



Discontinuities and Distractions—Rethinking Security for the Year 2040

Findings from a RAND Corporation Workshop

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Preface

This report is based on a workshop convened by the RAND Corporation in New York City on September 8, 2017, to discuss how to better define, anticipate, and address global trends and discontinuities that could shape the world through the year 2040. Nineteen participants from a wide range of disciplines and professions analyzed continuities and discontinuities from previous eras and anticipated likely or consequential developments in the coming 25 years. Continuities were those trends and events that were unsurprising, even if they occurred at an accelerated pace. Discontinuities, also known as “black swans,” are developments that were deemed impossible and thus never considered, yet they proved consequential enough to change history, making a trend line suddenly jump or even disappear. The most consequential continuities cited were that (1) life expectancy in many parts of the world would continue to rise, (2) extreme weather events would increase in frequency, and (3) the advancement of technologies would continue to progress rapidly. The most consequential discontinuities cited were that (1) artificial intelligence could displace a significant portion of the labor force; (2) advanced genomic editing could become a disruptive force; (3) climate change and extreme weather could spark mass migration; and (4) shifts in climate, energy, and demography could alter the international power balance.

This research was conducted within the International Security and Defense Policy Center (ISDP) of the RAND National Security Research Division (NSRD). NSRD conducts research and analysis for the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the defense agencies, the Navy, the Marine Corps, the U.S. Coast Guard, the U.S. Intelligence Community, allied foreign governments, and foundations. For more information on the RAND ISDP Center, see <http://www.rand.org/nsrd/ndri/centers/isdp.html> or contact the Center director (contact information provided on the web page).

Security 2040

This report is part of a broader effort, an initiative of RAND Ventures, to envision critical security challenges in the world of 2040, considering the effects of political, technological, social, and demographic trends that will shape those security challenges in the coming decades. The research was conducted within the RAND Center for Global Risk and Security.

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Summary

This report is based on a workshop convened by the RAND Corporation in New York City on September 8, 2017, to discuss how to better define, anticipate, and address global trends and discontinuities that could shape the world through the year 2040. The workshop featured off-the-record presentations and facilitated brainstorming exercises involving 19 experts from a range of disciplines and professions, including political science, engineering, anthropology, mathematics, economics, public policy, and media and publishing. Participants analyzed and prioritized continuities and discontinuities from three previous periods in history (1910–1935, 1950–1975, and 1990–2015) and discussed a wide range of possible scenarios for the years 2015–2040.

This report summarizes and synthesizes many of the observations from the workshop, informed by existing RAND analysis and additional perspectives by the authors. The most consequential continuities cited were that (1) life expectancy in many parts of the world would continue to rise because of medical and technological advances, (2) extreme weather events would increase in frequency and climate change would continue to advance, and (3) rapid progress in the advancement of technologies would challenge the capacity of government to adapt to these changes. The most consequential discontinuities cited were that (1) artificial intelligence could displace a significant portion of the labor force, triggering high unemployment in certain sectors (while potentially increasing employment in others and/or generating new sectors) and challenging traditional notions of work and human purpose; (2) advanced genomic editing could be used in benign or malign ways to alter individuals or entire species; and (3) shifts in climate, energy, and demography could affect coastal communities, spark mass migration, and affect the international power balance overall because some countries might be disproportionately harmed by these trends while others might benefit.

Economic transformations that were envisioned by 2040 included a rising ratio of dependents to workers in most industrialized countries, with negative implications for ratios of debt to gross domestic product. Extreme weather events have become more frequent and are likely to become costlier. Managed migration might be a necessary response by 2040. While food price volatility will likely rise in the short term, long-term food supplies are more likely to adapt. Scarcity might not prove to be as acute a problem as some believe; food and oil production have thus far kept up with rising global demand and are not seen as limiting factors in the future.

The report lays out some potential changes on the battlefield, where robots and drones could be doing even more of the fighting. The trend toward more-automated warfare aligns with recent

RAND research, which anticipates a decline in both interstate and intrastate conflicts.¹ The conference workshop also addressed information insecurity, the possible end of privacy, and the many ways in which the liberal international order might be amended—or collapse. Problems of governance in liberal democracies were seen as the fundamental obstacle to designing solutions to the challenges anticipated in 2040.

Based on the discussions at the workshop and subsequent analysis, the report identifies five possible areas for further RAND research: (1) planning for an anticipated employment shock, (2) managing domestic and international migration where needed, (3) the implications of aging populations in Russia and China, (4) the certainty of the uncertain, and (5) the next revolution in military affairs.

¹ Thomas S. Szayna, Angela O’Mahony, Jennifer Kavanagh, Stephen Watts, Bryan Frederick, Tova C. Norlen, and Phoenix Voorhies, *Conflict Trends and Conflict Drivers: An Empirical Assessment of Historical Conflict Patterns and Future Conflict Projections*, Santa Monica, Calif.: RAND Corporation, RR-1063-A, 2017.

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1. Introduction

The United States is facing a period of domestic and international turbulence that could prove as consequential as any since the Cold War. Over the coming 25 years, disruptions and discontinuities in the international system might be brought on by accelerating technological advancement, social and economic dislocations, environmental stressors, or electoral unrest. Moreover, these discontinuities are likely to coexist and commingle in unexpected ways. They require that policymakers spend more time anticipating the world of 2040—even while many complain that they lack time to think even a week ahead.

On September 8, 2017, the RAND Corporation convened a one-day workshop in New York City with a diverse group of 19 experts to discuss how to better define, anticipate, and address these global trends and discontinuities. The “Security 2040” workshop brought together next-generation RAND researchers with thought leaders from the worlds of business, technology, publishing, think tanks, and national security to engage in structured exercises in long-term thinking and strategic planning.

The challenge posed to workshop participants—selected not only as experts but also as leaders from well-networked organizations, representing a variety of disciplines and experiences to allow the broadest range of perspectives on security—was not to attempt to predict the future. Rather, the challenge was to draw on both analytic and intuitive skills to anticipate and imagine the possible contours of the future in order to help policymakers prepare for the unexpected.

This report is not a conference summary but rather a synthesis of the wide-ranging discussion that took place. Because the workshop was held under the Chatham House rule, there is no attribution for any of the remarks referenced in the report. The methodologies of the workshop consisted of expert presentations; discussion of trend lines deemed likely to continue and of developments that would disrupt or destroy the status quo; “crowdsourcing” of the evaluations of how consequential these events might be, by allowing participants to vote on the various proposed scenarios; and discussion of possible remedies. A matrix was proposed for further analysis of emerging challenges to the world order. This document concludes with recommendations for further research.

2. Lessons of History: A 75-Year View of Surprise

To gain perspective on how the world might follow or defy predictions between now and 2040, RAND researchers analyzed three previous 25-year periods in U.S. history. These periods were chosen as illustrative of 25-year intervals where expectations and concerns voiced at the beginning of the epoch were quickly overtaken by events.²

For each period, researchers tracked developments that represented the continuation of earlier trends; these were fundamentally unsurprising, even if they occurred at an accelerated pace. Events that are seen as everyday occurrences, or “more of the same,” are known in the literature as “white swans.” We refer to them as *continuities*.³ Researchers also noted the “black swans”—developments that were deemed impossible and thus were never considered yet proved consequential enough to change history. These *discontinuities* can be understood as events that make a trend line suddenly jump or even disappear. Discontinuities and continuities are fluid and coexist, and the categories and brainstorming by workshop participants did not always lead to mutually exclusive listings. Certain continuities, such as climate change and advances in technology, for example, can become discontinuities if developments reach a disruption threshold—e.g., if extreme weather and coastal erosion leads to mass migration,⁴ or if advances in artificial intelligence (AI) lead to widespread employment dislocations. The following sections elaborate on these historic continuities and discontinuities, which are summarized in Tables 1 and 2, respectively.

² A preview of this argument is presented in Andrew Hoehn, Andrew Parasiliti, and Ali Wyne, “Can Washington Successfully Prepare for the Future?” *The National Interest*, April 5, 2018.

³ In mathematics, the graph of a continuous function is a connected curve that has no jumps, gaps, or holes. While this definition was shared with the group, discussants did not always adhere to it.

⁴ Anouch Missirian and Wolfram Schlenker, “Asylum Applications Respond to Temperature Fluctuations,” *Science*, Vol. 358, No. 6370, December 22, 2017, pp. 1610–1614.

Table 1. Participant Views of Historic Continuities

Continuities	1910–1935	1950–1975	1990–2015	2015–2040 (projected)
Significant improvement in human welfare (United States, then world)	Rapid improvement in U.S. public health: Life expectancy for men rises from 48.4 to 59.8 and from 51.8 to 63.9 for women. ^a	U.S. life expectancy rises to 65.6 for men and 71.1 for women.	U.S. life expectancy rises to 71.7 in 2015. Globally, war deaths fall notably.	Life expectancy continues to increase dramatically in rich nations; as the segment of the population that is not working rises, each worker will need to support more dependents. ^b
Rapid global economic expansion	Gross world product (GWP) roughly doubles, from an estimated \$1.1 trillion in 1900 to \$2.2 trillion in 1930. ^c	GWP nearly quadruples, from roughly \$4 trillion in 1950 to \$15 trillion in 1975.	GWP triples, from \$22.5 trillion in 1990 to \$74.3 trillion in 2015. ^d	GWP continues to grow, but at a slower rate.
Continuing urbanization	Urbanization in developed countries continues. In 1920, 14 percent of the global population lives in urban areas. ^e	By 1950, 30 percent of the population is urban.	By 2014, 54 percent of the population is urban.	By 2030, 60 percent of the global population is urban.
Population growth	Global population grows but at an arithmetic pace, from 1.75 billion to 2.15 billion. ^f	Population exceeds 4 billion in 1975.	Population hits 7.4 billion in 2015.	Global population growth continues but at a much slower pace.

NOTE: The periods chosen here are linked to the presentations at the workshop, selected because they illustrate the co-occurrence of trends and discontinuities.

^a United Nations, Department of Economic and Social Affairs, Population Division, “Life Expectancy at Birth,” World Population Prospects 2014 database, undated.

^b United Nations, Department of Economic and Social Affairs, Population Division, *World Population Ageing 2015*, New York, ST/ESA/SER.A/390, 2015, pp. 34–39.

^c In 1990 dollars. J. Bradford DeLong, *Estimating World GDP, One Million B.C. to Present*, Berkeley, Calif.: University of California, Berkeley, May 1998.

^d Federal Reserve Bank of St. Louis, “Gross Domestic Product for World,” database, undated.

^e United Nations, Department of Economic and Social Affairs, Population Studies, *Growth of the World’s Urban and Rural Population 1920–2000*, New York, No. 44, 1969.

^f United Nations, Population Division, undated.

Table 2. Participant Views of Historic Discontinuities

Discontinuities	1910–1935	1950–1975	1990–2015	2015–2040 (projected)
Character of U.S. military power	Military features small standing forces for national defense, rapid changes are seen in military technology—e.g., manned flight, internal combustion, radar/radio.	The United States establishes large standing forces and a Department of Defense to manage it (1.5 million in the active military). United States establishes large overseas commitments.	Conventional forces challenged by development of irregular, “low-signature” warfare. The United States establishes a substantial presence in the Middle East; its presence declines in Europe.	Competition for control of cyberspace and space intensifies as these domains become increasingly dominant. Machines do more of the fighting.
Nuclear weapons	Nuclear capability is not yet developed.	The atomic age begins.	The collapse of the Soviet Union diminishes the perception of threat to the United States from nuclear weapons.	Possible first use of nuclear weapons by a state since World War II, or nuclear terrorism by a nonstate actor.
Military research and development (R&D)	Private-sector technologies introduced to military.	U.S. military is the primary driver of R&D.	The private sector again becomes the driver of R&D that is then used by military.	Private sector drives R&D.
Energy	U.S. and global oil economy emerges (0.57 mbbl to 2.72 mbbl). ^a	U.S. oil production peaks in 1970; U.S. oil imports triple over the next five years.	The United States again becomes a net oil exporter of petroleum products in 2011.	Advances in fracking, alternative energy, and electric and public transportation reduce dependence on liquid petroleum.
Breakthrough technology sparks rapid social change	Industrial revolution and World War I reorder Western governments and societies.	The birth control pill is introduced.	The internet is introduced; the first website is published in 1991.	Antimicrobial-resistant viruses create new waves of health crises. Additive manufacturing disrupts economies and supply chains.
Geopolitical	Circumstances marked by World War I, Russian Revolution, and the Great Depression.	Russia tests atomic bomb in 1947. Sputnik launch frightens United States in 1957. Other events include rapid decolonization, the Korean and Vietnam wars, and the oil embargo of 1973.	The Soviet Union collapses; Russia and China liberalize their economies and join the World Trade Organization. Other events include the 9/11 attacks, 2008 financial crises, the Russian annexation of Crimea, the 1992 Treaty of Maastricht establishing the European Union, and a decline in global poverty.	Climate change benefits some countries but hurts others, altering balance of power.

^a U.S. Energy Administration, “U.S. Field Production of Crude Oil,” February 28, 2018. Mbbl = megabarrel.

Trends and Discontinuities: Perspective from Three Previous Epochs

To review the concerns and assumptions of world leaders at the dawn of each of these quarter-centuries is to be reminded of the futility of attempting to predict the next 25 years. The overall picture, as shown in Table 1, shows that the continuities across these periods are profound, but there are also shocks to the systems that confound the expectations and long-range planning of policymakers.

1910–1935: “The Nucleus from Which a Force Can Grow”

The inaugural remarks of American presidents offer a window into the challenges these leaders expected to face—and how different reality can turn out to be. William Howard Taft’s 1909 inaugural in no way foreshadowed the outbreak of World War I five years later. Taft was mainly focused on domestic issues, cementing reforms that had been introduced after the financial crisis of 1907 and closing a projected \$100 million deficit that had swelled as a result of the panic, recession, and stock-market crash. He vowed to cut taxes and reduce tariffs to boost U.S. exports, though he promised a “maximum tariff against those countries whose trade policy toward us equitably requires such discrimination.”⁵

Taft, a former Secretary of War, was determined to have peace. “We favor every instrumentality, like that of the Hague Tribunal and arbitration treaties made with a view to its use in all international controversies, in order to maintain peace and to avoid war,” he declared. He viewed a strong navy, not a large army, as “the best conservator of our peace with other nations, and the best means of securing respect for the assertion of our rights, the defense of our interests, and the exercise of our influence in international matters,” mainly in Latin America and Asia. He reassured Americans that

[t]he distance of our shores from Europe and Asia of course reduces the necessity for maintaining under arms a great army, but it does not take away the requirement of mere prudence—that we should have an army sufficiently large and so constituted as to form a nucleus out of which a suitable force can quickly grow.

On April 6, 1917, the day an unprepared United States declared war on Germany, that nucleus consisted of 127,151 soldiers and 181,620 National Guard members.⁶

Taft also expressed deep concern over both the domestic political tensions arising from Asian immigration and the potential foreign policy implications of mistreatment of foreign nationals in the United States, and he spoke at length about the need to promote better relations between black and white Americans. In these ways, Taft’s concerns show striking similarities with those of today—and little prescience for the challenges his administration would face.

⁵ William Howard Taft, Inaugural Address, March 4, 1909.

⁶ Jim Garamone, “World War I: Building the American Military,” *Defense News*, March 27, 2017.

1950–1975: “No Corner of the Earth Can Be Isolated”

At the midpoint of the 20th century, President Harry S. Truman declared that the first 50 years of the century would become known as “the most turbulent and eventful period in recorded history. The swift pace of events promises to make the next 50 years decisive in the history of man on this planet.”⁷ In this, he was more prescient than most, anticipating the pace and consequence of events over the next quarter-century, if not the details.

In his second State of the Union address, Truman noted that the United States had been mainly preoccupied with domestic concerns at the turn of the century but had found itself at the center of world affairs in the aftermath of World War II. In language that presaged what would later be known as *globalization*, he declared, “The scientific and industrial revolution which began two centuries ago has, in the last 50 years, caught up the peoples of the globe in a common destiny. Two worldshattering wars have proved that no corner of the earth can be isolated from the affairs of mankind.”

Truman was determined to ensure the continuation of Europe’s reconstruction, then in its second year: “If we were to stop this program now . . . we should be just as foolish as a man who, for reasons of false economy, failed to put a roof on his house after building the foundation and the walls.” The Korean War would begin six months later, but Truman mentioned neither Korea nor Vietnam.

Truman warned that mankind could use the new powers of technology to advance civilization or destroy itself—the ultimate discontinuity. “We are working toward the time when the United Nations will control weapons of mass destruction and will have the forces to preserve international law and order,” he said, advancing a vision that still, 50 years later, has not been realized.

1990–2015: “No Time to Be Astonished”

This period began and ended with the United States in a state of profound uncertainty. In his February 22, 1990, address to the U.S. Congress, the new Czech President Václav Havel noted that analysts within and outside the Soviet Union had become increasingly aware of Communism’s internal contradictions. He continued, however:

I don’t think any of us knew how little it would take for these problems to manifest themselves in all their enormity and for the longings of these nations [within the Soviet Union] to emerge in all their strength. The mask fell away so rapidly that, in the flood of work, we have literally no time even to be astonished.

“Astonishment” became the watchword for a period that brought the collapse of the Soviet Union, the expansion of the North Atlantic Treaty Organization (NATO), the terrorist attacks of September 11, 2001, the intensifying involvement of the United States in Afghanistan and the

⁷ Harry S. Truman, Address to the Congress of the United States on the State of the Union, January 4, 1950.

Middle East, the invention of the internet, the rise of China, and the election of the first African-American U.S. president followed by the election of Donald Trump.

The whirlwind of geopolitical change was matched by a sharp increase in the pace of technological change and globalization. The dramatic speed, vast geographic scope, and unpredictability of change challenged societies—and political leaders—around the world.

2015–2040: “Inventing the Future”

What could differentiate the period from 2015 to 2040 from its predecessors is the advent of exponentially more powerful tools of observation, analysis, and learning. For example, the nanoscope is transcending the limits of optical microscopy; in theory, no object is now too small to observe.⁸ Smart sensors are transforming data collection. Big data and algorithms allow us to leapfrog previous limitations on analysis. AI and machine learning are overcoming some of the limitations of the human brain. Meanwhile, biogenetics could be used in benign or malign ways to alter individuals or entire species.

“The best way to predict the future is to invent it.”⁹ A conference participant cited this old maxim to remind other participants that some anticipated or feared events are man-made. Until and unless we see the development of an AI that exceeds human capabilities (Vernor Vinge dubbed this moment “the Singularity,”¹⁰ the point after which the world passes beyond our ability to understand it), the most-consequential scenarios are subject to human agency to at least some degree. Table 3 presents some of the developments that were deemed by participants to be most consequential, meaning those that would have major effects on the status quo or future global security, regardless of how likely or unlikely they are to occur.

⁸ Royal Swedish Academy of Sciences, “The Nobel Prize in Chemistry, 2014,” Popular Science Background series, undated.

⁹ Numerous versions of the quotation have been attributed to Abraham Lincoln, Allan Kay, and many others.

¹⁰ Vernor Vinge, *The Coming Technological Singularity: How to Survive in the Post-Human Era*, VISION-21 Symposium sponsored by NASA Lewis Research Center and the Ohio Aerospace Institute, March 30–31, 1993.

Table 3. Most-Consequential Scenarios, 2015–2040, as Identified and Ranked by Expert Participants

Likely significant continuities
Life expectancy continues to rise; by 2040, many humans live to 90.
Climate change continues.
Machine learning advances.
Erosion of privacy and control of personal data continues.
A "great convergence" occurs between developed and developing economies.
The number of people dying in wars continues to decrease.
Brain-machine interfaces advance.
Potential discontinuities
AI rapidly displaces a significant portion of the labor force; unemployment soars, traditional concepts of work and individual purpose are challenged; political and social unrest increase.
The use of genomic editing (CRISPR/Cas-9) becomes widespread.
Climate change leads to increased migration.
There is an emergence or revival of a powerful religion or ideology.
Quantum computing causes loss of data security.
Membership in communities is increasingly neither based on geography nor fixed; identity becomes increasingly flexible.
AI exceeds human capabilities (aka "The Singularity" or "Super-Intelligence"); machines supplant humans; and/or humans transfer their brains to computers (aka "eternalism").
Nuclear weapons are used for the first time since 1945.
Robotic and cyber warfare eclipses physical dominance.
Fully autonomous vehicles replace individual automobiles and parking.
Attacks are made on transoceanic fiber optic cables and/or space systems.
Concerns over resource scarcity are replaced by concerns over equitable distribution.
A sharing economy based on e-commerce upends traditional ownership and retail.
Liquid petroleum is no longer the primary fuel for transportation.

Note that not all the continuities in Table 1 are necessarily desirable, nor are all the discontinuities in Table 2 disastrous: Some might be quite positive on balance. The most negative scenarios are not “black swans”—they are not even surprises; they are, at root, problems of governance.

A principal concern running throughout the workshop was the prospect that technology and other trends will exacerbate inequality both within and among countries. Experts discussed predictions that AI could displace millions of workers within a decade or less, but also the proposition that concern over global scarcity will be replaced by concern over distribution of resources and equity. Concerning AI, one participant stressed that while dislocation has invariably attended major technological breakthroughs—witness the aftermath of the agricultural revolution and the industrial revolutions, for example—the displacement resulting from AI is

likely to occur far more quickly and affect a far wider segment of the world's population. AI has already displaced workers in manufacturing and retail, with no signs yet of offsetting employment. It remains to be seen how well AI-savvy entrepreneurial outfits are able to absorb displaced workers, especially in countries (such as the United States) where the rate of business formation has been declining for years and the ability of existing businesses to provide higher-quality health care and larger pensions is increasingly doubtful. In an AI-centric—or at least AI-fueled—economy, then, government policy could prove to be an increasingly important social stabilizer.

In addition to the scenarios in Table 3, participants discussed a wide range of trends and issues deemed relevant to U.S. and international security and prosperity in 2040. These are discussed in the following chapters.

3. Participant Views on Likely Economic Transformations by 2040

Participants identified a range of well-defined and less-certain challenges to global economic stability in 2040. Looming large is the growing U.S. ratio of debt to gross domestic product (GDP), which will rise from 74 percent of GDP in 2015 to 103 percent of GDP in 2040 without fiscal reform.¹¹ Even if faster economic growth were to materialize, both spending cuts and revenue increases must be enacted, or debt will squeeze other national priorities. Existing political and bureaucratic mechanisms have failed to deal with the problem, and the potential for crisis in the U.S. and global financial systems likely increases the longer the issue goes unaddressed.

A less certain future is one in which China's economic growth abruptly stalls—a development akin to Japan's "lost decade." The more conventional scenario holds that Chinese growth continues apace and the United States cannot match China's ability to fund its expansive foreign policy aims. This would challenge U.S. geopolitical primacy but not necessarily U.S. economic fortunes, which might be enhanced by strong demand from a prosperous China and an increasingly prosperous Asia.

A third source of economic and sociopolitical insecurity was a scenario in which, for the first time, millennials and younger generations of Americans are not better off than their parents in 2040. One driver of such a development would be a shrinking labor market in which AI replaces millions of retail, service, and administrative jobs. One participant reported that up to 3.2 million U.S. call-center jobs paying up to \$45,000 per year could be eliminated by better AI within a few years, not a few decades.¹² Blue-collar workers have already been affected by automation. However, experts suggested that older Americans might be increasingly hard hit, both because they are the most expensive cohort of worker and because they are presumed not to pick up new technological skills as quickly as younger people. This could be a particular challenge for workers over the age of 45, who might well live another 40 years.¹³

Mass unemployment would challenge not only individual purpose but also the relationship between the individual and the state. AI-induced mass unemployment was the top vote-getter among the consequential scenarios put forth by the 19 workshop participants as outlined in

¹¹ Howard Shatz, *U.S. International Economic Strategy in a Turbulent World*, Santa Monica, Calif.: RAND Corporation, RR-1521-RC, 2016.

¹² Four days later, former Citigroup head Vikram Pandit predicted that 30 percent of banking jobs could disappear in the next five years due to AI. Chanyaporn Chajaroen, "Pandit Says 30% of Bank Jobs May Disappear in the Next Five Years," *Bloomberg News*, September 12, 2017.

¹³ Vasilis Kontis, James E Bennett, Colin D. Mathers, Guangquan Li, Kyle Foreman, and Majid Ezzati, "Future Life Expectancy in 35 Industrialised Countries: Projections with a Bayesian Model Ensemble," *The Lancet*, Vol. 389, No. 10076, February 21, 2017, pp. 1323–1335.

Table 3. However, one participant noted that the global surge in working-age people has peaked and will now decline. If the effect of AI on employment turns out to be less than anticipated, workers could unexpectedly experience higher wages and more power vis-à-vis employers than in recent decades.

Several experts warned that current econometrics do not accurately capture the impact of some of the changes that are occurring. If this is true, we should expect more surprises on the road to 2040. For example, the advent of Netflix has allowed Americans to spend less in movie theaters, many of which have closed. Yet it might create a net increase in pleasure and convenience, which are not measured.

The futurology of the 1960s and 1970s was predicated on the assumption that such resources as food and energy would become scarcer as the population grew. These fears have not materialized, and the ability to extract shale oil at competitive prices in the United States has dramatically lessened price and supply instability while also reducing the geopolitical importance of oil producers over time.

Classic economic sensitivities are changing as we move toward 2040 and the service sector grows while automation lowers the cost of labor inputs. If U.S. labor costs fall relative to the cost of transporting inputs, reshoring of manufacturing becomes more likely.

The price and supply of lithium, essential to modern batteries, could be a constraining factor. Lithium prices have increased from \$1,590 per ton in 2002 to \$9,100 per ton in 2017,¹⁴ sparking fears of a “super cycle” in which supplies lag demand for lithium batteries for electric vehicles.¹⁵ Lithium mining is extremely polluting, moreover, forcing difficult choices between the goals of environmental protection and carbon reduction.

¹⁴ “Lithium Price,” Metalary, undated.

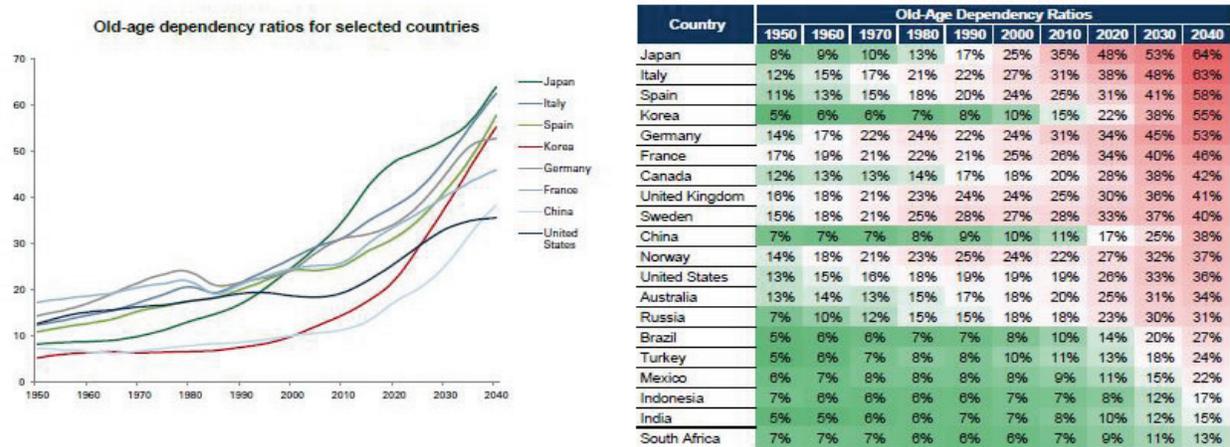
¹⁵ Henry Sanderson, “Electric Car Demand Sparks Lithium Supply Fears,” *Financial Times*, June 8, 2017.

4. Demographics and Dependency Concerns

Demographic changes will also shape and define economic and employment trends in the coming decades. While the full economic impact of automation and an aging population is uncertain, existing categories of home care for the elderly, physical therapy, and rehabilitation for aging citizens—who will be receiving new bionic body parts and other dramatic medical advances—are likely to be high-growth industries.

The rising ratio of “old age” dependents to workers in 2040 will impose a heavy economic burden on the young, as shown in Figure 1. One participant stated that, in the absence of entitlement reform, “all we have [are] dependency ratios.” These ratios can be calculated in different ways, but a high dependency ratio reflects a larger number of seniors and children relative to working-age people in a population, which tends to raise a country’s debt-to-GDP ratio. Much depends on whether people over the age of 65 are dependent on working people for support, whether they are healthy as they age, and whether they work for more years before retiring.¹⁶ The stress might be no less acute for having been long forecast.

Figure 1. Old-Age Dependency Ratios



SOURCES: United Nations, Population Division, undated; Steve Strongin, “Past and Future Problems,” Goldman Sachs Global Investment Research, September 2017, not available to the general public, cited with permission of the author.

NOTE: Old-age dependency ratios = (population over 65)/(working age population).

¹⁶ See for example, Michael D. Hurd, Paco Martorell, Adeline Delavande, Kathleen J. Mullen, and Kenneth M. Langa, *Dementia’s Mounting Toll on the U.S. Economy*, Santa Monica, Calif.: RAND Corporation, IG-115, 2013.

Worst-affected by 2040 will be Japan, which has rejected immigration as a solution to its aging demographic, trailed by Italy, Spain, South Korea, and Germany. China and India have markedly different demographic outlooks, but both will see their dependency ratios rise in the coming decades. Improvements in health care and wellness could mitigate the rising costs of long-term care for seniors. By 2040, workers in developed nations will likely be retiring later and living longer, healthier lives, with an uncertain employment market for aging workers.

Education faces dramatic disruption. Formal education ends for most Americans by age 22. The United States lacks a societal mechanism for reeducating millions of workers in midlife (often multiple times). Another open question is how the United States might finance the reeducation of 50-year-old workers who might be expected to live another 35 years.

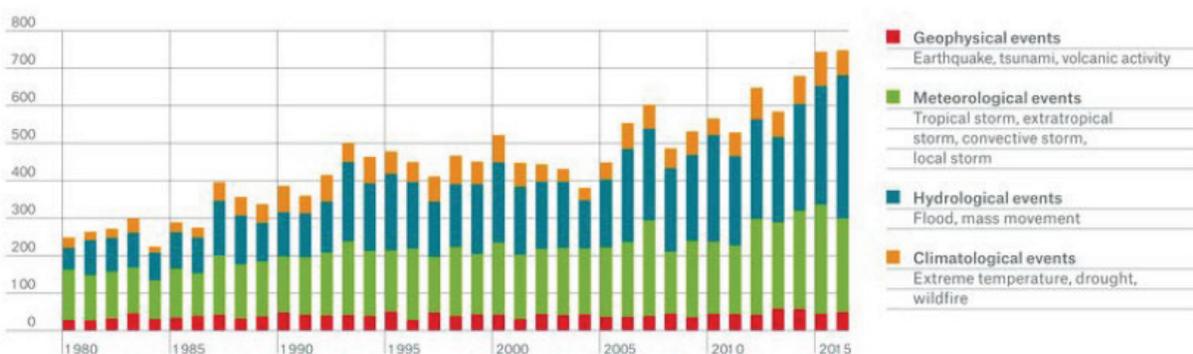
Meanwhile, as machines do more of the heavy lifting, people will invent new things to do with their time—as we have done for the millennia since we began inventing tools. We cannot imagine what these new activities will be, but we might anticipate that the advent of a large population segment with time on its hands could produce economic, political, or cultural transformations.

5. Food, Weather, and Climate Insecurity

A presentation by one participant anticipated a number of effects from extreme weather incidents, including economic losses from disasters, food price volatility, and mass migration.

Worldwide, both the number and the economic cost of natural disasters roughly tripled between 1980 and 2015, and this trend is seen as likely to continue.¹⁷ The rising economic costs are shown in Figure 2. The number of storms and floods have increased most, but extreme temperatures, drought, and wildfires have also grown more frequent. In 2017, the United States experienced 16 extreme weather events, each of which caused at least \$1 billion in damages, for a record total of \$306 billion.¹⁸ A world where an event on the scale of Hurricane Harvey (causing \$150 billion or more in damage) occurs each year is imaginable before 2040.

Figure 2. Overall Economic Losses Caused by Natural Disasters



SOURCE: Munich RE, *Topics Geo 2016: Natural Catastrophes 2016, Analyses, Assessments, Positions*, 2017; Strongin, 2017.

Because of the prolonged discussion this issue generated, the participants then attempted to analyze and anticipate the likely impacts. The overall impact of climate change on global food supplies is uncertain. Agriculture in regions susceptible to extreme weather (especially island and coastal communities) or higher temperatures could be highly vulnerable; other regions that are currently less productive, such as areas in Russia and Canada, might gradually come under cultivation. Agricultural yields could rise or stay flat as a result of climate-driven crop rotation. If Siberia melts into a vast northern bread basket, for example, what effect would that have on Russia's politics and foreign policies?

¹⁷ Munich RE, 2017, p. 56.

¹⁸ National Oceanic and Atmospheric Administration, National Centers for Environmental Information, "Billion-Dollar Weather and Climate Disasters," 2018.

Climate-induced mass migration might be one of the most demanding challenges of the coming decades. Extreme weather, warming trends, and rising water levels will make some areas uninhabitable. For the United States, this raises questions about the extent of commitments to coastal communities and infrastructure. If national infrastructure must generally be rebuilt or renewed every 50 years, should it be rebuilt in climates that are more hospitable? Should there be incentives to encourage the relocation of populations away from coastal areas?

Internationally, the challenge of climate-induced migration could be even more dire. Experts imagined various climate-driven conflict scenarios. For example, if sea levels rise faster than expected, the people of Bangladesh would be forced to resettle, with those in coastal regions the first affected. Where would they go, and how would the international community accommodate such a massive movement of population? Which economies could or would support or accept such migration? How would the international community manage such a forced resettlement, which would be vast (and likely not a one-off)? The daunting challenges and difficult trade-offs of “managed migration” might be less than those posed by uncontrolled migration, which is sure to occur otherwise.

6. Perspectives on Potential Changes in Warfare

RAND research has assessed that a continued decline in both interstate and intrastate armed conflict that began after the Cold War is expected to continue through 2040.¹⁹ The growth in the automation of warfare, where drones and robots do even more of the killing, would likely complement this trend. The expansion of warfare to cyber, information, media, and space realms—where there are no clearly defined rules, “attacks” are often meant to confuse or disrupt rather than kill, and the attacker might be unknown—nonetheless signal a dangerous and uncertain era.

There is of course a “back to the future” scenario that cannot be ruled out. RAND has projected that declining U.S. preeminence and declining capabilities of international organizations could increase chances of interstate war, and that weakening capacity of state institutions and falling economic growth could spark intrastate conflict.²⁰ The advent of disruptive technologies, such as additive manufacturing, could put more weapons and lethal technologies in the hands of nonstate actors and adversaries. Finally, the use of nuclear weapons could shatter the nuclear taboo and perhaps be accompanied by a breakout of other nuclear weapons threshold states, such as Iran and Saudi Arabia.

RAND researchers have also identified the challenges of information warfare, in terms of both Russian disinformation strategies and the role of social media analytics in hybrid warfare.²¹

¹⁹ Thomas S. Szayna, Angela O’Mahony, Jennifer Kavanagh, Stephen Watts, Bryan Frederick, Tova C. Norlen, and Phoenix Voorhies, *Conflict Trends and Conflict Drivers: An Empirical Assessment of Historical Conflict Patterns and Future Conflict Projections*, Santa Monica, Calif.: RAND Corporation, RR-1063-A, 2017.

²⁰ Szayna et al., 2017.

²¹ See Christopher Paul and Miriam Matthews, *The Russian “Firehose of Falsehood” Propaganda Model: Why It Might Work and Options to Counter It*, Santa Monica, Calif.: RAND Corporation, PE-198-OSD, 2016; William Marcellino, Meagan L. Smith, Christopher Paul, and Lauren Skrabala, *Monitoring Social Media: Lessons for Future Department of Defense Social Media Analysis in Support of Information Operations*, Santa Monica, Calif.: RAND Corporation, RR-1742-OSD, 2017.

7. Views on Information Insecurity and the End of Privacy

The erosion of privacy as a meaningful expectation in daily life was cited as a major concern in the coming decades. At the same time, participants noted that surrendering some forms of privacy (e.g., sharing of not only a one-time location and destination but also habitual movements over time when using a driverless car) could lead to large societal benefits, such as significant declines in traffic congestion and traffic deaths.²²

RAND's Security 2040 project is exploring a range of ways in which technology could make the future more or less secure. Three new areas of concern were explored at the workshop:

- **A critical data breach goes undetected.** As hackers become more sophisticated, they are also better able to disguise their invasions, as demonstrated by the penetration of the Office of Personnel Management and Russian election meddling. The recent Equifax breach, among others, highlights the large gaps between breach, detection, public disclosure, and adoption of remedies.
- **Quantum computing renders existing information security practices obsolete.** Technological advances will allow computers to solve problems at a rate that is orders of magnitude faster than current computers, introducing new vulnerabilities and threats to encryption technologies.²³
- **Insecurity grows over the quality of information.** Information overload is already decreasing human cognitive ability to “distinguish the wheat from the chaff,” and a policymaker flagged this as a growing problem for government. At the same time, the technical ability to fabricate information, including highly realistic manufactured video footage of famous people speaking text written by a computer, is advancing faster than remedies to “fake news.” Participants questioned the ability of “information diets,” “information hygiene,” and “circuit breakers” to increase the time available for decisionmaking at crucial junctions.

Not everyone thought the accelerating speed and quantity of information was problematic. One person noted that misinformation can now be detected and corrected much faster than ever before, and that widespread access to “high end” information has diffuse benefits—including pleasure. “I’ve never read more magazine articles in my life—because of Twitter.”

²² Nidhi Kalra and David G. Groves, *The Enemy of Good: Estimating the Cost of Waiting for Nearly Perfect Automated Vehicles*, Santa Monica, Calif.: RAND Corporation, RR-2150-RC, 2017.

²³ This is the subject of a forthcoming RAND Security 2040 document by Evan Peet and Michael Vermeer.

8. Views on Amending the Liberal International Order

Workshop participants discussed the prospects for the liberal international order in the coming decades. RAND has conducted a multiyear study on the history, benefits, and prospects of the liberal international order under U.S. leadership.²⁴ The following is a summary of themes discussed; it does not represent a consensus view among participants.

Pessimistic Scenario

The world of 2040 could be more multilateral and potentially less stable. During the Cold War, the world enjoyed “peace through stalemate.” A system with contested leadership, multiple power centers, and more-lethal and more-disruptive technologies—including in the hands of nonstate actors—could make for a more violent and conflict-prone world.

Many expressed fears of a dark 2040 in which the United States has declined and cannot or will not play the role of steward of the global liberal order, with no successor or partner to shoulder the burdens of global leadership. Other liberal democracies weaken economically, militarily, and politically, due to some combination of slow economic growth, rising unemployment, and nativist sentiment. Authoritarian regimes would benefit. China’s rise, unchecked by a global alliance of flourishing democracies, could create an illiberal order.

On the other hand, such an economic rise and integration led some to suggest that China would not wish to overturn the existing world order, only to push it toward evolving in ways that favor or accommodate Chinese interests. Russia, by contrast, was described by many as a declining but dangerous power—perhaps more of an outlier, rather than an investor, in the international system.

As the liberal order fractured, more states would operate outside its umbrella, while nonstate actors would become more numerous, powerful, and networked. Nuclear nonproliferation is a harder problem now that Ukraine and Libya have given up their nuclear weapons, only to see their sovereignty threatened while nuclear North Korea endures. Even assuming Iranian compliance with the Joint Comprehensive Plan of Action, the expiration of the nuclear deal in 2030 creates uncertainty.

Bioengineered weapons pose a growing threat, as does the commercial use of genomic editing to change more and more human DNA. As biotechnology advances, the ethics and stakes are both dangerous and unknowable.

²⁴ See, for example, Michael J. Mazarr and Ashley L. Rhoades, *Testing the Value of the Postwar International Order*, Santa Monica, Calif.: RAND Corporation, RR-2226-OSD, 2018.

Optimistic Scenario

Participants also noted positive countervailing forces:

- The emergence of consensus without states: Cities are cooperating on climate change and regional regulatory schemes have been adopted. Modern global communications make it ever more possible for people to join together to solve problems.
- The international institutions established after World War II achieved what they set out to achieve, namely to halt great-power conflict, which took on greater urgency in the Cold War, given the potential destructive power of nuclear weapons. These institutions might need to be amended, but they have not failed.

The question is whether we will find ways to amend and modernize the global order before a catastrophe necessitates reform.

Rethinking Power: “Finite and Infinite Players”

One expert presented a working theory of geopolitical and corporate power politics based on the concept of “finite and infinite players.”²⁵ A finite player attempts to achieve limited goals in a limited period of time. An infinite player wants to achieve maximalist goals and is willing to fight for as long as it takes, at nearly any cost, to achieve victory. During the Vietnam War, for example, the United States was a finite player, whereas North Vietnam was willing to bear any number of casualties for as long as necessary to achieve unification under the Hanoi government. In business, finite players seek to crush their competition quickly. Infinite players seek to change the industry in which they operate, if not the world. Their strategy might shift, but their vision will not.

Competitors lose by misunderstanding whether their opponent is a finite or infinite player. Israel, for example, is an infinite player. It will play for as long as it takes to ensure its survival. The United States has been behaving as a finite player in an infinite game in Iraq, Afghanistan, and Syria. It aims to solve crises and then leave, but it has been frustrated by weaker adversaries willing to suffer unimaginable losses for as long as it takes to prevail because the battlefield is their homeland, not America’s. The relevant resources are human will and the ability of leadership to prepare, inspire, or coerce its people to sacrifice and suffer for a greater goal. The implications of this theory were discussed at length.

²⁵ See Simon Sinek, *Find Your Why: A Practical Guide for Discovering Purpose for You and Your Team*, New York: Portfolio, 2017; Simon Sinek, *Leaders Eat Last: Why Some Teams Pull Together and Others Don’t*, New York: Portfolio, 2014; and Simon Sinek, “Playing the Infinite Game,” YouTube, July 18, 2017.

Cognitive and Temporal Hurdles to a Secure 2040

Many of the workshop participants’ deepest fears about the challenges to security and national well-being in 2040 stem from envisioned failures of human cognition, psychology, and governance. Technology is often a trigger or an accelerant. The overarching concern, however, is that the human brain and human systems of governance are not evolving fast enough to master the complex challenges of the coming era. Some of these fears, and countervailing hopes, are summarized in Table 4.

Table 4: Expert Participants’ Views: Sources of Angst and Hope

Angst	Hope
<ul style="list-style-type: none"> The complexity of human systems will soon exceed human cognitive ability. We are unable to understand or process events, or respond in machine-time. In the past, there were natural pauses in human activity that provided time to think and reason, but these are disappearing. The instantaneous and distracting nature of modern technology discourages sustained thinking. 	<ul style="list-style-type: none"> Can we introduce "circuit breakers" as a way of breaking down complex systems into component parts and introducing temporal controls? Complexity can be a friend, not an enemy. "Complexity" is used as a continuous variable, and it offers option to hedge. We can develop tools to manage the world’s increasingly complex systems.
<ul style="list-style-type: none"> Historically, the United States has mobilized for acute foreign policy crises. It is much more difficult to mobilize for the kind of chronic problems we now face. 	<ul style="list-style-type: none"> The United States—and all players—can choose different strategies, including whether to behave as a “finite” or “infinite” player in geopolitics. Leaders can learn to make wiser decisions.
<ul style="list-style-type: none"> Is speed unstoppable? Is it within our power to slow down? 	<ul style="list-style-type: none"> Speed can be managed, as can the tools we choose to use. Over several thousand years, humans have migrated from performing labor to supervising tools that perform labor. We have been eliminating work since we developed the first tool; we then find something new to do. This process is not changing, only its pace.
<ul style="list-style-type: none"> Pace of life, chaos, and confusion begets a sense of vulnerability and triggers backlashes, such as a rise in nativism or other damaging social or political movements. 	<ul style="list-style-type: none"> There are more educated and networked humans now available to tackle human problems than at any other time in history.
<ul style="list-style-type: none"> Our children face a worse future for the first time in U.S. memory; we might be "objectively" better off but we don't feel better off. 	<ul style="list-style-type: none"> Concern over scarcity will be replaced by concern over distribution and equity. This is historic progress, albeit unsettling.
<ul style="list-style-type: none"> The world is in a race between nihilistic powers (willing to push the nuclear button and destroy the planet to preserve themselves) and three or four great powers dedicated to trying to prevent catastrophe. The outcome is unclear. 	<ul style="list-style-type: none"> Postwar liberal international institutions are challenged but have not failed. Nations have acted in concert and through the United Nations to attempt to halt North Korea’s nuclear program and defeat the most nihilistic of actors—the Islamic State of Iraq and the Levant. NATO remains strong.

SOURCE: Opinions expressed at the workshop; these do not necessarily reflect the authors’ views.

9. Recommendations for Future Research

The workshop highlighted two areas of special concern from participants about the period from 2017 to 2040: the need to prepare for well-understood potential threats and the need to build resilience to deal with the certain uncertainty—that is, what we know cannot be predicted. Both categories could be ripe for subsequent RAND research. We offer five areas for future research based on the lessons of this workshop and other RAND activities:

1. **Planning for Employment Shock:** Our workshop participants rated the threat of massive employment dislocations from the introduction of AI as a likely and consequential threat to U.S. well-being well before 2040. What proactive policies might the federal or state governments consider that could address the coming dislocation *before* millions of Americans lose their jobs to AI? Is it feasible to offer proactive retraining to workers in sectors that are obviously threatened by automation, such as call centers? What kinds of federal and state policies, if any, have been effective in stimulating entrepreneurship and alternative job creation?²⁶
2. **Managing Migration:** Participants expressed concern that mass migration, as a result of climate changes and extreme weather, might be one of the most demanding challenges of the coming decades, on both a domestic and international level.
 - a. **Domestic Relocation:** Many experts now view it as likely that climate change and the increased frequency of severe weather will lead to further migration, especially in low-lying coastal areas subject to frequent storms and flooding. These issues are already in play following Hurricanes Katrina and Sandy and the 2017 disasters in Puerto Rico and Houston. A further area for research could be to evaluate the pros and cons of designating certain high-risk areas as long-term “relocation zones” based on the most-advanced methodologies for calculating cost and risk. If the United States were to designate such zones, should it introduce negative or positive incentives for employers and populations to relocate to low-risk areas where climate change is likely to have beneficial effects? Regulatory changes to the flood insurance market are already under discussion, but are there other kinds of policy measures that could be more cost-effective or beneficial? U.S. policy has encouraged domestic relocation during some historical periods, including the 19th-century “opening of the West” and the infrastructure projects and tax policies that helped urbanites buy homes in the suburbs after World War II. Are there lessons to be learned?

²⁶ Osonde A. Osoba and William Welser IV, *The Risk of Artificial Intelligence to Security and the Future of Work*, Santa Monica, Calif.: RAND Corporation, PE-237-RC, 2017b.

- b. **International Migration:** Which of the envisioned scenarios by which mass migration could cause global instability are most plausible? And how should the United States and the international community respond? The world has witnessed the impact of uncontrolled migration in Europe since 2015, in the form of the Brexit vote and European electoral shifts. Should U.S. security and/or development assistance be more tightly focused on helping governments anticipate migration from communities threatened by climate change and political conflict, and seek to manage it in an orderly fashion? What, if any, are the emerging “best practices” from such efforts?
3. **Aging Adversaries:** What are the security implications of aging adversaries, as Russia and China get older? More broadly, if robots will be doing more of the working and fighting in 2040, will the demographic distribution of the population still matter?
4. **The Certainty of the Uncertain:** Our analysis of previous historical periods and deliberations about the potential discontinuities of the coming decades signal an urgent need for methodologies that open a wider lens to anticipate all contingencies and scenarios. At RAND, researchers continue to apply robust decisionmaking and gaming approaches to develop methodological innovations that expand their capacity to break out of linear thinking and provide policymakers with more-expansive assessments and options.
5. **The Next Revolution in Military Affairs:** What are the implications for warfare of automation, cyber, AI, robotics, big data, and drones? The frontiers of AI and information warfare are undefined; seizing territory is no longer the first priority in an attack. What are the rules of cyberwarfare? Should AI use in autonomous weapons be banned, as many leading technologists are advocating? Seizing or destroying the enemy’s data is becoming both an objective and a means of warfare. How should we view combat involving only machines? Will the United States develop and maintain its edge in these technologies? In 2017, China announced a strategy to become the world leader in AI by 2030,²⁷ and Russian President Vladimir Putin reportedly concurred that the leader in AI technologies will “rule the world.”²⁸ Major countries are discussing weaponization of AI,²⁹ even as technology leaders (including Elon Musk and Bill Gates) warn that AI poses an existential threat to humans. But not all observers are as concerned.³⁰ Should the United States seek an international consensus to restrict certain AI uses? Talks at the United

²⁷ Elsa Kania, “China’s Artificial Intelligence Revolution,” *The Diplomat*, July 27, 2017a.

²⁸ Radina Gigova, “Who Vladimir Putin Thinks Will Rule the World,” CNN, September 2, 2017.

²⁹ Robert W. Button, “Artificial Intelligence and the Military,” RAND Blog, July 9, 2017; Elsa Kania, *Battlefield Singularity: Artificial Intelligence, Military Revolution, and China’s Future Military Power*, Washington, D.C.: Center for New American Security, November 28, 2017b.

³⁰ Marjory Blumenthal, Andrew Parasiliti, and Ali Wyne, “AI’s Promise and Risks,” *TechCrunch*, October 24, 2017.

Nations are already under way on regulation of lethal autonomous weapon systems, yet many question whether it is possible to enforce governmental agreements when private corporations are ahead of states in developing and applying the technologies.³¹ Which, if any, of the principles of arms control that were developed in the 20th century could be adapted and reapplied to the challenges we will face in the first half of the 21st?

³¹ Paul Scharre, “The Lethal Autonomous Weapons Governmental Meeting,” *Just Security*, November 9, 2017.

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