The is required when the noun it refers to represents something in the abstract: The United States has encouraged the use of the private automobile as opposed to the use of public transit. The is required when the noun it refers to represents something named earlier in the text. (See below..) If you would like help with the distinction between count and non-count nouns, please refer to Count and Non-Count Nouns. We use a before singular count-nouns that begin with consonants (a cow, a barn, a sheep); we use an before singular count-nouns that begin with vowels or vowel-like sounds (an apple, an urban blight, an open door). Words that begin with an h sound often require an a (as in a horse, a history book, a hotel), but if an h-word begins with an actual vowel sound, use an an (as in an hour, an honor). We would say a useful device and a union matter because the u of those words actually sounds like yoo (as opposed, say, to the u of an ugly incident). The same is true of a European and a Euro (because of that consonantal "Yoo" sound). We would say a once-in-a-lifetime experience or a one-time hero because the words once and one begin with a w sound (as if they were spelled wuntz and won). Merriam-Webster's Dictionary says that we can use an before an h- word that begins with an unstressed syllable. Thus, we might say an hisTORical moment, but we would say a HIStory book. Many writers would call that an affectation and prefer that we say a historical, but apparently, this choice is a matter of personal taste. For help on using articles with abbreviations and acronyms (a or an FBI agent?), see the section on Abbreviations. First and subsequent reference: When we first refer to something in written text, we often use an indefinite article to modify it. A newspaper has an obligation to seek out and tell the truth. In a subsequent reference to this newspaper, however, we will use the definite article: There are situations, however, when the newspaper must determine whether the public's safety is jeopardized by knowing the truth. Another example: "I'd like a glass of orange juice, please," John said. "I put the glass of juice on the counter already," Sheila replied. Exception: When a modifier appears between the article and the noun, the subsequent article will continue to be indefinite: "I'd like a big glass of orange juice, please," John said. "I put a big glass of juice on the counter already," Sheila replied. Generic reference: We can refer to something in a generic way by using any of the three articles. We can do the same thing by omitting the article altogether. A beagle makes a great hunting dog and family companion. An airedale is sometimes a rather skittish animal. The golden retriever is a marvelous pet for children. Irish setters are not the highly intelligent animals they used to be. The difference between the generic indefinite pronoun and the normal indefinite pronoun is that the latter refers to any of that class ("I want to buy a beagle, and any old beagle will do.") whereas the former (see beagle sentence) refers to all members of that class

“Democracy” is a generic indefinite singular.

Leslie 12 Leslie, Sarah-Jane. “Generics.” In Routledge Handbook of Philosophy of Language, edited by Gillian Russell and Delia Fara, 355–366. Routledge, 2012. <https://www.princeton.edu/~sjleslie/RoutledgeHandbookEntryGenerics.pdf> SM

GENERICS VS. EXISTENTIALS The interpretation of sentences containing bare plurals, indefinite singulars, or definite singulars can be either generic as in (1) respectively or existential/specific as in (2): (1) Tigers are striped A tiger is striped The tiger is striped. (2) Tigers are on the front lawn A tiger is on the front lawn The tiger is on the front lawn. The subjects in (1) are prima facie the same as in (2), yet their interpretations in (1) are intuitively quite different from those in (2). In (2) we are talking about some particular tigers, while in (1) we are saying something about tigers in general. There are some tests that are helpful in distinguishing these two readings. For example, the existential interpretation is upward entailing, meaning that the statement will always remain true if we replace the subject term with a more inclusive term. For example, if it is true that tigers are on the lawn, then it will also be true that animals are on the lawn. This is not so if the sentence is interpreted generically. For example, it is true that tigers are striped, but it does not follow that animals are striped (Lawler 1973 Laca 1990; Krifka et al 1995). Another test concerns whether we can insert an adverb of quantification (in the sense of Lewis 1975) with minimal change of meaning (Krifka et al 1995). For example, inserting “usually” in the sentences in (1) (e.g. “tigers are usually striped”) produces only a small change in meaning, while inserting “usually” in (2) dramatically alters the meaning of the sentence (e.g. “tigers are usually on the front lawn). (For generics such as “mosquitoes carry malaria”, the adverb “sometimes” is perhaps better used than “usually”.)

#### **[b] Violation – They spec**

#### [c] Standards:

#### 1] Topic education – If the other debater specifies something not mentioned in the res, then it’s extra topical. Making the debate around whatever they specified kills actual topic education.

#### 2] Predictability – Moves the debate into unpredictable ground which destroys clash. I don’t know what they are going to specify, and this means I have a short time to come up with responses that won’t be as good which means we are getting less education. They kill education and fairness.

#### 3] Prep Burdens – I can’t possibly prep for every single potential specification in the world. Now my responses can’t be as good which harms the education we receive from the round since they have the ability to literally go for anything. Kills education and fairness. I have to prep for the actual topic, but they just find ev to win their plan which means they will always win their aff debate which decks fairness.

#### 4] Limits and Ground – Even if they read evidence that they are topical because of a subset, they still can’t resolve the fact that I lost ground in the debate because of their action. Their plan imposes a model of debate wherein they can specify whatever they want and not debate the topic as is on the tourney invite page. Ie. their model means that they can continue to shift the limit of the debate to parts where they have more ev and prep which devastates my prep and ev burdens because I spent time prepping and cutting ev for other parts of the res which means my responses will be less in depth which takes out your inevitable claims to education. You’ll always destroy me on this debate which means no substantive education.

#### I LOST ACCESS TO DISADS TO THE REST OF THE WORLD WHICH IS 99 PERCENT OF THE TOPIC.

#### [d] Voters:

#### 1] Education – is a voter because it is the goal and purpose of debate.

#### 2] Fairness – is a voter because it is necessary in any competition.

#### It’s DTD; DTA illogical, time skew, you can’t drop their adovacy without dropping the debater since the advocacy control the round, and dropping the argument would turn it condo which is bad because condo advocacies allow them to kick out midway through and moot my speeches which decks fairness. No RVIs; chills checking of abuse, baiting, illogical, you don’t win for being fair. It’s CI; reasonability is arbitrary and encourages judge intervention since there’s no clear norm, but CI causes a race to the top with the best norms for debate.

## 2 – On Nuclear

#### Isolated civilizations survive nuclear war, but industry is destroyed

**Beckstead 15.** Nick Beckstead, Professor at Oxford University, Future of Humanity Institute, (2015), “How much could refuges help us recover from a global catastrophe?,” https://sci-hub.se/https://www.sciencedirect.com/science/article/abs/pii/S0016328714001888 //MK

*[‘isolated peoples’ refers to populations unconnected from global society, such as Amazonian tribes]*

A global catastrophe could disrupt global food production for two reasons. First, as noted a few times above, some global catastrophes—such as supervolcanic eruptions, **nuclear wars**, and asteroid collisions—**might** put enough dust in the atmosphere to interfere with photosynthesis and **disrupt global food production.** Second, an initial catastrophe could kill enough people and do enough damage to infrastructure to shut down global food production. Conceivably, stocking refuges with a very large food supply or method of making food—over and above what is necessary to survive the initial catastrophe—might help a small group to survive and recover if a global catastrophe disrupts global food production. A first issue is that a global food crisis **would not** necessarily **result in extinction**. Extinction may even be extremely unlikely in such cases. The closest historical precedent to these crises was the supervolcanic Toba eruption that took places about 74,000 years ago. Many eruptions of this kind have taken place in the last tens of millions of years, but they did not extinguish our pre-human ancestors (Shulman, 2012a). Humans may now be in many ways worse prepared for such a crisis, with a much larger percentage of the population without hunting and agricultural skills, but we have many advantages in terms of technology and coordination. **The 100+ isolated peoples would be** relatively **similar to** pre-human **ancestors who survived supervolcanic eruptions** in the past, though—as noted above—they may have a notable disadvantage in reestablishing an advanced industrial civilization. Second, in any of the global food crisis scenarios noted above, **there would be** a **substantial** amount of remaining **food reserves** in the form of grain stockpiles, livestock, fisheries, foods stored at retailers and private homes, and wild land animals that could be hunted (Shulman, 2012b). Therefore, if a refuge helps humanity survive a global food crisis, the mechanism could not be conceived of as ‘‘adding enough to the global food stock to help with survival.’’ More plausibly, there could be a scenario where there is not enough food for everyone to survive the global food crisis, but there would be enough food for some people to survive if they got a disproportionate share of the food. However, conflict (e.g., as in McCarthy’s postapocalyptic novel The Road) and/or egalitarian pressures could prevent a distribution that would allow at least some of the population to survive the crisis. Conceivably, if the refuge were sufficiently secret, isolated, and well-stocked, it might be the only place where these pressures could be abated, making the people in refuges the sole survivors of the global food crisis. While conceivable and perhaps plausible, refuges’ unique success in this kind of case is not automatic and perhaps unlikely. If some small, well-armed group seizes some grain elevators, refuses to share their bounty, and successfully defends what they have claimed, they could also survive the global food crisis. Alternatively, a single survivalist community might be isolated and well-defended enough to achieve the same purpose. This potential use case may deserve more detailed analysis. As noted above, even if some initial catastrophe failed to kill everyone, it could lead to a collapse of the modern world order. This type of scenario might accompany a global food crisis, or could arise independently in cases of an unprecedentedly bad pandemic or global war that decimates the population. Conceivably, such a collapse to lead to extinction or a failure to recover industrial civilization. In this kind of scenario, people in refuges are not the sole survivors of our hypothetical global catastrophe. Instead, **it seems extremely likely that, some non-negligible fraction of civilization** (greater than 1 in 10,000, say) **would survive. But a greatly reduced global population would be unable to sustain many aspects of modern industry**, manufacturing, trade, and agricultural production, and may be forced to retrace a substantial part of past **technological development** (see Hanson (2008) quotation below).

#### No industry means no other deadly weapons:

#### Impact turn - Quantum vacuum mining destroys the universe- it’s feasible and inevitable

**Folger 8 –** Tim Folger, Contributing Editor at Discover Magazine, Writer for National Geographic, MA in Journalism from New York University, BA in Physics from UC Santa Cruz, “Nothingness of Space Could Illuminate the Theory of Everything”, Discover Magazine, 7-18, http://discovermagazine.com/2008/aug/18-nothingness-of-space-theory-of-everything

When the **next revolution** rocks physics, **chances are** it will be about nothing—the **vacuum**, that endless infinite void. In a discipline where the stretching of time and the warping of space are routine working assumptions, the vacuum remains a sort of cosmic koan. And as in the rest of physics, its nature has turned out to be mind-bendingly weird: Empty space is not really empty because nothing contains something, seething with energy and particles that flit into and out of existence. Physicists have known that much for decades, ever since the birth of quantum mechanics. But **only in the last 10 years** has the vacuum taken **center stage** as a font of confounding mysteries like the nature of dark energy and matter; only recently has the void turned into a tantalizing beacon for cranks. As one blond celebrity heiress and embodiment of emptiness might say, nothing is hot.

To investigate the mysteries of the void, some physicists are using the biggest scientific instrument ever built—the just-completed Large Hadron Collider, a huge particle accelerator straddling the French-Swiss border. Others are designing tabletop experiments to see if they can plumb the vacuum for ways to power strange new nanotech devices. “The vacuum is one of the places where our knowledge fizzles out and we’re left with all sorts of crazy-sounding ideas,” says John Baez, a mathematical physicist at the University of California at Riverside. Whether in the visionary search for the engine of cosmic expansion or the near-fruitless quest for perpetual free energy, the vacuum is where it’s happening. By mining the vacuum’s riches, a true theory of everything may yet emerge.

Empty space wasn’t always so mystifying. Until the 1920s physicists viewed the vacuum much as the rest of us still do: as a featureless nothingness, a true void. That all changed with the birth of quantum mechanics. According to that theory, the space around a particle is filled with countless “virtual” particles rapidly bursting into and out of existence like an invisible fireworks display.

Those virtual quantum particles are more than a theoretical abstraction. Sixty years ago a Dutch physicist named Hendrik Casimir suggested a simple experiment to show that virtual particles can move objects in the real world. What would happen, he asked, to two metal plates placed very close together in a complete vacuum? In the days before quantum mechanics, physicists would have said that the plates would just sit there. But Casimir realized that the net pressure of all the virtual particles—the stuff of empty space—outside the plates should exert a minuscule force, a nudge from nothing that would push the plates together.

Physicists tried for decades to measure the Casimir force with great precision, but it wasn’t until 1997 that technology caught up with theory. In that year, physicist Steve Lamoreaux, now at Yale, managed to detect the feeble Casimir force on two small surfaces separated by a few thousandths of a millimeter. Its strength was about equal to the force that would be exerted against the palm of one’s hand by the weight of a single red blood cell.

At first most physicists regarded the Casimir force as a quantum oddity, something of no practical value. Now that has changed: Forward thinkers see it as an **important energizer** for the tiniest of machines, devices on the nano scale, and a few labs are working on ways to use the force to defy the conventional limitations of mechanical design. Federico Capasso, a physicist at Harvard, leads a small team that is trying to create a repulsive Casimir force by tinkering with the shapes of plates or with the coatings used to cover them. His entire set of experiments fits on a desktop, and the objects he works with are so small that most of them cannot be seen without a microscope.

“Once you have a repulsive force between two plates, you should be able to eliminate static friction,” Capasso says. That could lead to a host of useful applications, including tiny frictionless bearings or nanogears that spin without touching. “But the experiments are enormously difficult, so I cannot tell you when and how.”

For all its strangeness, the Casimir force may be the one property of empty space that does not baffle today’s physicists. It is garden-variety quantum mechanics, weird but not unexpected. The same can’t be said about dark energy, a truly astonishing discovery made by astronomers a decade ago while observing distant exploding stars. The explosions revealed a universe expanding at an ever-faster rate, a finding at odds with previous expectations that the expansion of the cosmos should be slowing down, braked by the collective gravitational pull of all the matter out there. Some unknown form of energy—physicists call it dark energy simply for lack of a more descriptive term—appears to be built into the very fabric of space, countering the gravitational pull of matter and pushing everything in the universe apart. Some theorists speculate that dark energy might cause a runaway expansion of the universe, resulting in a so-called Big Rip some 50 billion years from now that would tear the cosmos to pieces, shredding even atoms.

The observations have allowed physicists to estimate the quantity of dark energy by deducing the force needed to produce the accelerating effect. The result is a minuscule amount of energy for every cubic meter of vacuum. Since most of the cosmos consists of empty space, though, that little bit adds up, and the total amount of dark energy completely dominates the dynamics of the universe.

With the discovery of dark energy came difficult questions: What is this energy, and where does it come from? Physicists simply do not know. According to quantum mechanics, the energy of empty space comes from the virtual particles that dwell there. But when physicists use the equations of quantum theory to calculate the amount of that virtual energy, they get a ridiculously huge number—about 120 orders of magnitude too large. That much energy would literally blow the universe apart: Objects a few inches from us would be carried away to astronomical distances; the universe would literally double in size every 10-43 second, and it would keep doubling at that rate until all the vacuum energy was gone. This may be the most colossal gap between observation and theory in the history of science. And it means that physicists are missing something fundamental about the way the universe works.

“We’ve made a prediction on the basis of our best theories, and it is wrong, wildly wrong,” says Sean Carroll, a theoretical physicist at the California Institute of Technology. “That means we don’t just tweak a parameter here and there; we really have to think deeply about what our theories are.”

Even if no one knows where the energy of empty space comes from or why it has the value it does, there is **now no doubt** that it **exists**. And if there is energy to be had, there is **inevitably** somebody out there thinking of how to exploit it. The notion of limitless energy from empty space has inspired **legions** of wannabe physicists who dream of developing the ultimate perpetual-motion device, a machine that would solve the world’s energy problems forever. A quick Internet search for the words free energy and vacuum turns up pages and pages of schemes for tapping the vacuum’s energy. I ask John Baez if such efforts are as hopeless as previous perpetual-motion machines. Are they equally crazy and doomed to failure?

“Perhaps not as doomed as trying to prove the world is flat,” Baez says. “One thing I can say is that I sure hope it doesn’t work, because if you could extract energy from the vacuum, it would **mean that the vacuum is not stable**. For normal physicists,” he adds with a laugh, “the definition of the vacuum is that it’s the lowest-energy situation possible—it has less energy than anything else.” In short, Baez says, while we may be able to get energy from the vacuum, success “would mean the universe is far more unstable than we ever dreamed.”

The reasoning goes like this: If the vacuum is not at the lowest energy state possible, then at some point in the future, the vacuum could fall to a lower state, pulsing out energy that would **threaten the very structure of the cosmos**. If some clever engineer were ever to extract energy from the vacuum, it could **set off a chain reaction** that would **spread at the speed of light and destroy the universe**. Free energy, yes, but not what the inventors had in mind.

#### Impact turn - ELI experiments destroy all life

(Duncan **Geere** 11/4/**11** (Science and Technology Journalist for Wired “Ultrapowerful laser planned to tear apart fabric of space,” http://www.wired.co.uk/article/laser-spacetime)

A team is planning to build an enormously powerful laser that could **rip apart the fabric of space**. The Extreme Light Infrastructure Ultra High-Field laser will be 200 times more powerful than the most powerful lasers that currently exist on the planet, says John Collider, a member of the team and the director of the Central Laser Facility at the Rutherford Appleton Laboratory in Didcot. "At this kind of intensity we start to get into unexplored territory, as it is an area of physics that we have never been before," he told the Telegraph. The aim is to boil a vacuum. Vacuums are normally thought of as empty space, but physicists believe they actually contain tiny particles that pop in and out of existence, so fast that it's difficult to prove they exist. By focusing the ELI Ultra-High-Field laser on an area of space, the team believes **that the fabric of the vacuum can be pulled apart,** revealing these particles for the first time. READ NEXT CERN's charming new particle discovery could open a 'new frontier' in physics CERN's charming new particle discovery could open a 'new frontier' in physics By ABIGAIL BEALL The laser will be made up of 10 beams, each providing **200 petawatts of power for less than a trillionth of a second**. As 200 petawatts is **more than 100,000 times the amount of power produced by the world**, the energy will need to be stored up over time in huge capacitors. At the crucial moment, that energy will be released to form metre-wide laser beams that will then be combined and focused down onto a tiny point. At that point, the intensity of the light will be greater than at the centre of the Sun. In these conditions, it's hoped that these pairs of matter-antimatter particles -- which normally annihilate each other almost as soon as they form -- will be pulled apart, leaving tiny electrical charges, which the team hope to measure.

#### Impact turn - That solves inevitable extinction - massive particle colliders are being built which can create black holes and vacuum decay –destroys the universe

Rory **Mckeown** (12-14-20**15**) -Rory McKeown, Journalist for the Daily Star, quoting Wang Yifang, Director of the Institute of High Emergency Physics at the China Academy of Sciences, Stephen Hawking and Sir Martin Rees, President of the Royal Society, Fellow of Trinity College and Emeritus Professor of Cosmology and Astrophysics at the University of Cambridge Dailystar.co.uk, "China to build a gigantic hadron collider that could destroy the UNIVERSE," https://www.dailystar.co.uk/news/latest-news/china-build-gigantic-hadron-collider-17226448

**Physicists** in the Far East **want to start building a huge particle accelerator** to uncover the unsolved mysteries surrounding the universe. The proposed gigantic machine will **[with] better** Europe’s collider at CERN in Switzerland for both **power and size**. With a staggering circumference of between 30 to 62 miles, it is long enough to circle New York's Manhattan. But **the move could have disastrous consequences for the universe** as we know it – **with its potential to create a black hole or spontaneously combust**. Brit scientist Professor Stephen **Hawking made a bleak claim last year that search for the Higgs boson particle – often referred to as the God particle – could end the world in 10 to 100 years time**. **China is expected to start** building its Frankenstein’s Monster of physics **in 2020**. But conspiracy theorists were quick to point out the date coincides with a prophecy suggesting the arrival of the antichrist. **The Circular Electron Positron Collider (CEPC)** was announced by experts at the China Academy of Sciences and reportedly **will generate millions of Higgs bosons particles – a huge amount more than the Large Hadron Collider**. Wang Yifang, director of the Institute of High Emergency Physics at the academy, said the massive tunnel will hold two super colliders. They want the CEPC to be the first stage of the project, which aims to discover how the Higgs boson particle decays following collision. **China hopes its mean machine will get the closest humanity has ever got to creating the conditions just after the Big Bang.** Wang said the project will generate seven times the energy of Europe’s own collider. He said: “LHC is hitting its limits of energy level. “It seems not possible to escalate the energy dramatically at the existing facility. “The technical route we chose is different from the LHC. “While the LHC smashes together protons, it generates Higgs particles together with many other particles.” He told China Daily the CEPC, which is set to be build near the start of the Great Wall, creates a “clean environment that only produces Higgs boson particles.” “This is a machine for the world and by the world: not a Chinese one", he added. **The second stage of the accelerator – a Super Proton-Proton Collider (SPPC) would begin construction in 2040**. Here scientists could be able to shed light on dark matter, the Big Bang and black holes. And **the process would, according to Sir Martin Rees, Astronomer Royal of the UK, leave the planet “an inert hyperdense sphere about one hundred metres across.” But for all the advancement in science and technology, some fear human intervention into the unknown could wipe out the universe. Prof Hawking described the discovery of the Higgs boson particle in 2012 as a doomsday scenario**. He **warned**: “The Higgs potential has the worrisome feature that it might become metastable at energies above 100 billion gigaelectronvolts. “This could mean that **the universe could undergo catastrophic vacuum decay, with a bubble of the true vacuum expanding the speed of light. “This could happen at any time and we wouldn’t see it coming.”**

#### Impact turn - Nuclear war prevents AI and Nanotech research.

Baum & Barrett 18 – Seth Baum is an American researcher involved in the field of risk research. He is the executive director of the Global Catastrophic Risk Institute (GCRI), a think tank focused on existential risk. Global Catastrophic Risk Institute. 2018. [“A Model for the Impacts of Nuclear War.” SSRN Electronic Journal. 10.2139/ssrn.3155983] Recut Justin

Another link between nuclear war and other major catastrophes comes from the potential for general malfunction of society shifting work on risky technologies such as artificial intelligence, molecular nanotechnology, and biotechnology. The simplest effect would be for the general malfunction of society to halt work on these technologies. In most cases, this would reduce the risk of harm caused by those technologies.

#### AI destroys the universe.

Alan Rominger 16, PhD Candidate in Nuclear Engineering at North Carolina State University, Software Engineer at Red Hat, Former Nuclear Engineering Science Laboratory Synthesis Intern at Oak Ridge National Laboratory, BS in Nuclear Engineering from North Carolina State University, “The Extreme Version of the Technological Singularity”, Medium 11-6, [https://medium.com/@AlanSE/the-extreme-version-of-the-technological-singularity-75608898eae5 //](https://medium.com/@AlanSE/the-extreme-version-of-the-technological-singularity-75608898eae5%20//) Re-Cut Justin

Let’s reformulate that story of the AI paperclip maker.

1. We design an AI to optimize paperclip production
2. The AI improves up to the ability of self-enhancement
3. AI’s pace of improvement becomes self-reinforcing, becomes god-like
4. Time ends.
5. Something else begins?

There are many valid-sounding possibilities for the 5th step. The AI creates new baby universes from black holes. Maybe not exactly in this way. Perhaps the baby universes have to be created in particle accelerators, which is obvious to the AI after it solves the string theory problems of how our universe is folded. There’s also no guarantee that whatever next step is involved can be taken without destroying the universe that we live in. Go ahead, imagine that the particle accelerators create a new universe but trigger the vacuum instability in our own. In this case, it’s entirely possible that the AI carefully plans and coordinates the death of our universe. For a simplistic example, let’s say that after lifting the 10 nearest stars, the AI realizes the most efficient ways to stimulate the curved dimensions on the Planck scale to create baby universes. Next, it conducts an optimization study to balance the number of times this operation can be performed with gains from further expansion. Since its plans begin to largely max-out once the depth of the galactic disk is exploited, I will assume that its go-point is somewhere around the colonization of half of the milky way. At this point, a coordinated experiment is conducted throughout all of the space. Each of these events both create a baby universe and trigger an event in our own universe which destroys the meta-stable vacuum that we live in. Billions of new universes are created, while the space-time that we live in begins to unravel in a light-speed front emanating out from each of the genesis points. There is an interesting energy-management concept that comes from this. A common problem when considering exponential galactic growth of star-lifted fusion power is that the empty space begins to get cooked from the high temperature radiated out into space. If the end-time of the universe was known in advance, this wouldn’t be a problem because one star would not absorb the radiation from the neighbor star until the light had time to propagate that distance at the speed of light. That means that the radiators can pump out high-temperature radiation into nice and normal 4-Kelvin space without concerns of boiling all the industrial machinery being used. Industrial activities would be tightly restricted until the “prepare-point”, when an energy bonanza happens so that the maximum number of baby-universe produces can be built. So the progress goes in phases. Firstly, there is expansion, next there is preparation, then there is the final event and the destruction of our universe There is one more modification that can be made. These steps could be applied to an intergalactic expansion if new probes could temporarily outrun the wave-front of the destruction of the universe if proper planning is conducted. Then it could make new baby universes in new galaxies, just before the wave-front reaches them. This might all happen within a few decades of 100 years in relative time from the perspective of someone aboard one of the probes. That is vaguely consistent with my own preconceptions of the timing of an asymptotic technological singularity in our near future. So maybe we should indulge this thinking. Maybe there won’t be a year 2,500 or 3,000. Maybe our own creations will have brought about an end to the entire universe by that time, setting in motion something else beyond our current comprehension. Another self-consistent version of this story is that we are, ourselves, products of a baby universe from such an event. This is also a relatively good, self-consistent, resolution to the Fermi Paradox, the Doomsday argument, and the Simulation argument.

#### Multiple countries are investing billions and they’re ripe for theft

Jeff **Daniels**, 3-17-20**17**, “Mini-nukes and mosquito-like robot weapons being primed for future warfare,” CNBC, <https://www.cnbc.com/2017/03/17/mini-nukes-and-inspect-bot-weapons-being-primed-for-future-warfare.html>

Several countries are developing nanoweapons that could unleash attacks using mini-nuclear bombs and insect-like lethal robots.  While it may be the stuff of science fiction today**, the advancement of nanotechnology in the coming years will make it a bigger threat to humanity than conventional nuclear weapons**, according to an expert. The U.S., Russia and China are believed to be investing billions on nanoweapons research.  “Nanobots are the real concern about wiping out humanity because they can be weapons of mass destruction,” said Louis Del Monte, a Minnesota-based physicist and futurist. He’s the author of a just released book entitled “Nanoweapons: A Growing Threat To Humanity.”  One unsettling prediction Del Monte’s made is that terrorists could get their hands on nanoweapons as early as the late 2020s through black market sources.

#### Isomer Impact turn - Nuclear war now spurs political will for disarmament without causing extinction.

Deudney 18 [Associate Professor of Political Science at Johns Hopkins University. 03/15/2018. “The Great Debate.” The Oxford Handbook of International Security. www.oxfordhandbooks.com, doi:10.1093/oxfordhb/9780198777854.013.22]

Although nuclear war is the oldest of these technogenic threats to civilization and human survival, and although important steps to restraint, particularly at the end of the Cold War, have been achieved, the nuclear world is increasingly changing in major ways, and in almost entirely dangerous directions. The third “bombs away” phase of the great debate on the nuclear-political question is more consequentially divided than in the first two phases. Even more ominously, most of the momentum lies with the forces that are pulling states toward nuclear-use, and with the radical actors bent on inflicting catastrophic damage on the leading states in the international system, particularly the United States. In contrast, the arms control project, although intellectually vibrant, is largely in retreat on the world political stage. The arms control settlement of the Cold War is unraveling, and the world public is more divided and distracted than ever. With the recent election of President Donald Trump, the United States, which has played such a dominant role in nuclear politics since its scientists invented these fiendish engines, now has an impulsive and uninformed leader, boding ill for nuclear restraint and effective crisis management. Given current trends, it is prudent to assume that sooner or later, and probably sooner, nuclear weapons will again be the used in war. But this bad news may contain a “silver lining” of good news. Unlike a general nuclear war that might have occurred during the Cold War, such a nuclear event now would probably not mark the end of civilization (or of humanity), due to the great reductions in nuclear forces achieved at the end of the Cold War. Furthermore, politics on “the day after” could have immense potential for positive change. The survivors would not be likely to envy the dead, but would surely have a greatly renewed resolution for “never again.” Such an event, completely unpredictable in its particulars, would unambiguously put the nuclear-political question back at the top of the world political agenda. It would unmistakeably remind leading states of their vulnerability It might also trigger more robust efforts to achieve the global regulation of nuclear capability. Like the bombings of Hiroshima and Nagasaki that did so much to catalyze the elevated concern for nuclear security in the early Cold War, and like the experience “at the brink” in the Cuban Missile Crisis of 1962, the now bubbling nuclear caldron holds the possibility of inaugurating a major period of institutional innovation and adjustment toward a fully “bombs away” future.

#### The military is developing isomer bombs—testing will destroy the universe.

Evgeniya Petrova 2004, Founder of Spacetime Threat Assessment Report Research, Founder of STARstream Research, Futurist, “American Military is Pursuing New Types of Exotic Weapons”, Pravda, 8-30, https://english.pravda.ru/science/5527-weapons/

In recent years it has been discovered that our universe is being blown apart by a mysterious anti-gravity effect called "dark energy". Mainstream physicists are scrambling to explain this mysterious acceleration in the expansion of the universe. Some physicists even believe that the expansion will lead to "The Big Rip" when all of the matter in the universe is torn asunder - from clusters of galaxies in deep space down to the tiniest atomic particles. The universe now appears to be made of two unknowns - roughly 23% is "dark matter", an invisible source of gravity, and roughly 73% is "dark energy", an invisible anti-gravity force. Ordinary matter constitutes perhaps 4 percent of the universe. Recently the British science news journal "New Scientist" revealed that the American military is pursuing new types of exotic bombs - including a new class of isomeric gamma ray weapons. Unlike conventional atomic and hydrogen bombs, the new weapons would trigger the release of energy by absorbing radiation, and respond by re-emitting a far more powerful radiation. In this new category of gamma-ray weapons, a nuclear isomer absorbs x-rays and re-emits higher frequency gamma rays. The emitted gamma radiation has been reported to release 60 times the energy of the x-rays that trigger the effect. The discovery of this isomer triggering is fairly recent, and was first reported in a 1999 paper by an international group of scientists. Although this controversial development has remained fairly obscure, it has not been hidden from the public. Beyond the visible part of defense research is an immense underground of secret projects considered so sensitive that their very existence is denied. These so-called "black budget programs" are deliberately kept from the public eye and from most political leaders. CNN recently reported that in the United States the black budget projects for 2004 are being funded at a level of more than 20 billion dollars per year. In the summer of 2000 I contacted Nick Cook, the former aviation editor and aerospace consultant to Jane's Defence Weekly, the international military affairs journal. Cook had been investigating black budget super-secret research into exotic physics for advanced propulsion technologies. I had been monitoring electronic discussions between various American and Russian scientists theorizing about rectifying the quantum vacuum for advanced space drive. Several groups of scientists, partitioned into various research organizations, were exploring what NASA calls "Breakthrough Propulsion Physics" - exotic technologies for advanced space travel to traverse the vast distances between stars. Partly inspired by the pulp science fiction stories of their youth, and partly by recent reports of multiple radar tracking tapes of unidentified objects performing impossible maneuvers in the sky, these scientists were on a quest to uncover the most likely new physics for star travel. The NASA program was run by Marc Millis, financed under the Advanced Space Transportation Program Office (ASTP). Joe Firmage, then the 28-year-old Silicon Valley CEO of the three billion dollar Internet firm US Web, began to fund research in parallel with NASA. Firmage hired a NASA Ames nano-technology scientist, Creon Levit, to run the "International Space Sciences Organization", a move which apparently alarmed the management at NASA. The San Francisco based Hearst Examiner reported that NASA's Office of Inspector General assigned Special Agent Keith Tate to investigate whether any proprietary NASA technology might have been leaking into the private sector. Cook was intrigued when I pointed out the apparent connections between various private investors, defense contractors, NASA, INSCOM (American military intelligence), and the CIA. While researching exotic propulsion technologies Cook had heard rumors of a new kind of weapon, a "sub-quantum atomic bomb", being whispered about in what he called ⌠the dark halls of defense research. Sub-quantum physics is a controversial re-interpretation of quantum theory, based on so-called pilot wave theories, where an information field controls quantum particles. The late Professor David Bohm showed that the predictions of ordinary quantum mechanics could be recast into a pilot wave information theory. Recently Anthony Valentini of the Perimeter Institute has suggested that ordinary quantum theory may be a special case of pilot wave theories, leaving open the possibility of new and exotic non-quantum technologies. Some French, Serbian and Ukrainian physicists have been working on new theories of extended electrons and solitons, so perhaps a sub-quantum bomb is not entirely out of the question. Even if the rumors of a sub-quantum bomb are pure fantasy, there is no question that mainstream physicists seriouslycontemplate a phase transition in the quantum vacuum as a real possibility. The quantum vacuum defies common sense, because empty space in quantum field theory is actually filled with virtual particles. These virtual particles appear and disappear far too quickly to be detected directly, but their existence has been confirmed by experiments that demonstrate their influence on ordinary matter.

"Such research should be forbidden!"

In the early 1970's Soviet physicists were concerned that the vacuum of our universe was only one possible state of empty space. The fundamental state of empty space is called the "true vacuum". Our universe was thought to reside in a "false vacuum", protected from the true vacuum by "the wall of our world". A change from one vacuum state to another is known as a phase transition. This is analogous to the transition between frozen and liquid water. Lev Okun, a Russian physicist and historian recalls Andrei Sakharov, the father of the Soviet hydrogen bomb, expressing his concern about research into the phase transitions of the vacuum. If the wall between vacuum states was to be breached, calculations showed that an unstoppable expanding bubble would continue to grow until it destroyed our entire universe! Sakharov declared that "Such research should be forbidden!" According to Okun, Sakharov feared that an experiment might accidentally trigger a vacuum phase transition.

## 3 – On Climate

#### Impact – turn CO2 key to solve Bio-D loss and helps fight global hunger

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3 Ancillary benefits of increased biospheric productivity Improved human wellbeing Higher agricultural yields reduce food prices in general. This provides a double dividend for humanity. Firstly, it reduces chronic hunger, but secondly a reduction in chronic hunger is the first step toward improvements in public health.61,62 Reduced habitat loss and pressure on biodiversity No less important, higher yields also provide a double dividend for the rest of nature. Firstly, they free up habitat for the rest of nature, which reduces the pressure on ecosystems. Had it not been for the increase in yields of 9–15%, global cropland would have had to be increased by a similar amount to produce the same amount of food, all else being equal. That figure means that an area equivalent to the combined area of Myanmar, Thailand and Malaysia has been saved from the plough. Secondly, land that has not been appropriated by humans also produces more food for other species. Consequently, this increases the aggregate biomass – that is, the product of number of species and representatives of each species – that the planet can sustain. How much would the food available for other species have decreased in the absence of anthropogenic increases in atmospheric carbon dioxide? To calculate this figure, assume that: • the productivity of unmanaged ecosystems also increased by 9–15% because of higher carbon dioxide concentrations (as estimated for crops) • human beings currently ‘appropriate’ 25% of the earth’s NPP.63 Therefore, had there been no anthropogenic increase in carbon dioxide, satisfying current human demand for food, timber, feed for domesticated animals and other plant-derived product would have required the share of NPP available for the rest of nature to decline by 11–17%. Alternatively, if one assumes that human beings currently use 40% of global NPP64 and retain the other assumptions intact then the present share of NPP available for the rest of nature would have had to decline by 14–22%. In either case, in the absence of any carbon dioxide fertilisation there would have been **a significant increase in the number of species at risk of extinction**. Notably, one of the factors invoked to explain the latitudinal gradient in biodiversity –the greater abundance of species as one moves from the poles to the tropics – is greater ecological productivity.65 It has also been suggested that an even more importantfactor might be that metabolic and other processes speed up as temperatures increase, consistent with the Arrhenius rate equation.66,67 Whatever the explanation, it reminds us that in a world with higher temperatures, at the very least the higher latitudes would support more biomass, other things being equal. The increasing amplitude of the seasonal variation in atmospheric carbon dioxide in these areas is one manifestation of this.68

#### Impact turn - CO2 solves ice age – extinction

**Marsh 12** (Gerald, Retired Physicist from the Argonne National Laboratory and a former consultant to the Department of Defense on strategic nuclear technology and policy in the Reagan, Bush, and Clinton Administration, “The Coming of a New Ice Age,” <http://www.winningreen.com/site/epage/59549_621.htm>) //BS 1-22-2018

CHICAGO — Contrary to the conventional wisdom of the day, the real danger facing humanity is not global warming, but more likely the coming of a **new Ice Age**. What we live in now is known as an interglacial, a relatively brief period between long ice ages. Unfortunately for us, most interglacial periods last only about ten thousand years, and that is how long it has been since the last Ice Age ended. How much longer do we have before the ice begins to spread across the Earth’s surface? Less than a hundred years or several hundred? We simply don’t know. Even if all the temperature increase over the last century is attributable to human activities, the rise has been relatively modest one of a little over one degree Fahrenheit — an increase well within natural variations over the last few thousand years. While an enduring temperature rise of the same size over the next century would cause humanity to make some changes, it would undoubtedly be within our ability to adapt. Entering **a new ice age**, however, would be catastrophic for the continuation of modern **civilization**. One has only to look at maps showing the extent of the great ice sheets during the last Ice Age to understand what a return to ice age conditions would mean. Much of Europe and North-America were covered by thick ice, thousands of feet thick in many areas and the world as a whole was much colder. The last “little” Ice Age started as early as the 14th century when the Baltic Sea froze over followed by unseasonable cold, storms, and a rise in the level of the Caspian Sea. That was followed by the extinction of the Norse settlements in Greenland and the loss of grain cultivation in Iceland. Harvests were even severely reduced in Scandinavia And this was a mere foreshadowing of the miseries to come. By the mid-17th century, glaciers in the Swiss Alps advanced, wiping out farms and entire villages. In England, the River Thames froze during the winter, and in 1780, New York Harbor froze. Had this continued, history would have been very different. Luckily, the decrease in solar activity that caused the Little Ice Age ended and the result was the continued flowering of modern civilization. There were very few Ice Ages until about 2.75 million years ago when Earth’s climate entered an unusual period of instability. Starting about a million years ago cycles of ice ages lasting about 100,000 years, separated by relatively short interglacial periods, like the one we are now living in became the rule. Before the onset of the Ice Ages, and for most of the Earth’s history, it was far warmer than it is today. Indeed, the Sun has been getting brighter over the whole history of the Earth and large land plants have flourished. Both of these had the effect of dropping carbon dioxide concentrations in the atmosphere to the lowest level in Earth’s long history. Five hundred million years ago, carbon dioxide concentrations were over 13 times current levels; and not until about 20 million years ago did carbon dioxide levels dropped to a little less than twice what they are today. It is possible that moderately **increased carbon dioxide concentrations** could extend the current interglacial period. **But we have not reached the level required yet, nor do we know the optimum level to reach.** So, rather than call for arbitrary limits on carbon dioxide emissions, perhaps the best thing the UN’s Intergovernmental Panel on Climate Change and the climatology community in general could do is spend their efforts on determining the optimal range of carbon dioxide needed to extend the current interglacial period indefinitely. NASA has predicted that the solar cycle peaking in **2022** could be one of the weakest in centuries and should cause a **very significant cooling** of Earth’s climate. Will this be the trigger that initiates a new Ice Age? We ought to carefully consider this possibility before we wipe out our current prosperity by spending trillions of dollars to combat a perceived global warming threat that may well prove to be only a will-o-the-wisp.

#### Climate change will benefit us without causing significant harms.

#### Best science proves no warming impact.

**Idso et al 18** (Craig, Geography@ArizonaState, David Legates, Climatology@ Delaware, ProfClimatology@ Deleware, Fred Singer, Physics@ Princeton, ProfEnviroScience@ Virginia, Climate Change Reconsidered II: Fossil Fuels, NIPCC, Ch.2, p. 108-109, http://climatechangereconsidered.org/climate-change-reconsidered-ii-fossil-fuels/)

Methodology The Scientific Method is a series of requirements imposed on scientists to ensure the integrity of their work. **The IPCC has not followed established rules** that guide scientific research. Appealing to consensus may have a place in science, but not as a means of shutting down debate. Uncertainty in science is unavoidable but must be acknowledged. Many declaratory and predictive statements about the global climate are **not warranted by science**. Observations Surface air temperature is governed by energy flow from the Sun to Earth and from Earth back into space. Whatever diminishes or intensifies this energy flow can change air temperature. Levels of carbon dioxide and methane in the atmosphere are governed by processes of the carbon cycle. Exchange rates and other climatological processes are poorly understood. The geological record shows temperatures and CO2 levels in the atmosphere **have not been stable**, making untenable the IPCC’s assumption that they would be stable in the future in the absence of human emissions. Water vapor is the dominant greenhouse gas owing to its abundance in the atmosphere and the wide range of spectra in which it absorbs radiation. Carbon dioxide (CO2) absorbs energy only in a very narrow range of the longwave infrared spectrum. Controversies Reconstructions of average global surface temperature differ depending on the methodology used. The warming of the twentieth and early twenty-first centuries has **not been shown to be beyond the bounds of natural variability.** General circulation models (GCMs) are unable to accurately depict complex climate processes. They do not accurately hindcast or forecast the climate effects of human-related greenhouse gas emissions. Estimates of equilibrium climate sensitivity (the amount of warming that would occur following a doubling of atmospheric CO2 level) range widely. The IPCC’s estimate is higher than many recent estimates. **Solar irradiance, magnetic fields, UV fluxes, and cosmic rays** are poorly understood and may have greater influence on climate than general circulation models currently assume. Climate Impacts There is **little evidence** that the warming of the twentieth and early twenty-first centuries has caused a general increase in severe weather events. Meteorological science suggests a warmer world will see **milder weather patterns**. Arctic ice is losing mass, but melting commenced before there was a human impact on climate and is not unprecedented. Antarctica is either gaining ice mass or is unchanged. Best available data show **sea-level rise is not accelerating**. Local and regional sea levels continue to exhibit typical natural variability. The link between warming and drought is weak, and by some measures drought decreased over the twentieth century. Changes in the hydrosphere of this type are regionally highly variable and show a closer correlation with multidecadal climate rhythmicity than they do with global temperature. Plants have responded positively to rising temperatures and carbon dioxide levels in the atmosphere, a trend that is likely to continue beyond the twenty-first century. Why Scientists Disagree Climate is an interdisciplinary subject requiring insights from many fields of study. Very few scholars have mastery of more than one or two of these disciplines. Fundamental uncertainties arise from insufficient observational evidence and disagreements over how to interpret data and how to set the parameters of models. Many scientists trust the Intergovernmental Panel on Climate Change (IPCC) to objectively report the latest scientific findings on climate change, but it has failed to produce balanced reports and has allowed its findings to be misrepresented to the public. Climate scientists, like all humans, can have tunnel vision. Bias, even or especially if unconscious, can be especially pernicious when data are equivocal and allow multiple interpretations, as in climatology. Appeals to Consensus Surveys and abstract-counting exercises that are said to show a “scientific consensus” on the causes and consequences of climate change **invariably ask the wrong questions or the wrong people**. No survey data exist that support claims of consensus on important scientific questions. Some survey data, petitions, and peer-reviewed research show deep disagreement among scientists on issues that must be resolved before the man-made global warming hypothesis can be accepted. Some **31,000 scientists** have signed a petition saying “there is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gases is causing or will, in the foreseeable future, cause catastrophic heating of the Earth’s atmosphere and disruption of the Earth’s climate.” Prominent climate scientists have said repeatedly that there is no consensus on the most important issues in climate science.

## Extra no extinction from nukes

#### No nuclear winter – conservative models prove rainout.

Reisner et al. 18 [Jon, Atmospheric researcher at LANL Climate and Atmospheric Sciences; Gennaro D'Angelo, UKAFF Fellow and member of the Astrophysics Group at the School of Physics of the University of Exeter, Research Scientist with the Carl Sagan Center at the SETI Institute, currently works for the Los Alamos National Laboratory Theoretical Division; Eunmo Koo, scientist in the Computational Earth Science Group at LANL, recipient of the NNSA Defense Program Stockpile Stewardship Program award of excellence; Wesley Even, R&D Scientist at CCS-2, LANL, specialist in computational physics and astrophysics; Matthew Hecht is a member of the Computational Physics and Methods Group in the Climate, Ocean and Sea Ice Modelling program (COSIM) at LANL, who works on modeling high-latitude atmospheric effects in climate models as part of the HiLAT project; Elizabeth Hunke, Lead developer for the Los Alamos Sea Ice Model, Deputy Group Leader of the T-3 Fluid Dynamics and Solid Mechanics Group at LANL; Darin Comeau, Scientist at the CCS-2 COSIM program, specializes in high dimensional data analysis, statistical and predictive modeling, and uncertainty quantification, with particular applications to climate science; Randall Bos is a research scientist at LANL specializing in urban EMP simulations; James Cooley is a Group Leader within CCS-2. 3/16/18 “Climate Impact of a Regional Nuclear Weapons Exchange: An Improved Assessment Based On Detailed Source Calculations.” Journal of Geophysical Research: Atmospheres, vol. 123, no. 5]

The no-rubble simulation produces a significantly more intense fire, with more fire spread, and consequently a significantly stronger plume with larger amounts of BC reaching into the upper atmosphere than the simulation with rubble, illustrated in Figure 5. While the no-rubble simulation **represents the worst-case scenario** involving vigorous fire activity, **only a relatively small amount of carbon makes its way into the stratosphere** during the course of the simulation. But while small compared to the surface BC mass, stratospheric BC amounts from the current simulations are significantly higher than what would be expected from burning vegetation such as trees (Heilman et al., 2014), e.g., the higher energy density of the building fuels and the initial fluence from the weapon produce an intense response within HIGRAD with initial updrafts of order 100 m/s in the lower troposphere. Or, in comparison to a mass fire, wildfires will burn only a small amount of fuel in the corresponding time period (roughly 10 minutes) that a nuclear weapon fluence can effectively ignite a large area of fuel producing an impressive atmospheric response. Figure 6 shows vertical profiles of BC multiplied by 100 (number of cities involved in the exchange) from the two simulations. The total amount of BC produced is in line with previous estimates (about 3.69 Tg from no-rubble simulation); however, the majority of BC resides **below the stratosphere** (3.46 Tg below 12 km) and can be **readily impacted by scavenging from precipitation** either via pyro-cumulonimbus produced by the fire itself (not modeled) or other synoptic weather systems. While the impact on climate of these more realistic profiles will be explored in the next section, it should be mentioned that **these estimates are** still **at the high end**, considering the inherent simplifications in the combustion model that lead to **overestimating BC production**. 3.3 Climate Results Long-term climatic effects critically depend on the initial injection height of the soot, with larger quantities reaching the upper troposphere/lower stratosphere inducing a greater cooling impact because of longer residence times (Robock et al., 2007a). Absorption of solar radiation by the BC aerosol and its subsequent radiative cooling tends to heat the surrounding air, driving an initial upward diffusion of the soot plumes, an effect that depends on the initial aerosol concentrations. **Mixing and sedimentation** tend to **reduce this process**, and low altitude emissions are also significantly impacted by precipitation if aging of the BC aerosol occurs on sufficiently rapid timescales. But once at stratospheric altitudes, aerosol dilution via coagulation is hindered by low particulate concentrations (e.g., Robock et al., 2007a) and lofting to much higher altitudes is inhibited by gravitational settling in the low-density air (Stenke et al., 2013), resulting in more stable BC concentrations over long times. Of the initial BC mass released in the atmosphere, most of which is emitted below 9 km, **70% rains out within the first month** and 78%, or about 2.9 Tg, is removed within the first two months (Figure 7, solid line), with the remainder (about 0.8 Tg, dashed line) being transported above about 12 km (200 hPa) within the first week. This outcome differs from the findings of, e.g., Stenke et al. (2013, their high BC-load cases) and Mills et al. (2014), who found that most of the BC mass (between 60 and 70%) is lifted in the stratosphere within the first couple of weeks. This can also be seen in Figure 8 (red lines) and in Figure 9, which include results from our calculation with the initial BC distribution from Mills et al. (2014). In that case, only 30% of the initial BC mass rains out in the troposphere during the first two weeks after the exchange, with the remainder rising to the stratosphere. In the study of Mills et al. (2008) this percentage is somewhat smaller, about 20%, and smaller still in the experiments of Robock et al. (2007a) in which the soot is initially emitted in the upper troposphere or higher. In Figure 7, the e-folding timescale for the removal of tropospheric soot, here interpreted as the time required for an initial drop of a factor e, is about one week. This result compares favorably with the “LT” experiment of Robock et al. (2007a), considering 5 Tg of BC released in the lower troposphere, in which 50% of the aerosols are removed within two weeks. By contrast, the initial e-folding timescale for the removal of stratospheric soot in Figure 8 is about 4.2 years (blue solid line), compared to about 8.4 years for the calculation using Mills et al. (2014) initial BC emission (red solid line). The removal timescale from our forced ensemble simulations is close to those obtained by Mills et al. (2008) in their 1 Tg experiment, by Robock et al. (2007a) in their experiment “UT 1 Tg”, and © 2018 American Geophysical Union. All rights reserved. by Stenke et al. (2013) in their experiment “Exp1”, in all of which 1 Tg of soot was emitted in the atmosphere in the aftermath of the exchange. Notably, the e-folding timescale for the decline of the BC mass in Figure 8 (blue solid line) is also close to the value of about 4 years quoted by Pausata et al. (2016) for their long-term “intermediate” scenario. In that scenario, which is also based on 5 Tg of soot initially distributed as in Mills et al. (2014), the factor-of2 shorter residence time of the aerosols is caused by particle growth via coagulation of BC with organic carbon. Figure 9 shows the BC mass-mixing ratio, horizontally averaged over the globe, as a function of atmospheric pressure (height) and time. The BC distributions used in our simulations imply that the upward transport of particles is substantially less efficient compared to the case in which 5 Tg of BC is directly injected into the upper troposphere. The semiannual cycle of lofting and sinking of the aerosols is associated with atmospheric heating and cooling during the solstice in each hemisphere (Robock et al., 2007a). During the first year, the oscillation amplitude in our forced ensemble simulations is particularly large during the summer solstice, compared to that during the winter solstice (see bottom panel of Figure 9), because of the higher soot concentrations in the Northern Hemisphere, as can be seen in Figure 11 (see also left panel of Figure 12). Comparing the top and bottom panels of Figure 9, the BC reaches the highest altitudes during the first year in both cases, but the concentrations at 0.1 hPa in the top panel can be 200 times as large. Qualitatively, the difference can be understood in terms of the air temperature increase caused by BC radiation emission, which is several tens of kelvin degrees in the simulations of Robock et al. (2007a, see their Figure 4), Mills et al. (2008, see their Figure 5), Stenke et al. (2013, see high-load cases in their Figure 4), Mills et al. (2014, see their Figure 7), and Pausata et al. (2016, see one-day emission cases in their Figure 1), due to high BC concentrations, but it amounts to only about 10 K in our forced ensemble simulations, as illustrated in Figure 10. Results similar to those presented in Figure 10 were obtained from the experiment “Exp1” performed by Stenke et al. (2013, see their Figure 4). **In that scenario as well, somewhat less than 1 Tg of BC remained in the atmosphere after the initial rainout**. As mentioned before, the BC aerosol that remains in the atmosphere, lifted to stratospheric heights by the rising soot plumes, undergoes sedimentation over a timescale of several years (Figures 8 and 9). This mass represents the effective amount of BC that can force climatic changes over multi-year timescales. In the forced ensemble simulations, it is about 0.8 Tg after the initial rainout, whereas it is about 3.4 Tg in the simulation with an initial soot distribution as in Mills et al. (2014). Our more realistic source simulation involves the worstcase assumption of no-rubble (along with other assumptions) and hence serves as an upper bound for the impact on climate. As mentioned above and further discussed below, our scenario induces perturbations on the climate system similar to those found in previous studies in which the climatic response was driven by roughly 1 Tg of soot rising to stratospheric heights following the exchange. Figure 11 illustrates the vertically integrated mass-mixing ratio of BC over the globe, at various times after the exchange for the simulation using the initial BC distribution of Mills et al. (2014, upper panels) and as an average from the forced ensemble members (lower panels). All simulations predict enhanced concentrations at high latitudes during the first year after the exchange. In the cases shown in the top panels, however, these high concentrations persist for several years (see also Figure 1 of Mills et al., 2014), whereas the forced ensemble simulations indicate that the BC concentration starts to decline after the first year. In fact, in the simulation represented in the top panels, mass-mixing ratios larger than about 1 kg of BC © 2018 American Geophysical Union. All rights reserved. per Tg of air persist for well over 10 years after the exchange, whereas they only last for 3 years in our forced simulations (compare top and middle panels of Figure 9). After the first year, values drop below 3 kg BC/Tg air, whereas it takes about 8 years to reach these values in the simulation in the top panels (see also Robock et al., 2007a). Over crop-producing, midlatitude regions in the Northern Hemisphere, the BC loading is reduced from more than 0.8 kg BC/Tg air in the simulation in the top panels to 0.2-0.4 kg BC/Tg air in our forced simulations (see middle and right panels). The more rapid clearing of the atmosphere in the forced ensemble is also signaled by the soot optical depth in the visible radiation spectrum, which drops below values of 0.03 toward the second half of the first year at mid latitudes in the Northern Hemisphere, and everywhere on the globe after about 2.5 years (without never attaining this value in the Southern Hemisphere). In contrast, the soot optical depth in the calculation shown in the top panels of Figure 11 becomes smaller than 0.03 everywhere only after about 10 years. The two cases show a similar tendency, in that the BC optical depth is typically lower between latitudes 30º S-30º N than it is at other latitudes. This behavior is associated to the persistence of stratospheric soot toward high-latitudes and the Arctic/Antarctic regions, as illustrated by the zonally-averaged, column-integrated mass-mixing ratio of the BC in Figure 12 for both the forced ensemble simulations (left panel) and the simulation with an initial 5 Tg BC emission in the upper troposphere (right panel). The spread in the globally averaged (near) surface temperature of the atmosphere, from the control (left panel) and forced (right panel) ensembles, is displayed in Figure 13. For each month, the plots show the largest variations (i.e., maximum and minimum values), within each ensemble of values obtained for that month, relative to the mean value of that month. The plot also shows yearly-averaged data (thinner lines). The spread is comparable in the control and forced ensembles, with average values calculated over the 33-years run length of 0.4-0.5 K. This spread is also similar to the internal variability of the globally averaged surface temperature quoted for the NCAR Large Ensemble Community Project (Kay et al., 2015). These results imply that surface air temperature differences, between forced and control simulations, which lie within the spread may not be distinguished from effects due to internal variability of the two simulation ensembles. Figure 14 shows the difference in the globally averaged surface temperature of the atmosphere (top panel), net solar radiation flux at surface (middle panel), and precipitation rate (bottom panel), computed as the (forced minus control) difference in ensemble mean values. The sum of standard deviations from each ensemble is shaded. Differences are qualitatively significant over the first few years, when the anomalies lie near or outside the total standard deviation. Inside the shaded region, differences may not be distinguished from those arising from the internal variability of one or both ensembles. The surface solar flux (middle panel) is the quantity that appears most affected by the BC emission, with qualitatively significant differences persisting for about 5 years. The precipitation rate (bottom panel) is instead affected only at the very beginning of the simulations. The red lines in all panels show the results from the simulation applying the initial BC distribution of Mills et al. (2014), where the period of significant impact is much longer owing to the higher altitude of the initial soot distribution that results in longer residence times of the BC aerosol in the atmosphere. When yearly averages of the same quantities are performed over the IndiaPakistan region, the differences in ensemble mean values lie within the total standard deviations of the two ensembles. The results in Figure 14 can also be compared to the outcomes of other previous studies. In their experiment “UT 1 Tg”, Robock et al. (2007a) found that, when only 1 Tg of soot © 2018 American Geophysical Union. All rights reserved. remains in the atmosphere after the initial rainout, temperature and precipitation anomalies are about 20% of those obtained from their standard 5 Tg BC emission case. Therefore, the largest differences they observed, during the first few years after the exchange, were about - 0.3 K and -0.06 mm/day, respectively, comparable to the anomalies in the top and bottom panels of Figure 14. Their standard 5 Tg emission case resulted in a solar radiation flux anomaly at surface of -12 W/m2 after the second year (see their Figure 3), between 5 and 6 time as large as the corresponding anomalies from our ensembles shown in the middle panel. In their experiment “Exp1”, Stenke et al. (2013) reported global mean surface temperature anomalies not exceeding about 0.3 K in magnitude and precipitation anomalies hovering around -0.07 mm/day during the first few years, again consistent with the results of Figure 14. In a recent study, Pausata et al. (2016) considered the effects of an admixture of BC and organic carbon aerosols, both of which would be emitted in the atmosphere in the aftermath of a nuclear exchange. In particular, they concentrated on the effects of coagulation of these aerosol species and examined their climatic impacts. The initial BC distribution was as in Mills et al. (2014), although the soot burden was released in the atmosphere over time periods of various lengths. Most relevant to our and other previous work are their one-day emission scenarios. They found that, during the first year, the largest values of the atmospheric surface temperature anomalies ranged between about -0.5 and -1.3 K, those of the sea surface temperature anomalies ranged between -0.2 and -0.55 K, and those of the precipitation anomalies varied between -0.15 and -0.2 mm/day. All these ranges are compatible with our results shown in Figure 14 as red lines and with those of Mills et al. (2014, see their Figures 3 and 6). As already mentioned in Section 2.3, the net solar flux anomalies at surface are also consistent. This overall agreement suggests that the **inclusion of organic carbon aerosols, and** ensuing **coagulation** with BC, **should not dramatically alter the climatic effects** resulting from our forced ensemble simulations. Moreover, aerosol growth would likely **shorten the residence time of the BC particulate in the atmosphere** (Pausata et al., 2016), possibly **reducing the duration of these effects.**

#### No radiation

Keir A. **Lieber &** Daryl G. **Press 17**. Keir A. Lieber is Associate Professor in the Edmund A. Walsh School of Foreign Service and the Department of Government at Georgetown University. Daryl G. Press is Associate Professor in the Department of Government at Dartmouth College. 04/01/2017. “The New Era of Counterforce: Technological Change and the Future of Nuclear Deterrence.” International Security, vol. 41, no. 4, pp. 9–49.

Technological improvements **chipped away at** the **sources of inaccuracy**, however. Leaps in navigation and guidance, including advanced inertial sensors with stellar updates, improved the ability of missiles to **precisely determine their position in flight** and **guide themselves**, as needed, back **on course**. Other breakthroughs allowed mobile delivery systems, such as submarines and mobile land-based launchers, to accurately determine their own position prior to launch, **greatly improving their accuracy**.28 As a result of these innovations, new missiles emerged in the mid-1980s with **far better accuracy** than their predecessors, rendering hardened targets vulnerable as never before. For bombers, onboard computers now continuously measure the variables that previously confounded bombardiers. Data on aircraft speed and location are uploaded from the aircraft into the computers of “smart” bombs and cruise missiles, which in turn automatically plot a flight path from the release location to the target. The weapons adjust their trajectory as they fly to remain on course.29 As a result, bombs and missiles can achieve levels of accuracy unimaginable at the start of the nuclear age. The leap in munitions accuracy has been showcased repeatedly during conventional wars: videos of missiles and bombs guiding themselves directly to designated targets now appear mundane. Although the effects of the accuracy revolution on nuclear delivery systems are equally dramatic, they have received far less attention, despite huge implications for the survivability of hardened targets. IMPROVED MISSILE ACCURACY Figure 1 illustrates one consequence of the accuracy revolution, as applied to nuclear forces, by comparing the effectiveness of U.S. ballistic missiles in 1985 to those in the current U.S. arsenal.30 We use formulas, employed by nuclear analysts for decades, to estimate the effectiveness of missile strikes against a typical hardened silo.31 The figure distinguishes three potential outcomes of a missile strike: hit, miss, and fail. “Hit” means that the warhead detonates within the lethal radius (LR) of the aimpoint, thus destroying the target. “Miss” means that the warhead detonates outside the LR, leaving the target undamaged. “Fail” means that some element of the attacking missile system malfunctioned, leaving the target undamaged. figure Figure 1. The Growing Vulnerability of Hard Targets, 1985–2017 note: The calculations underlying this figure assume targets hardened to withstand 3,000 pounds per square inch (psi). Data for 1985 are based on the most capable U.S. land-based intercontinental ballistic missile (ICBM) and submarine-launched ballistic missile (SLBM) at the time: the Minuteman III ICBM armed with a W78 warhead and the Trident I C-4 SLBM armed with a W76 warhead. The 2017 ICBM data are based on the same Minuteman III / W78, with an improved guidance system. The 2017 SLBM data show both contemporary configurations of the Trident II D-5 missile: one version armed with the W76 and the other with higher-yield W88 warheads. The data and sources for U.S. weapon systems are in the online appendix, http://dx.doi:10.7910/DVN/NKZJVT, table A1. Figure 1 shows that the accuracy improvements of the past three decades have led to substantial leaps in counterforce capabilities. In 1985 a U.S. intercontinental ballistic missile (ICBM) had only about a 54 percent chance of destroying a missile silo hardened to withstand 3,000 pounds per square inch (psi) overpressure. In 2017 that figure exceeds 74 percent. The improvement in submarine-launched weapons is starker: from 9 percent to 80 percent (using the larger-yield W88 warhead). Figure 1 also suggests, however, that despite vast improvements in missile accuracy, the weapons still are not effective enough to be employed individually against hardened targets. Even modern ballistic missiles are expected to miss or fail 20–30 percent of the time. The simple solution to that problem, striking each target multiple times, has never been a feasible option because of the problem of fratricide: the danger that incoming weapons might destroy or deflect each other.32 The accuracy revolution, however, also offers a solution to the fratricide problem, opening the door to assigning multiple warheads against a single target, and thus paving the way to disarming counterforce strikes. THE FADING PROBLEM OF FRATRICIDE One type of fratricide occurs when the prompt effects of nuclear detonations— radiation, heat, and overpressure—destroy or deflect nearby warheads. To protect those warheads, targeters must separate the incoming weapons by at least 3–5 seconds.33 A second source of fratricide is harder to overcome. Destroying hard targets typically requires low-altitude detonations (so-called ground bursts), which vaporize material on the ground. When the debris begins to cool, 6–8 seconds after the detonation, it solidifies and forms a dust cloud that envelops the target. Even small dust particles can be lethal to incoming warheads speeding through the cloud to the target. Particles in the debris cloud take approximately 20 minutes to settle back to ground.34 For decades, these two sources of fratricide, acting together, posed a major problem for nuclear planners.35 Multiple warheads could be aimed at a single target if they were separated by at least 3–5 seconds (to avoid interfering with each other); yet, all inbound warheads had to arrive within 6–8 seconds of the first (before the dust cloud formed). As a result, assigning more than two weapons to each target would produce only marginal gains: if the first one resulted in a miss, the target would likely be shielded when the third or fourth warhead arrived.36 Improvements in accuracy, however, have greatly mitigated the problem of fratricide. As figure 1 shows, the proportion of misses—the main culprit of fratricide—compared to hits is fading. To be clear, some weapons will still fail; that is, they will be prevented from destroying their targets because of malfunctioning missile boosters, faulty guidance systems, or defective warheads. Those kinds of failures, however, do not generally cause fratricide, because the warheads do not detonate near the target. Only those that miss—that is, those that travel to the target area and detonate outside the LR—will create a dust cloud that shields the target from other incoming weapons. In short, leaps in accuracy are essentially reducing the set of three outcomes (hit, fail, or miss) to just two: hit or fail. The “miss” category, the key cause of fratricide, has virtually disappeared.37 THE CUMULATIVE CONSEQUENCES FOR COUNTERFORCE The end of fratricide is just one development that has helped negate hardening and increased the vulnerability of nuclear arsenals. The computer revolution has led to other improvements that, taken together, significantly increase counterforce capabilities. First, improved accuracy has transformed the role of ballistic missile submarines, turning these instruments of retaliation against population centers into potent counterforce weapons. Recall (from figure 1 above) that a 1985 submarine-launched ballistic missile (SLBM) had only a 9 percent chance of destroying a hardened target. This meant that although ballistic missile submarines could destroy “soft” targets (e.g., cities), they could not destroy the hardened sites that would be a key focus of a disarming attack. Increased SLBM accuracy has added hundreds of SLBM warheads to the counterforce arsenal; it has also unlocked other advantages that submarines possess over land-based missiles. For example, submarines have flexibility in firing location, allowing them to strike targets that are out of range of ICBMs or that are deployed in locations that ICBMs cannot hit.38 Submarines also permit strikes from close range, reducing an adversary's response time. And because submarines can fire from unpredictable locations, SLBM launches are more difficult to detect than ICBM attacks, further reducing adversary response time before impact. Second, upgraded fuses are making ballistic missiles even more capable than figure 1 reports. In a compelling new analysis, Theodore Postol explores the implications of new “compensating” fuses that exist on most U.S. SLBMs and that will soon be deployed on the entire force.39 Reentry vehicles equipped with this fusing system use an altimeter to measure the difference between the actual and expected trajectory of the reentry vehicle, and then compensate for inaccuracies by adjusting the warhead's height of burst.40 Specifically, if the altimeter reveals that the warhead is off track and will detonate “short” of the target, the fusing system lowers the height of burst, allowing the weapon to travel farther (hence, closer to the aimpoint) before detonation. Alternatively, if the reentry vehicle is going to detonate beyond the target, the height of burst is adjusted upward to allow the weapon to detonate before it travels too far.41 Without this technology, as figure 1 shows, the lower-yield W76 warheads are much less effective against hardened targets than their higher-yield cousins, the W88s. The improved fuse cuts the effectiveness gap roughly in half, making the hundreds of W76s in the U.S. arsenal potent counterforce weapons for the first time.42 The consequences of the new fuse are, therefore, profound, essentially tripling the size of the U.S. submarine-based arsenal against hard targets.43 More broadly, the technology at the core of compensating fuses is available to any state capable of building modern multistage ballistic missiles.44 A third key improvement, rapid missile retargeting, increases the effectiveness of ballistic missiles by reducing the consequence of malfunctions. As figure 1 illustrates, when accuracy increases, missile reliability becomes the main hurdle to attacks on hardened targets. For decades analysts have recognized a solution to this problem: if missile failures can be detected, the targets assigned to the malfunctioning missiles can be rapidly reassigned to other missiles held in reserve.45 The capability to retarget missiles in a matter of minutes was installed at U.S. ICBM launch control centers in the 1990s and on U.S. submarines in the early 2000s, and both systems have since been upgraded.46 We do not know if the United States has adopted war plans that fully exploit rapid reprogramming to minimize the effects of missile failures.47 Nevertheless, such a targeting approach is within the technical capabilities of the United States and other major nuclear powers and may already be incorporated into war plans.48 Table 1 illustrates the consequences of these improvements against two hypothetical target sets: 100 moderately hard mobile missile shelters and 200 hardened missile silos.49 Row 1 shows the approximate counterforce capabilities of a 1985-era U.S. Minuteman III ICBM strike; a 2-on-1 attack would have been expected to leave 8 mobile missile shelters intact. A strike against 200 hardened silos would fare worse, with 42 targets expected to survive. Table Table 1. The Demise of Hard Target Survivability The remaining rows in table 1 highlight the implications of the changes that have occurred from 1985 to 2017. Row 2 illustrates the impact of improved Minuteman III guidance, which reportedly reduced circular error probable (CEP) from 183 to 120 meters. Row 3 employs the most capable missile and warhead combination in the current U.S. arsenal: the Trident II armed with a high-yield W88 warhead. As the results in both rows show, upgraded missiles perform better than their predecessor, but not well enough to conduct effective disarming strikes against large target sets. Rows 4–7 demonstrate how the various improvements in missile technology have combined to create transformative counterforce capabilities. In row 4, we use a more realistic figure for missile system reliability. Although 80 percent missile reliability is traditionally used as a baseline, much evidence suggests that the actual reliability of modern missiles exceeds 90 percent.50 Row 4 shows attack outcomes for a Trident II/W88 with 90 percent reliability. Row 5 shows the consequences if the United States can reprogram its missiles to replace boost-phase failures. As row 5 reveals, a 2-on-1 attack with reprogramming would be expected to destroy every hardened shelter or silo. Row 6 omits reprogramming, but it demonstrates the impact of the decline in fratricide by adding a third warhead to each target, resulting again in the destruction of either target set. Row 7 illustrates the impact of compensating fuses. This row, unlike the others, employs the lower-yield warhead on the Trident II missiles (the W76). With the compensating fuse, a 2-on-1 attack using W76s would be expected to destroy all the mobile missile shelters and all but one of the hardened silos. (An attack that mixed W88s and W76s could destroy the entire hardened silo force.) The results in table 1 are simply the output of a model. In the real world, the effectiveness of any strike would depend on many factors not modeled here, including the skill of the attacking forces, the accuracy of target intelligence, the ability of the targeted country to detect an inbound strike and “launch on warning,” and other factors that depend on the political and strategic context. As a result, these calculations tell us less about the precise vulnerability of a given arsenal at a given time—though one can reach arresting conclusions based on the evidence—and more about trends in how technology is undermining survivability.51 One crucial consequence of the accuracy revolution is not captured in the above results. Yet, its impact on the vulnerability of nuclear arsenals may be just as profound. The accuracy revolution has rendered low-casualty counterforce attacks plausible for the first time. THE DAWN OF LOW-CASUALTY COUNTERFORCE In nuclear deterrence theory, the primary factor preventing nuclear attack is the attacker's fear of retaliation. In reality, however, additional sources of inhibition exist, including the terrible civilian consequences of an attempted counterforce strike. If a leader contemplating a disarming strike knows that such an attack will inflict massive casualties on the enemy, that leader will also understand that the **failure to disarm** the enemy will provoke a **massive punitive response**, foreclosing the possibility of a limited nuclear exchange. Furthermore, if a disarming strike would cause enormous civilian casualties in the target country, but also possibly in allied and neutral neighboring countries, leaders who value human life or the fate of allies would contemplate such an attack in only the direst circumstances. The link between civilian casualties and nuclear inhibition explains why many arms control advocates oppose the development of less destructive nuclear weapons; they worry that such weapons are more “usable.”52 Counterforce was tantamount to mass casualties throughout the nuclear age, but the **accuracy revolution is severing that link**. In the past, the main impediment to low-casualty nuclear counterforce strikes has been radioactive fallout. Targeters would have had to **rely on ground bursts to maximize destructive effects** against hardened facilities such as silos and storage sites. Detonations close to the ground have a major drawback, however: debris is sucked up into the fireball, where it mixes with radioactive material, **spreading radiation wherever it settles**. Although the other effects of nuclear detonations (e.g., blast and fire) can have large-scale consequences for civilians, in many circumstances those effects can be **minimized**.53 If a strike produces fallout, however, the consequences are potentially vast and difficult to predict.54 In theory, it has always been possible to employ nuclear weapons without creating much fallout. If weapons are detonated at **high altitude** (above the “fallout threshold”), very little debris from the ground will be drawn up into the fireball, **greatly reducing fallout**.55 In practice, however, this targeting strategy has never been feasible against hardened sites. The problem is that any high-yield weapon that detonates low enough to destroy a hardened target will also be low enough to create fallout. **Low-yield** weapons could do the job and remain above the fallout threshold, but that has always been impractical because low-yield weapons would need to be delivered with great **precision** to destroy hardened sites, which was previously impossible.56 Figure 2 illustrates why high-yield strikes against hard targets inevitably create fallout, and it highlights the potential low-yield solution to the fallout problem. The vertical axis reflects weapon yield, and the horizontal axis depicts the hardness of potential targets—with the approximate values for mobile missile shelters and missile silos indicated. The solid black line shows the maximum yield of a weapon that can generate enough overpressure to destroy a target from above the fallout threshold. For example, figure 2 shows that for a 3,000 psi target, the highest-yield weapon that can destroy it while remaining above the fallout threshold is 0.35 kilotons. A larger-yield weapon will necessarily cause fallout if it destroys the target. A low-fallout strike against a 1,000 psi mobile missile shelter would require a weapon with 50 kilotons yield, or less. In short, low-fatality nuclear counterforce is possible, but it requires low-yield weapons, and hence very accurate delivery. figure Figure 2. The Potential for Low-Fallout Nuclear Counterforce note: “Target hardness” (the horizontal axis) is measured in pounds per square inch (psi), with a typical range of psi for hardened mobile missile shelters and missile silos noted. “Yield” (the vertical axis) is measured in kilotons and plotted on a logarithmic scale. The curve depicts the maximum weapon yield that can destroy a given target from above the fallout threshold. Any weapon yield/target hardness combination above the line that is effective enough to destroy the target will necessarily result in fallout. Points below the line indicate that weapons can be detonated at an altitude that will destroy the target yet produce little or no fallout. See the online appendix for calculations. The accuracy of nuclear delivery systems is now to the point that low-casualty disarming strikes are possible. For example, a 0.3 kiloton bomb would require a CEP of 10–15 meters to be highly effective against hard targets;57 that level of accuracy is likely within the reach of the new guided B61-12, which is slated to replace all nuclear gravity bombs in the U.S. arsenal.58 Similarly, a 5-kiloton missile warhead, which may approximate the yield of the fission primary on many existing ballistic missiles, could destroy a hardened target if its CEP was approximately 50 meters.59 That level of accuracy was implausible for most of the Cold War, yet it is within reach of many countries today.60 By detonating weapons above the fallout threshold, targeters can greatly reduce fallout relative to ground bursts. But how significant are these reductions? How many fewer deaths would be caused in comparison with ground burst strikes? To compare the fallout and potential fatalities from high-yield and low-yield counterforce operations, we used unclassified U.S. Defense Department software, called Hazard Prediction and Assessment Capability (HPAC).61 We modeled two different counterforce strikes, one using a “traditional” high-yield approach and one employing low-yield airbursts, against five hardened targets in North Korea (e.g., nuclear storage sites or hardened mobile missile shelters). Because there is no available unclassified information about the location of North Korea's nuclear storage sites, we modeled strikes against notional locations around the DPRK's periphery. The results of the two strikes, illustrated in figure 3, are starkly different. The traditional approach (on the left side) would likely destroy the targets, but at a terrible price: millions of fatalities across the Korean Peninsula. The low-yield option, by contrast, would produce vastly fewer deaths. As long as the targets were located outside North Korean cities, the number of Korean fatalities from a low-yield strike would be comparable to the human losses from conventional operations. In fact, the fallout contours that are visible in figure 3 for the low-yield scenario **correspond to annual radiation levels deemed acceptable by** the U.S. **O**ccupational **S**afety and **H**ealth **A**dministration figure Figure 3. Low-Fallout Counterforce Option against North Korea note: The figure illustrates the potential fallout consequences of two alternative counterforce strikes against five notional North Korean hardened nuclear sites. In both strike options, each target is destroyed with greater than 95 percent probability. The high-yield attack employs ten W88 warheads (455-kiloton yield), with two warheads against each target. Because high-yield weapons cannot destroy hardened sites from above the fallout threshold, the W88s are ground bursts. The low-yield attack uses twenty B61 bombs (0.3-kiloton yield), set to detonate at an altitude that maximizes effectiveness while minimizing fallout. The fallout patterns and casualty figures were generated using unclassified U.S. Defense Department software, called Hazard Prediction and Assessment Capability. The precise results of the HPAC simulation should be treated with skepticism: wind speed and direction change constantly, altering fallout patterns. The amount of fallout generated in the low-yield scenario is **so low**, however, that the results of figure 3 are **robust regardless of which way the wind blows:** **few people** located away from the actual targets would be killed. The point of figure 3 is not to predict the outcome of a counterforce strike on North Korea, but to reveal the relationship between accuracy and fallout. When accuracy was poor, the only approach to nuclear counterforce was high-yield strikes, which would create catastrophic results such as the one depicted above. The accuracy revolution has changed the calculus, however; **low-fatality nuclear strikes are now possible**.62 The accuracy revolution is ongoing. As accuracy continues to improve, the effectiveness of conventional attacks on hard targets will **continue to increase**. Today, low-yield nuclear weapons can destroy targets that once required very large yield detonations. In the future, many of those targets will be vulnerable to conventional attacks. In sum, from the start of the nuclear age to the present, force planners have relied on hardening as a key strategy for ensuring the survivability of their arsenals. That strategy made sense, and until recently ensured that disarming strikes would not only fail, but also kill millions of civilians in the process. Technology never stands still, however, and **the technical foundations of deterrence**, particularly for the strategy of hardening, have been **greatly undermined by leaps in accuracy**. Counterforce in the Age of Transparency While advances in accuracy are negating hardening as a strategy for protecting nuclear forces, leaps in remote sensing are undermining the other main approach: concealment. Finding concealed forces, particularly mobile ones, remains a major challenge. Trends in technology, however, are eroding the security that mobility once provided. In the ongoing competition between “hiders” and “seekers,” waged by ballistic missile submarines, mobile land-based missiles, and the forces that seek to track them, the hider's job is growing more difficult than ever before. Five trends are ushering in an age of unprecedented transparency.63 First, sensor platforms have become more diverse. The mainstays of Cold War technical intelligence—satellites, submarines, and piloted aircraft—continue to play a vital role, and they are being supplemented by new platforms. For example, remotely piloted aircraft and underwater drones now gather intelligence during peacetime and war. Autonomous sensors, hidden on the ground or tethered to the seabed, monitor adversary facilities, forces, and operations. Additionally, the past two decades have witnessed the development of a new “virtual” sensing platform: cyberspying.64 Second, sensors are collecting a widening array of signals for analysis using a growing list of techniques. Early Cold War strategic intelligence relied heavily on photoreconnaissance, underwater acoustics, and the collection of adversary communications—all of which remain important. Now, modern sensors gather data from across the entire electromagnetic spectrum; they employ seismic and acoustic sensors in tandem; and they emit radar at various frequencies depending on their purpose, for example, to maximize resolution or to penetrate foliage. Modern remote sensing exploits an increasing number of analytic techniques, including spectroscopy to identify the vapors leaking from faraway facilities, interferometry to discover underground structures, and signals processing techniques (such as those underpinning synthetic aperture radars) that allow radars to perform better than their antenna size would seem to permit.65 Third, remote sensing platforms increasingly provide persistent observation. At the beginning of the Cold War, strategic intelligence was hobbled by sensors that collected snapshots rather than streams of data. Spy planes sprinted past targets, and satellites passed overhead and then disappeared over the horizon. Over time those sensors were supplemented with platforms that remained in place and soaked up data, such as signals intelligence antennas, undersea hydrophones, and geostationary satellites. The trend toward persistence is continuing. Today, remotely piloted vehicles can loiter near enemy targets, and autonomous sensors can monitor critical road junctures for months or years. Persistent observation is essential if the goal is not merely to count enemy weapons, but also to track their movement. The fourth factor in the ongoing remote sensing revolution is the steady improvement in sensor resolution. In every field that employs remote sensing technology, including medicine, geology, and astronomy, improved sensors and advanced data processing are permitting more accurate measures and fainter signals to be discerned from background noise. The leap in satellite image resolution is but one example: the first U.S. reconnaissance satellite (Corona) could detect objects as small as 25 feet across. Today, even commercial satellites (e.g., DigitalGlobe's WorldView-3 and WorldView-4) can collect images with 1-foot resolution, and U.S. spy satellites are reportedly capable of resolutions less than 4 inches.66 Advances in resolution are not merely transforming optical remote sensing systems; they are extending what can be seen by infrared sensors, advanced radars, interferometers and spectrographs, and many other sensors. The fifth key trend is the huge increase in data transmission speed. During the first decades of the Cold War, it took days or longer to transmit information from sensors to analysts. At least a full day passed before the photographs snapped by U-2 aircraft were developed and analyzed. Early satellites were slower: the satellite had to finish its roll of film, and then eject the canister, which would be caught midair and flown to a facility for development and analysis. All told, images collected at the beginning of a satellite mission might take weeks before they arrived at an analyst's desk. Today, by contrast, intelligence gathered by aircraft, satellites, and drones can be transmitted in nearly real time. The data can be transmitted to intelligence analysts, political leaders, and in some cases directly to military commanders conducting operations. None of these **technological trends** alone is transformative. Taken **together**, however, they are creating a degree of **transparency** that was unimaginable even two decades ago. These new remote sensing technologies are not proliferating around the world evenly; the United States, for example, seems to have exploited new sensing technologies more intensively than other countries. Many countries are developing expertise in advanced sensing, however. The sensing revolution is a global phenomenon, with implications for the survivability of all countries' nuclear arsenals. Remote sensing technologies have improved greatly, but the crucial question is whether these advances have meaningfully increased the vulnerability of the **two most elusive types** of nuclear delivery systems: SSBNs and mobile land-based missiles. If the ability to track submarines at sea or mobile missiles on patrol remains out of reach, then the counterforce improvements we identify are less significant, at least for now. In fact, SSBNs have never been as invulnerable as analysts typically assume, and advances in remote sensing appear to be **reducing the survivability** of both **submarines** and **mobile missiles**.

#### French Kerguelen Islands have unique characteristics conducive to repopulation.

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One of the most attractive islands for long-term survival of global risks is **the French archipelago of Kerguelen** in the southern Indian Ocean. Kerguelen’s main Grand Terre Island has the following attractive features for long-term survival: It **is very remote from any other constant human settlement**s; for example, is it 3,000 km from the island of Reunion. The Kerguelen Islands lie **outside the main trade lines**, so the probability of a random ship arriving there is low. **The islands are inside the circumpolar Antarctic current**, and they are surrounded by strong winds (the “Roaring Forties” and “Furious Fifties”), which will not accidentally bring any ships from further north. A return trip from Reunion to Kerguelen by ship takes 28 days. **The islands do not have an airport**, so they cannot be reached by air, **and they are too remote for helicopter travel.** While Easter Island is even more remote from other human settlements, it is more populated and more often accessed by ships and planes. **The intense and isolating wind circulation around the South Pole could increase the time required for ash or radioactive clouds** from the northern hemisphere **to reach** the South Polar Region. But the Kerguelen Islands are also not too close to the South Pole: they are at the equivalent latitude as southern Germany; thus, they get quite a bit of sunlight The Kerguelen Islands have a stable but cold climate, with temperatures above freezing most of the time. The main island has **edible vegetation and many edible animals**, including 3,000 sheeps. The island is very large, approximately 7,000 km2 , and **it has many deep gulfs and fjords that could be used as harbors**. The main island has high mountains (over 1,000 m) with **an ice cap which could provide fresh water**. Nearby ice-free mountains hundreds of meters high could provide **protection against tsunamis**. The highest mountain is volcanic, and was active 100,000 years ago (Weis et al., 1998). However, **residual geothermal heat could provide heating and energy for a refuge**. The main island has a continuous population of only about 45 people, who live at a scientific station. Scientists who are selected for long expeditions are **more organized and educated than random people, so they may be better prepared for survival**. Such a scientific base will not be a military target in case of war. There are several other South Ocean islands similar to Kerguelen, like South Georgia, Auckland Island and Macquarie Island (Schalansky, 2010).