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Defense 2045

Assessing the Future Security Environment and Implications for Defense Policymakers

A Report of the CSIS International Security Program

AUTHOR

David T. Miller

FOREWORD

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Foreword

Yogi Berra is alleged to have warned, "Never make predictions, particularly about the future!" But we do it all the time because we have to. Assessing the future is always difficult because there is an infinite set of possible futures. As any prediction is almost guaranteed to be wrong, the objective is not to try to portend the future. Instead, the goal is to outline a set of assumptions that can be tested and identify a more plausible range of possible futures. There is an innate value in conducting such an analysis and thinking through these challenging problems, especially for elected officials and national leaders.

I recently wrote a book, *Is the American Century Over?*, so I am very familiar with the difficulties inherent in such long-range analysis. When I served as chair of the National Intelligence Council, I routinely challenged my analysts to identify which assumptions and variables, if changed, would undermine their assessments. It often made them uncomfortable to be asked, "What would make you wrong?" But such questions are important in trying to better weigh the varying alternatives and craft future scenarios. If we are not asking ourselves these uncomfortable questions, then we may find our fundamental assumptions are flawed and our final analysis is lacking.

Major David Miller has tackled these difficult challenges in a document I believe will be well worth the time of leaders within the national security community. He has done a prodigious amount of research on the drivers of the future security environment and has organized his findings intelligently in a well-constructed report.

As I challenged my analysts, I challenge the reader to consider: *What would make my thoughts on the future wrong?* Thankfully, Major Miller has gone a long way in helping us test these assumptions.

Dr. Joseph S. Nye Jr.
Harvard University Distinguished Service Professor
Cambridge, Massachusetts

Executive Summary

The U.S. national security community faces a strategic inflection point. While the U.S. military remains engaged globally in a range of conflicts, the large-scale counterinsurgency campaigns in Iraq and Afghanistan have ended. After a decade of nearly myopic focus on the Middle East, the United States seeks a pivot to the Asia-Pacific region while balancing myriad priorities. Yet some argue that the current strategic guidance documents, such as the 2015 National Security Strategy or 2014 Quadrennial Defense Review, fail to adequately describe the nature of the future security environment (FSE) or identify how the Department of Defense (DoD) must adapt.

In a period of budget austerity, appropriate prioritization becomes especially important for defense policymakers. In order to determine such priorities, it is first necessary to consider the nature of conflict and missions the U.S. military may face in the future. By assessing the key components, or drivers, of the FSE, an unknowable future becomes a bit clearer. This report, commissioned by the Center for Strategic and International Studies (CSIS), provides such an assessment. Drawing on qualitative data such as national security and foreign policy literature, DoD strategy and operational documents, and interviews with leading academics and practitioners in various fields, this report identifies and discusses the drivers of the FSE in order to guide future analysis and decisionmaking. It should not be taken as a holistic assessment, but instead as merely a first step in an ongoing dialogue.

Drivers of the FSE

Demographics. The global population will grow to 9.4 billion by 2045, with all net growth occurring in urban areas. The median global age will increase significantly, especially in the developed world.

Economics and National Power. Economic growth will not be uniform, with China likely surpassing the United States by 2030. Debt growth globally will constrain defense spending, and new currencies may erode the dollar's role.

Power Diffusion. Non-state actors' power relative to traditional regimes is growing. The G-20 has supplanted the G-8, but the real threat may come from a "G-Zero" world.

Emerging and Disruptive Technologies. A range of emerging technologies threatens to transform society—and war fighting—in dramatic, nearly unimaginable, ways.

Connectedness. The world is shrinking as sensors and devices connected to the Internet of Things (IoT) proliferate. Big Data may make information dominance possible. And fundamental changes in social and community group formation challenge governance.

Geopolitics. Resources such as food, water, and energy will become increasingly stressed. International regimes must adapt to include new players. Ideological conflict may increase.

As the services compete for resources in an austere budget environment, national security policymakers must identify and prioritize the investments that will reap the biggest gains in the FSE. In whatever form, conflict in the future is unavoidable, and the U.S. military must adapt.

1 Introduction

The U.S. national security community stands at a crossroads. After nearly 14 years of war, the U.S. military has ended its large-scale counterinsurgency (COIN) campaigns in Iraq and Afghanistan. But while Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) have ended, both countries face an uncertain future. The United States has waged an arguably successful counterterrorism campaign against al Qaeda, eliminating much of the group's leadership and ability to strike targets in the West. Yet the Islamic State has replaced al Qaeda as the predominant Salafi jihadist group and threatens U.S. allies and interests across the Middle East and North Africa. Chinese territorial assertions and aggressive behavior in the South and East China Seas undermine stability in one of the most populated and economically important areas of the world, and their seemingly routine penetrations of U.S. government networks emphasize a renewed focus on the cyber domain. Yet while most experts applaud the Obama administration's goal of rebalancing strategic focus on the Asia-Pacific theater, recent events have dictated continued emphasis on crises in Syria, Iraq, and Libya—as well as U.S. military deployments to combat the spread of Ebola in West Africa and help provide humanitarian assistance/disaster relief (HA/DR) in Nepal.

The 2011 National Military Strategy argues that "the ongoing shifts in relative power and increasing interconnectedness in the international order indicate a strategic inflection point."[1] This viewpoint was reiterated in the 2012 Defense Strategic Guidance: "As we responsibly draw down from [Iraq and Afghanistan], take steps to protect our nation's economic vitality, and protect our interests in a world of accelerating change, we face an inflection point."[2] Defense officials clearly recognize that the U.S. military must prepare for the future—and that the security environment and the Joint Force may look very different. Yet there are divergent views on the nature and types of security challenges the U.S. military will likely face in the future.

Recent strategy documents, such as the 2014 Quadrennial Defense Review (QDR), suggest that the DoD must "shift focus in terms of what kinds of conflicts it prepares for in the

1. Michael Mullen, chairman of the Joint Chiefs of Staff, *The National Military Strategy of the United States of America 2011: Redefining America's Military Leadership* (Washington, DC: DoD, 2011), 1, http://www.defense.gov/Portals/1/Documents/pubs/2011-National-Military-Strategy.pdf.

2. Department of Defense (DoD), *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (Washington, DC: DoD, 2012), 1, http://archive.defense.gov/news/Defense_Strategic_Guidance.pdf.

future, moving toward greater emphasis on the full spectrum of possible operations."[3] While the department should "preserve the expertise gained during the past ten years," the U.S. military "will no longer be sized to conduct large-scale prolonged stability operations."[4] Tellingly, the "key capability areas" outlined in the QDR overwhelmingly ignore population-centric warfare, such as COIN, HA/DR, or security cooperation and stability operations.[5]

Instead, the anti-access/area-denial (A2/AD) threat is arguably seen as the most pressing challenge for which the U.S. military must prepare. DoD's new Joint Concept for Access and Maneuver in the Global Commons (JAM-GC), an outgrowth of the former Air-Sea Battle concept, seeks to remedy a perceived deficiency in the U.S. military's abilities to confront a high-end threat.

Yet emerging disruptive technologies may soon make even JAM-GC obsolete. Autonomous drones, nanomanufactured weapons, or unforeseen "zero day" cyber attacks may prove an effective counter to our current Joint Force.

Even more troublesome, changes in demographics, such as rapid urbanization, alter the "human terrain" of future conflicts. An aging global population, especially in developed countries, challenges both the United States' and allies' abilities to support defense budgets while retaining cash-strapped social programs.

Information decentralization undercuts traditional power structures, enabling non-state actors to play a disproportionate role in areas where states formerly held absolute sovereignty. Geopolitical considerations, including resource management and international regimes, appear again at the forefront of foreign policy debates given a revanchist Russia. And the rise of authoritarian China threatens to reverse a half century of global democratization.

This report seeks to provide national security practitioners with an assessment of the key drivers shaping the security environment in the future out to the year 2045. While an attempt at predicting the future would prove at best futile and at worst wildly inaccurate, this report instead seeks to identify, explain, and analyze the specific factors that will most likely affect both the FSE and the nature of conflict and war fighting in the future. As such, it should be taken not as a point projection but instead as a method of beginning the conversation. The process of thinking through the future will hopefully illuminate—and test—basic assumptions we all make about the environment around us. Some of the drivers, such as demographics, are more easily modeled and provide a more accurate representation of how the future will likely unfold. Others, such as power diffusion or connectedness, instead offer varying alternatives.

3. DoD, *Quadrennial Defense Review 2014* (Washington, DC: DoD, 2014), vii, http://archive.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf.
4. Ibid.
5. Ibid., x–xi.

As retired general Martin Dempsey writes in his assessment of the 2014 QDR, "My greatest concern is that we will not innovate quickly enough or deeply enough to be prepared for the future, for the world we will face 2 decades from now. . . . The true risk is that we will fail to achieve the far-reaching changes to our force, our plans, our posture, our objectives, and our concepts of warfare."[6]

Now is the time for defense and national security policymakers to reflect on the drivers shaping the world around us and how the U.S. military can best posture for the future. This report hopefully serves as a first step.

6. Ibid., 64.

2 Drivers of the Future Security Environment

1. Demographics

Several ongoing demographic trends will dramatically shape the future security environment (FSE). While the world's population currently stands at 7.3 billion people, current UN estimates suggest that the world's population will grow to 9.4 billion by 2045, with much of that growth occurring in developing regions, especially Africa.[1] Aging societies across much of the industrialized world will strain fiscal budgets as the payer-payee ratio for social programs dramatically shifts. And the number of "megacities"—dense urban areas containing a population more than 10 million—will grow from 29 currently to more than 40 by 2030,[2] providing increasing challenges for land-based military operations.

POPULATION GROWTH

Perhaps no better example of exponential growth exists than that of the human population. The world did not accumulate its first billion people until approximately sometime in the early 1800s.[3] It took slightly longer than 100 years for the world's population to double to 2 billion. Yet in less than 90 years (from the late 1920s until early 2010s), the world population grew from 2 billion to its current 7.3 billion, according to UN estimates.[4] By the year 2045, the world's population will range somewhere between 8.6 and 10.2 billion people, according to the United Nations. Its "medium fertility" scenario, commonly cited as the middle-road figure, suggests 9.4 billion. (The U.S. Census Bureau currently estimates a slightly smaller 9.1 billion in 2045.[5])

1. UN Department of Economic and Social Affairs (DESA) Population Division, *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables* (New York: United Nations, 2015), 1–3, http://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf.

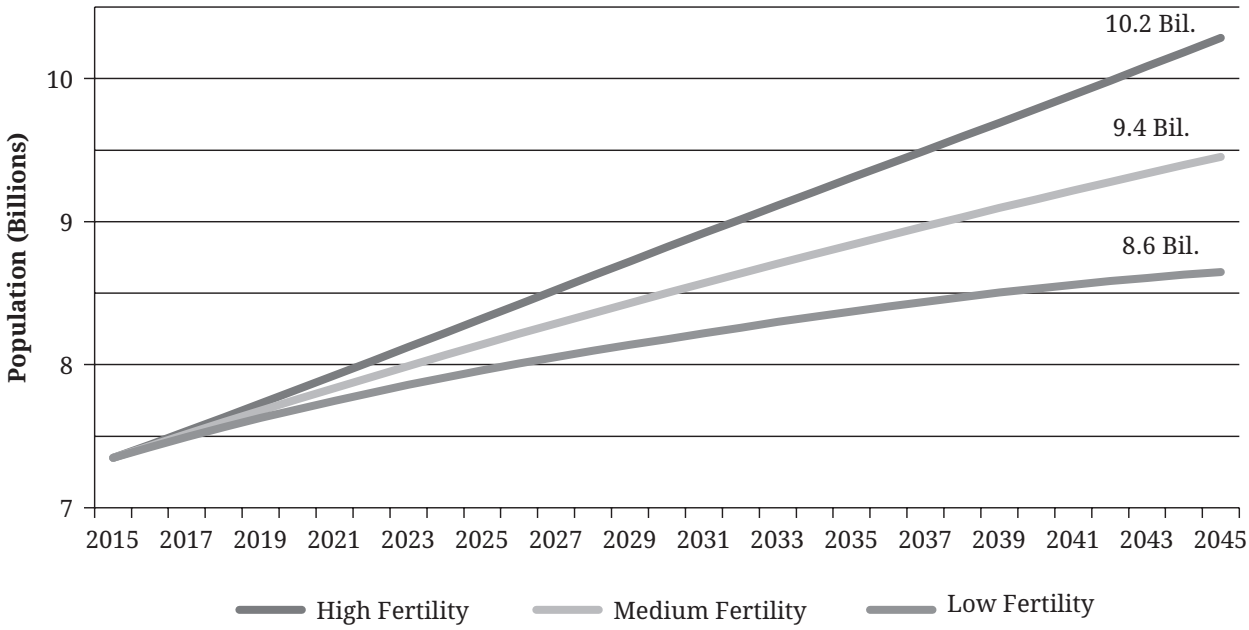
2. UN DESA Population Division, "Urban Agglomerations with 300,000 Inhabitants or More in 2014, by Country, 1950–2030 (thousands)," *World Urbanization Prospects: The 2014 Revision* (New York: United Nations, 2014), June 2014, http://esa.un.org/unpd/wup/CD-ROM/.

3. Refer to the U.S. Census Bureau, "World Population: Historical Estimates of World Population," http://www.census.gov/population/international/data/worldpop/table_history.php.

4. UN DESA Population Division, *World Population Prospects: The 2015 Revision*, database, http://esa.un.org/unpd/wpp/DVD/.

5. U.S. Census Bureau, "International Programs: International Database: Total Midyear Population for the World: 1950–2050," July 9, 2015, https://www.census.gov/population/international/data/idb/worldpoptotal.php.

UN World Population Estimate to 2045



Data Source: UN Department of Economic and Social Affairs (DESA), Population Division, *World Population Prospects: The 2015 Revision*.

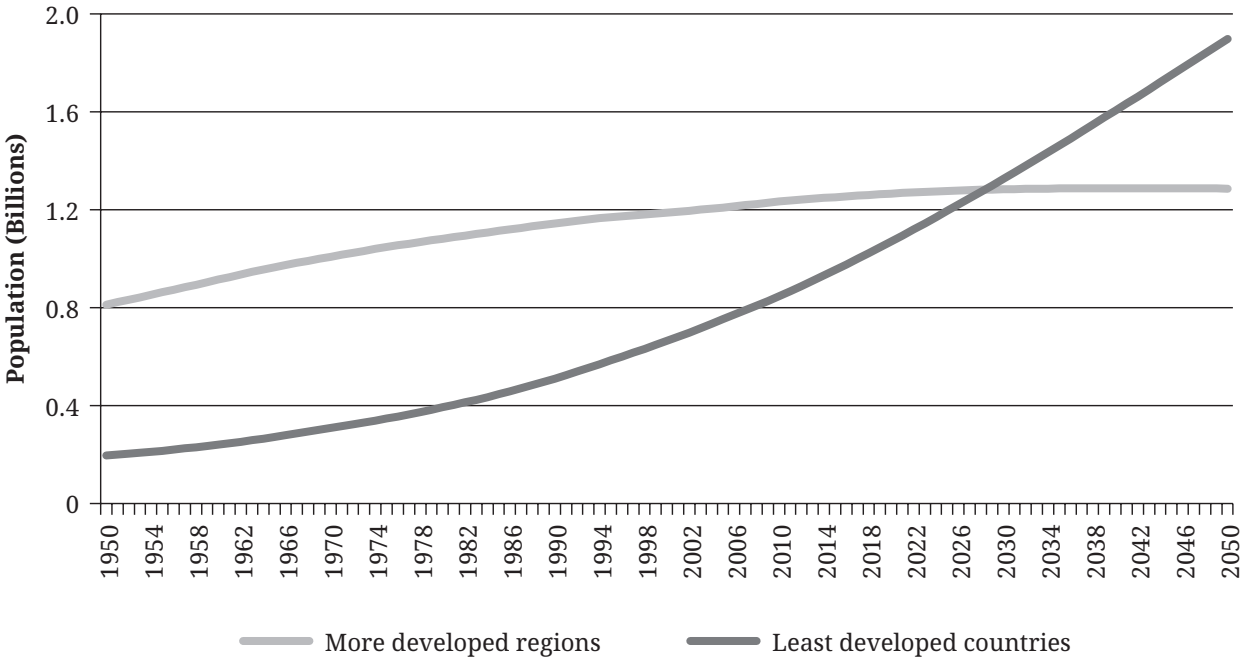
While the world will be a much more crowded place in 2045, the world's population growth rate has already begun to decline. These changes in growth rates, especially across and between regions, will prove as important to the FSE as the total number of people. According to the UN "low fertility" estimate, the world's population will begin to decline in approximately 2055.[6] Even in the medium fertility estimate, the population growth rate will drop to only 0.13 percent annually by 2100.

Between now and 2045, much of the developed world will see its populations decline. Europe is one such example. According to the United Nations, Europe's population will begin to shrink in 2020–2021. Using the United Nations' medium fertility estimates, between 2015 and 2045, Europe will lose approximately 3.3 percent of its population. But even Europe's population decline will not be uniform. Germany, for example, has been in decline for nearly two decades, having reached its peak population in 1998. Yet while many have focused on Western Europe's aging, Eastern Europe is likely to lead the continent in depopulation. According to the United Nations, Eastern Europe's population has been in decline since the early 1990s, fueled in part by net emigration. Between 2015 and 2045, the region will lose approximately 35 million people, nearly 12 percent of its population, making it the area of the world with the worst demographic outlook.

Japan also faces a bleak demographic future, having already been in decline since approximately 2010. Between 2015 and 2045, Japan is estimated to lose approximately 16 million people, more than 12 percent of its population. Even China, currently the world's

6. UN DESA Population Division, *World Population Prospects: The 2015 Revision*.

World Population, More Developed vs. Least Developed, 1950–2050



Data Source: UN DESA Population Division, *World Population Prospects: The 2015 Revision*; "More Developed Regions" include Europe, Northern America, Australia/New Zealand, and Japan; "Least Developed Countries" include 48 countries, mostly (34) in Africa.

most populous country, faces significant demographic headwinds. It will lose its most-populated distinction to India around 2022 and will begin to lose population in approximately 2028. The United Nations' medium fertility estimate suggests China's population will actually decline (by more than a million people) between 2015 and 2045; in a low fertility scenario, China loses 108 million.

Africa, conversely, is the region that will see the greatest population growth by 2045. Medium fertility estimates predict a growth from 1.1 billion in 2015 to 2.2 billion in 2045, a 91 percent increase; "high fertility" estimates suggest Africa's population will grow to more than 2.4 billion by 2045, an impressive 106 percent increase.

AGING

The world's population is growing, but it is also getting older. Medical advances, improved sanitation, cultural changes, urbanization, declining fertility, and a baby boom following World War II all contribute to an increasingly aging population globally. For much of the industrialized world, this aging will strain national budgets and squeeze defense spending.

The global population's age has been increasing steadily and shows no signs of slowing.[7] The global median age was 26.3 years at the turn of the century and is estimated to be

7. All aging data are derived from the UN DESA Population Division, unless otherwise noted.

29.6 years in 2015. By 2045 it will increase to 35.4 years. While the median age in the least developed countries will only be 25.1 years in 2045, for the more developed regions, it will stand at 45.3 years. The United States will fare better than many industrialized nations with an expected median age of 41.5 years in 2045. While it might be unsurprising that Europe, at 46.6 years, will exceed the global median, economic powerhouse China will as well. Although China's population is currently more youthful than the United States', by 2045 China's median population age will rise to 49.2 years, older even than Europe's. India, by contrast, will have a median age 13 years younger than China's. U.S. ally Japan takes top prize as the world's oldest in 2045, with a median age of 53.3 years, edging out Hong Kong and the Republic of Korea (each 52.5 years).

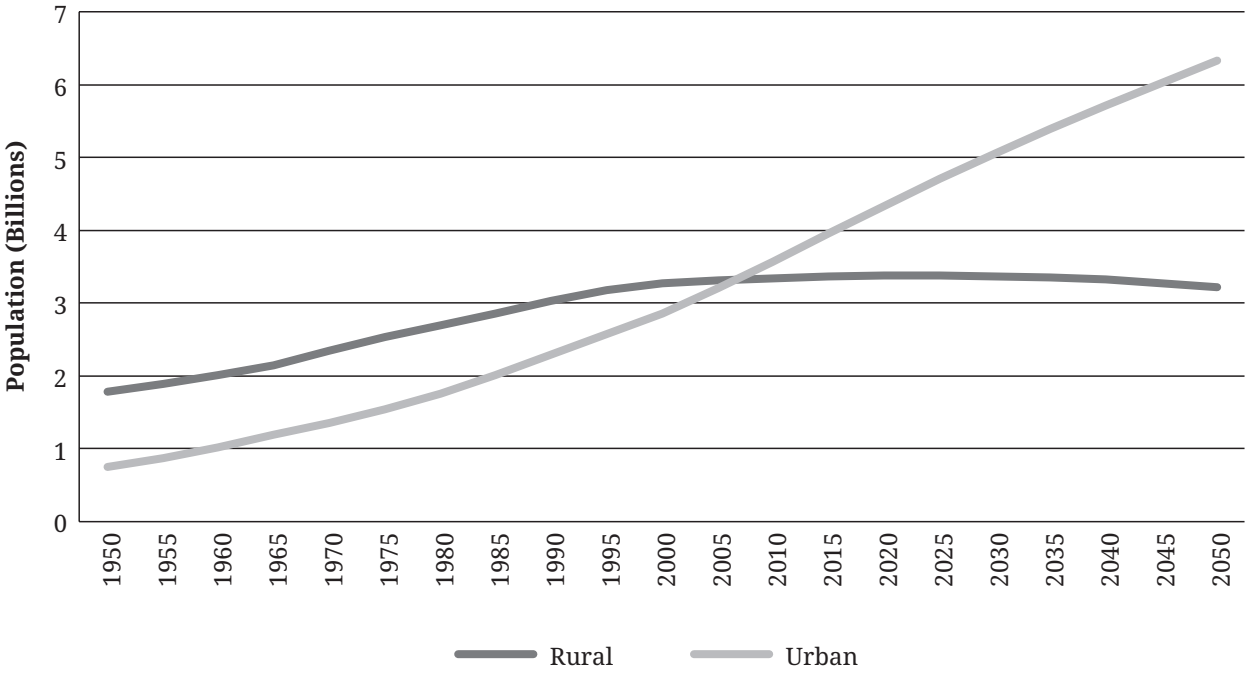
As the overall global population ages, it will cut the dependency ratio of old to young. The ratio of people aged 65 and older globally will grow from 8.3 percent in 2015 to 15.0 percent by 2045. In more developed regions of the world that proportion will grow from 17.6 percent to 25.8 percent. Currently, there are approximately eight young people (aged 15–64 years) for every person 65 years and older in the world. That dependency ratio will fall from its present 7.9:1 to 4.2:1 by 2045. The least developed countries will have the best dependency ratio in 2045, at 10.6:1, while the more developed regions will stand at only 2.3:1. Japan, Italy, and Spain will have the worst dependency ratios, all at a shocking 1.5:1.

These aging populations will have major implications for the economy and government budgets. As people retire, they typically draw down their savings, eliminating one source of capital for the economy and financial markets. They pay a lower share of taxes than the working-age population does, leading to smaller overall fiscal budgets. And perhaps most important, many developed countries have established large social security programs to provide for the elderly. A growing elderly population, especially when combined with all-time low payer-payee ratios, will further strain government resources. The United States alone, by some projections, has more than $200 trillion in unfunded liabilities—largely from social programs.[8] These unfunded liabilities are 12 times the size of the economy and the current level of national debt.

Given an aging—and, in many places, shrinking—population, many developed countries will be forced to compete for immigrants in the future. This competition will dramatically shift political debates on immigration, globalization, and the relationship between the citizen and the state. And while the United States currently possesses distinct advantages over rivals China and India in this competition, an arcane immigration system prevents it from maximizing possible benefits.

8. Laurence Kotlikoff, interview by Jim Puplava, "A Conspiracy to Hide the Truth: Why the True U.S. Government Debt Is $205 Trillion," *Economic Policy Journal*, November 9, 2013, http://www.economicpolicyjournal.com/2013/11/a-conspiracy-to-hide-truth-why-true-us.html.

World Population, Rural vs. Urban, 1950–2050



Data Source: UN DESA Population Division, *World Urbanization Prospects: The 2014 Revision*.

URBANIZATION

In addition to growing and aging, the world's population is also becoming more urban. The year 2007 marked the first year that more people lived in urban than in rural areas.[9] While more than 53 percent of the global population currently lives in cities, that proportion will grow to nearly 65 percent by 2045. In fact, the overall rural population globally will reach its peak in the next decade, according to the United Nations, and will actually decline by 90 million between 2015 and 2045.

Unlike overall population growth trends, which vary widely by region, this increasingly urban trend will affect every major region of the globe.[10] North and South America are, and will remain, the most urbanized continents, but the gap will shrink as less developed regions urbanize at faster rates. And while Africa and Asia are currently more rural than urban, both continents will be more urban than rural by 2045 (53 and 62 percent, respectively).

While "medium-sized cities and cities with less than 1 million inhabitants located in Asia and Africa" will see the fastest growth, another important aspect of the urbanization trend is the growth of "megacities," or cities with a population of more than 10 million.[11] There are currently 29 such megacities, and the United Nations estimates that by 2030 there will be 41.

9. UN DESA Population Division, "Urban and Rural Populations," *World Urbanization Prospects: The 2014 Revision*, http://esa.un.org/unpd/wup/CD-ROM/Default.aspx.

10. UN DESA Population Division, *World Urbanization Prospects: The 2014 Revision, Highlights* (New York: United Nations, 2014), http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf.

11. Ibid., 1.

Although cities are important drivers of economic, cultural, and social progress, increasing urbanization will create myriad challenges as well. Many megacities are coastal, so they are particularly at risk of rising sea levels due to climate change. According to one World Bank report, potential risks include "accelerated sea level rise, increase in sea surface temperatures, intensification of tropical and extra tropical cyclones, extreme waves and storm surges, altered precipitation and runoff, and ocean acidification."[12]

Another danger for many megacities is that of subsidence, due in part to development practices. According to a recent study by the Deltares Research Institute in the Netherlands, parts of Jakarta, Ho Chi Minh City, Bangkok, and many other coastal cities will sink below sea level without necessary action.[13] The authors estimate that the damage of urban subsidence globally is in the range of billions of dollars annually. Continued urbanization and development, especially in coastal megacities, will only exacerbate this risk in the future.

Some megacities also pose additional dangers to their populations. People in many megacities, moving from rural areas in search of employment, live in slums and shantytowns without access to basic sanitation. According to a recent Atlantic Council report, "Slum formation has been a central characteristic of rapid urbanization in the global South and is expected to continue well into the future."[14] The authors note that up to a billion people may now live in slums globally, which is of concern as "slum conditions create serious economic, social, political, and physical insecurities that can spread outward."[15] Many face a very real danger of violence from criminal elements or exposure to communicable diseases. And the problem will only grow in the future—the United Nations estimates that without concerted global action, the global slum population could reach 2 billion by 2030.[16]

The U.S. military—particularly the Army and Marines—are ill equipped to handle the requirements of future combat in dense urban environments. In a recent study, commissioned by Gen. Raymond Odierno, former chief of staff of the Army (CSA), the authors suggest, "A gap exists in the Army's doctrinal understanding of large cities."[17] The report argues that "fundamental assumptions" about traditional maneuver warfare are flawed when it comes to fighting in megacities. Impressively, the report calls upon the institution to use "imagination and a willingness to make bold choices" about its doctrine,

12. International Bank for Reconstruction and Development, *Climate Risks and Adaptation in Asian Coastal Megacities: A Synthesis Report* (Washington, DC: World Bank, 2010), xi, http://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf.

13. Gilles Erkens, Tom Bucx, Rien Dam, Ger De Lange, and John Lambert, "Sinking Coastal Cities," *Geophysical Research Abstracts* 16 (2014), http://media.egu.eu/media/documents/2014/11/gilles_erkens_scientific_abstract.pdf.

14. Peter Engelke and Magnus Nordenman, "Megacity Slums and Urban Insecurity," Atlantic Council, January 30, 2014, http://www.atlanticcouncil.org/blogs/futuresource/megacity-slums-and-urban-insecurity.

15. Ibid.

16. UN News Centre, "Urban Slum Dwellers Could Double to 2 Billion by 2030, UN Agency Says," October 1, 2003, http://www.un.org/apps/news/story.asp?newsid=8427.

17. Chief of Staff of the Army, Strategic Studies Group, *Megacities and the United States Army: Preparing for a Complex and Uncertain Future* (Arlington, VA: U.S. Army, 2014), 8, http://usarmy.vo.llnwd.net/e2/c/downloads/351235.pdf.

organization, training, materiel, leadership, personnel, and facilities (DOTMLPF) to address these challenges.[18] The study concludes, "To ignore megacities is to ignore the future."[19]

2. Economics and National Power

The United States' military strength indisputably hinges on its economic might. As acknowledged in the Quadrennial Defense Review (QDR), the U.S. economy "remains the foundation of U.S. power."[20] While economic strength does not guarantee military power, states cannot field truly world-class militaries without sufficient capital.

GROSS DOMESTIC PRODUCT (GDP) GROWTH AND MILITARY EXPENDITURES

The United States has long been the top economy globally, having surpassed the United Kingdom as early as the 1870s.[21] But in late 2014, China claimed the title of world's largest economy in purchasing power parity terms, and current projections indicate it will do the same in real GDP sometime between 2020 and 2030.[22]

While the relationship between economic strength and defense spending is clear, it is not necessarily linear. Comparing International Monetary Fund (IMF) GDP estimates with data from the Stockholm International Peace Research Institute (SIPRI) on military expenditures (all estimates from 2014) demonstrates this relationship.[23] Looking specifically at military expenditures by top 20 defense spending countries and top 20 GDP countries,[24] the average is approximately 2.4 percent of GDP spent on defense.[25] Yet this percentage was pulled up by the United States, which spent approximately 3.5 percent of its 2014 GDP on defense.[26] Excluding the United States, the remaining 23 countries spent roughly 2.0 percent of GDP on defense, on average. Ironically, that number matches what North Atlantic Treaty Organization (NATO) members have agreed to spend. Many NATO countries, however, significantly lag their 2 percent spending target. These "light" defense

18. Ibid., 21.
19. Ibid., 4.
20. DoD, *Quadrennial Defense Review 2014*, 9.
21. James Pethokoukis, "Sorry, China, the US Is Still the World's Leading Economic Power," American Enterprise Institute, April 30, 2014, http://www.aei-ideas.org/2014/04/sorry-china-the-us-is-still-the-worlds-leading-economic-power/.
22. Estimates range from as early as 2019 to nearly 2030. The U.S. National Intelligence Council's *Global Trends 2030* report suggests "a few years before 2030." National Intelligence Council (NIC), *Global Trends 2030: Alternative Worlds* (Washington, DC: NIC, 2012), iv, http://www.dni.gov/files/documents/GlobalTrends_2030.pdf.
23. Data compiled using the IMF's "World Economic Outlook Database" (April 2015, http://www.imf.org/external/pubs/ft/weo/2015/01/weodata/download.aspx) and SIPRI's "Military Expenditure Database" (accessed August 19, 2015, http://www.sipri.org/research/armaments/milex/milex_database).
24. For a total of 24 countries, as Mexico, Indonesia, the Netherlands, and Switzerland all ranked in the top 20 in terms of GDP but not military expenditures. Conversely, the United Arab Emirates (UAE), Colombia, Israel, and Algeria ranked in the top 20 for military expenditures, but not GDP.
25. No data available for Iran, Syria, Qatar, Kuwait, and Yemen (among others), which could alter the overall percentage if one of these were within the top 20 defense spenders.
26. Typically military expenditures are compared as a percentage of overall budgets, not GDP, yet the example is illustrative when considering that GDP is the total value of production of a country in a given year (combining consumer, government, and business spending with net exports).

Top 10 Economies by Real GDP in U.S. Dollars (USD)

	2011	*GDP (2011 USD TRN)*	*2030*	*GDP (2011 USD TRN)*	*2050*	*GDP (2011 USD TRN)*
1	U.S.	15.09	China	24.36	China	48.48
2	China	7.30	U.S.	23.38	U.S.	38.00
3	Japan	5.87	India	7.92	India	26.90
4	Germany	3.57	Japan	6.82	Brazil	8.95
5	France	2.77	Brazil	4.88	Japan	8.07
6	Brazil	2.48	Germany	4.37	Russia	7.12
7	UK	2.43	Russia	4.02	Mexico	6.71
8	Italy	2.20	France	3.81	Indonesia	5.95
9	Russia	1.86	UK	3.61	Germany	5.82
10	India	1.85	Mexico	2.83	France	5.71

Data Source: PricewaterhouseCoopers, "World in 2050: The BRICs and Beyond: Prospects, Challenges and Opportunities," January 2013, http://www.pwc.com/en_GX/gx/world-2050/assets/pwc-world-in-2050-report-january-2013.pdf.

spenders (spending below trend) include not only allies such as Germany and Japan but also China. Simply moving China up to the trend line would represent a nearly $90 billion increase in spending. Extrapolating further, if China, which currently spends 2.1 percent of its GDP on defense, expanded to levels of U.S.-defense spending (by percent), it would represent a 68 percent growth in defense expenditures.

Even though, by nearly all accounts, the United States will be the second largest economy by 2045, if defense spending as a percent of GDP remains at current levels, the United States might still rank highest in overall military expenditures. Yet as its economy falls further and further behind China's, the percentage of GDP required to match Chinese defense expenditures (if they maintain a constant rate) will continue to increase.

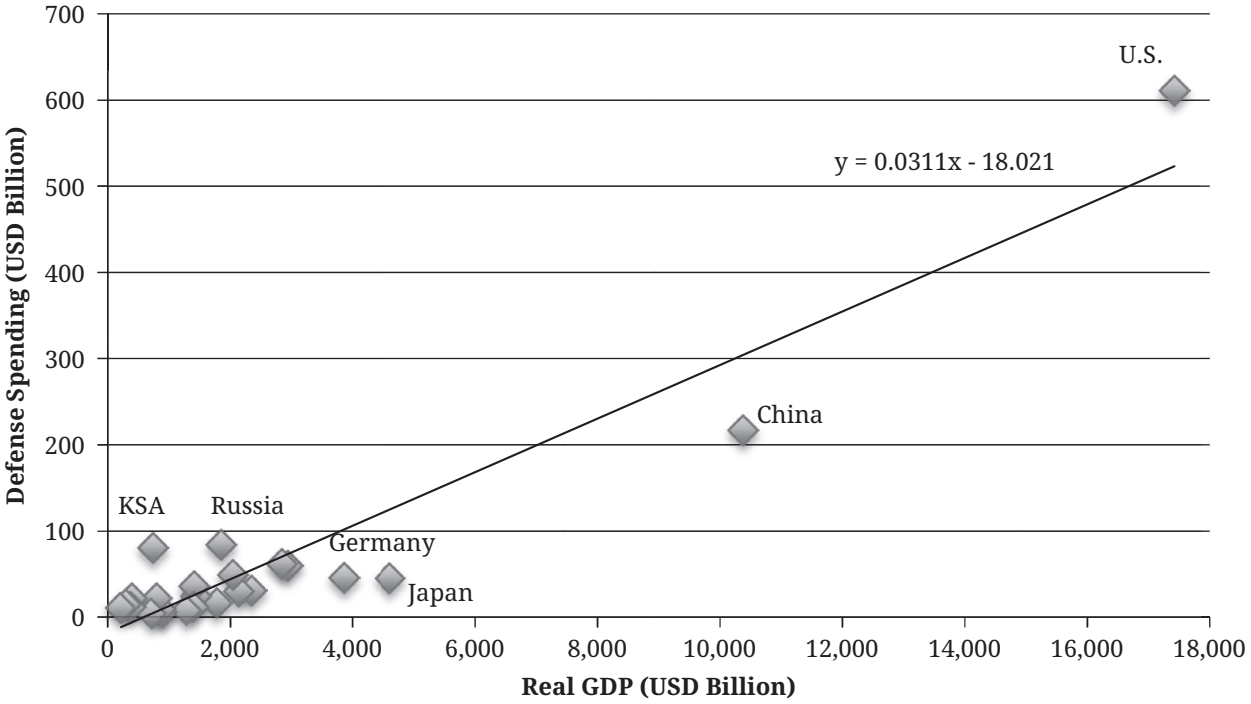
For the time being, however, the United States will remain the dominant global military power. One important reason is the United States' overwhelming accumulated military capital stock—in terms of not only physical equipment and weapons but also R&D, doctrine and training, and professionalization of the force. According to leading international relations scholar Dr. Joseph Nye Jr., while Chinese military spending may reach near parity with the United States' by midcentury, "in accumulated stocks of modern military equipment, the United States retains at least a 10:1 advantage over China without even counting American allies."[27]

DEBT AND SPENDING

> The most significant threat to our national security is our debt.—Admiral Michael Mullen (USN, ret.)[28]

27. Joseph S. Nye Jr., *Is the American Century Over?* (Malden, MA: Polity Press, 2015), 57.
28. CNN Wire Staff, "Mullen: Debt Is Top National Security Threat," CNN, August 27, 2010, http://www.cnn.com/2010/US/08/27/debt.security.mullen/.

2014 Defense Spending vs. GDP Comparison (USD Billion)



Data Source: SIPRI, IMF.

Public-sector debt burdens have been on the rise across much of the developed world for years. In the wake of the 2007–2008 financial crisis, deleveraging has been a significant headwind for economic growth. While projections for debt trajectories are not as abundant as those for GDP, clearly for much of the developed world, high levels of public-sector debt are here to stay.

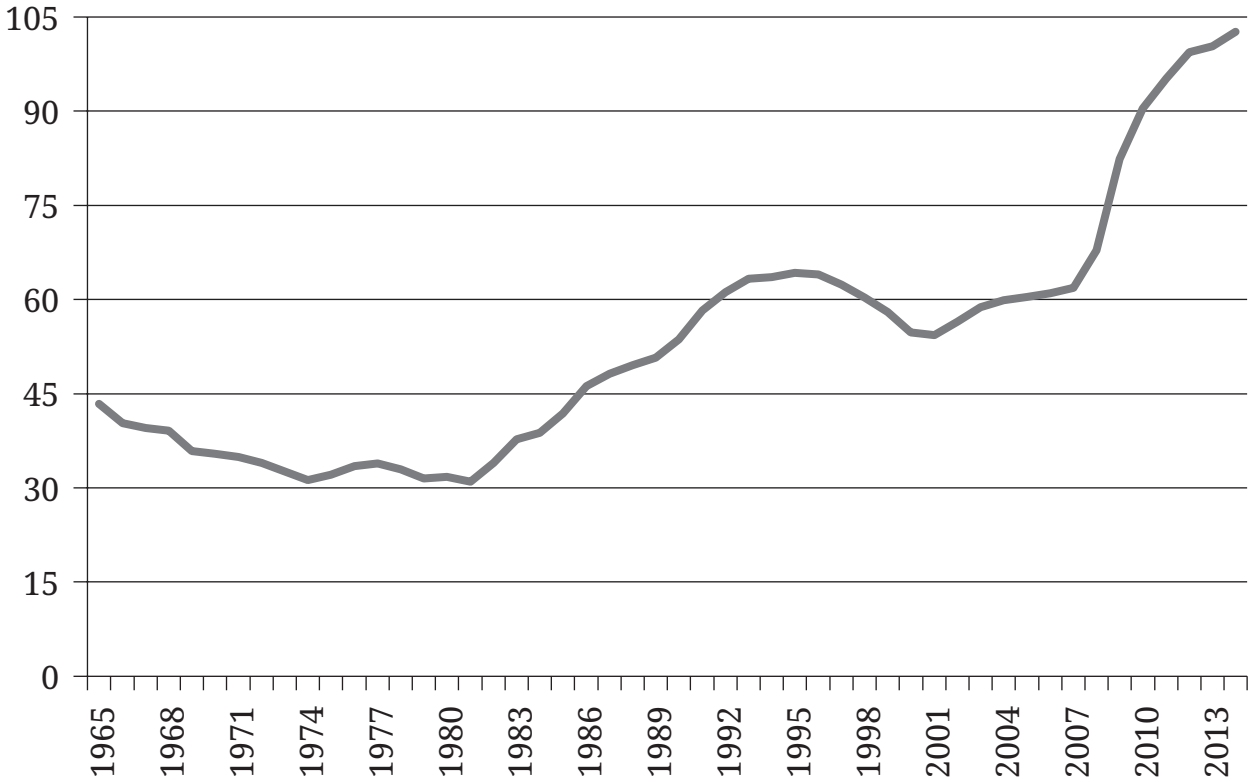
U.S. gross federal debt (including debt held by the public and other parts of the federal government) has been on the rise since 2001 and saw rapid expansion beginning with the 2007–2008 financial crisis and recession.

Much of the developed world's debt obligations stem from social programs, such as retirement and health benefits. According to the Congressional Budget Office (CBO), "Aging is the key driver of spending over the next 25 years," when considering increases in cost of social security and major health care programs.[29] CBO projections also suggest that the proportion of the federal budget spent on servicing debt obligations will nearly triple over the next quarter century—possibly representing the greatest increase of any component of federal spending if current policies are unchanged.[30]

29. U.S. Congressional Budget Office (CBO), "The 2014 Long-Term Budget Outlook in 26 Slides," July 2014, http://www.cbo.gov/sites/default/files/cbofiles/attachments/45527-SlideDeck.pdf.

30. Ibid., analysis based on Slide 4, "Components of Federal Spending."

U.S. Gross Federal Debt as a Percentage of GDP as of 2014



Data Source: Federal Reserve Bank of St. Louis FRED Database, "Gross Federal Debt as Percent of Gross Domestic Product," last updated July 30, 2015, http://research.stlouisfed.org/fred2/series/GFDGDPA188S#.

These debt burdens are not solely a U.S. affliction. According to the World Bank, "Since the onset of the global economic crisis in 2008, the level of public debt has increased significantly in many countries but this has been particularly pronounced in the world's more advanced economies."[31] In fact, according to a recent report by McKinsey Global Institute, "rather than reducing indebtedness, or deleveraging, all major economies today have higher levels of borrowing relative to GDP than they did in 2007. . . . That poses new risks to financial stability and may undermine global economic growth."[32] And while their analysis highlights some of the usual offenders—Ireland, Singapore, and Greece were the three countries that increased their leverage the most since 2007, for example—they worryingly note that "China's total debt has nearly quadrupled" and in terms of debt-to-GDP surpasses that of the United States.[33]

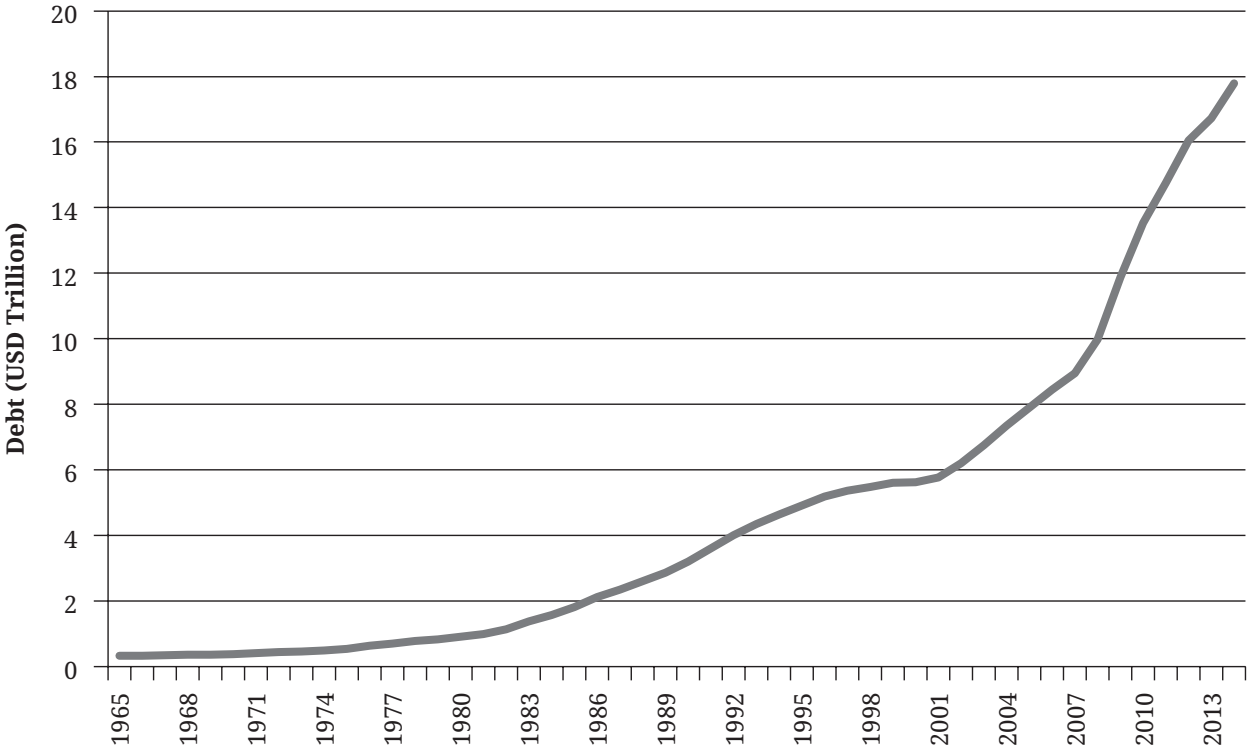
Much of this debt burden will continue to result from age-related unfunded liabilities. According to a report by the Bank of International Settlements (BIS), the omission of these

31. World Bank, *International Debt Statistics 2013* (Washington, DC: World Bank, 2013), 14, http://data.worldbank.org/sites/default/files/ids-2013.pdf.

32. Richard Dobbs, Susan Lund, Jonathan Woetzel, and Mina Mutafchieva, *Debt and (Not Much) Deleveraging* (n.p.: McKinsey Global Institute, 2015), http://www.mckinsey.com/insights/economic_studies/debt_and_not_much_deleveraging.

33. Ibid.

U.S. Gross Federal Debt (USD Trillion) as of 2014



Data Source: Federal Reserve Bank of St. Louis FRED Database, "Gross Federal Debt," last updated 20 February 2015, http://research.stlouisfed.org/fred2/series/FYGFD#; White House Council of Economic Advisers.

unfunded liabilities "leads us to the obvious conclusion that any assessment of the government fiscal situation based on a short-term perspective is incomplete and at best misleading."[34]

Debt levels for many advanced economies are already significant, and barring substantial debt write-offs (and the corresponding negative economic effects), the cost of debt service will continue to grow. It is likely that without a major change in policy, military budgets will continue to feel pressure across much of the developed world. Leading economist Dr. Carmen Reinhart, for one, is unequivocal: "There are going to be major impacts on defense spending, based on demographics."[35] By 2045, even developing countries such as China will undergo demographic transitions that will begin to lower productivity and provide additional detractions from defense spending.

If the current trajectory of U.S. defense spending remains, the U.S. military in the future will be a diminished force. According to the 2014 QDR, "If the fiscal environment does not improve, by 2021 the Joint Force will be too small and insufficiently modern to

34. Stephen G. Cecchetti, M. S. Mohanty, and Fabrizio Zampolli, *The Future of Public Debt: Prospects and Implications*, BIS Working Papers No. 300 (Basel: Bank for International Settlements, 2010), 6, http://www.bis.org/publ/work300.pdf.

35. Carmen Reinhart, interview with the author, January 20, 2015.

fully implement our defense strategy."[36] Looking even further out, according to a 2014 CSIS report, "If current [budget] trends continue . . . there will be no room for discretionary spending, either defense or nondefense, by 2036. In a real sense, the debate over whether the BCA sequester-level cuts will be lifted by FY 2021 is moot, because the larger vise on the U.S. federal budget—caused by the growing gap between entitlement programs spending and government revenue—will result in a deep defense drawdown."[37]

The Department of Defense (DoD) must determine how best to navigate the challenges of reduced defense spending while simultaneously managing growing personnel costs. From 2000 to 2014, the defense budget grew by 31 percent, for an average annual growth rate of 1.9 percent.[38] Military personnel costs grew by 46 percent, or 2.7 percent annually, over the same period. Yet these numbers fail to include the cost of maintaining the Defense Health Program, which provides medical care to "more than 9 million beneficiaries," from active duty, activated National Guard and Reserve, retirees, and their families.[39] Healthcare costs over this period rose an untenable 101 percent. And the CBO projects that healthcare spending will grow at an annualized 2.2 percent in real terms between 2015 and 2030.[40]

TRADE AND CURRENCY

The U.S. dollar has served as the world's primary reserve currency since the establishment of the Bretton Woods system in the 1940s and remains the currency most used in international trade and finance. Its status provides myriad benefits to the United States. For example, foreign willingness to accumulate dollar reserves has reduced (if not eliminated) the U.S. requirement of maintaining a current account balance.[41] This has enabled the United States to expand consumption, as foreign creditors provided capital inflows. Additionally, it has helped enable the government to run budget deficits for much of the past 40 years. According to a 2009 analysis by McKinsey Global Institute, treasury purchases by foreign creditors "reduced the U.S. borrowing rate by 50 to 60 basis points in recent years, generating a financial benefit of $90 billion."[42]

Yet the dollar's status as the world's reserve currency is under pressure. As a result of growing budget deficits, a decline in U.S. share of global output, excess money creation, and persistent current account deficits, the dollar's status as world reserve currency has

36. DoD, *Quadrennial Defense Review 2014*, 56.

37. Clark Murdock, Ryan Crotty, and Angela Weaver, *Building the 2021 Affordable Military* (Washington, DC: CSIS, June 2014), 2–3, http://csis.org/files/publication/140625_Murdock_Building2021Military_Web.pdf.

38. CBO, "Growth in DoD's Budget from 2000 to 2014," November 2014, https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/49764-MilitarySpending.pdf.

39. Ibid., 5.

40. CBO, *Long-Term Implications of the 2015 Future Years Defense Program* (Washington, DC: CBO, 2014), 24, https://www.cbo.gov/sites/default/files/cbofiles/attachments/49483-FDYP.pdf.

41. Bob McTeer, "Reserve Currency Status—a Mixed Blessing," *Forbes*, September 5, 2013, http://www.forbes.com/sites/bobmcteer/2013/09/05/reserve-currency-status-a-mixed-blessing/.

42. Richard Dobbs, David Skilling, Wayne Hu, Susan Lund, James Manyika, and Charles Roxburgh, *An Exorbitant Privilege? Implications of Reserve Currencies for Competitiveness* (n.p.: McKinsey Global Institute, 2009), http://www.mckinsey.com/insights/economic_studies/an_exorbitant_privilege.

trended down since 1976.[43] Currently, the euro stands as the second largest proportion of the world's allocated reserves, at 22.6 percent (compared with the dollar's 62.3 percent), and in terms of total world trade payments, at 29.3 percent (compared with the dollar's 43.5 percent).[44] Yet China has been aggressively pursuing expanded use of its currency, the renminbi (RMB), as an alternative to the dollar. In 2013, the RMB passed the euro as the second-most-used currency in trade finance.[45]

And while the RMB is still used only in a small proportion of global trade—and RMB-denominated assets account for a low share of total reserve assets—that may change in the future. According to Reinhart, "The renminbi is going to be a player in world currency markets . . . and it reflects the increased size and global importance of China. China's trade with the rest of the world has increased dramatically. Where there is trade, ultimately there is going to be finance."[46] Unlike in the case of Japan, which never particularly sought an international role for the yen, China clearly wants such an expanded role. And in Reinhart's opinion, "I think they're going to get it."[47]

One major justification for the RMB's greater role in international finance and foreign exchange markets lies in expanded opportunities for convertibility. If, as many economists predict, China increases transparency of its economy and capital markets, reduces capital control requirements, and provides additional liquidity of the RMB, more countries will undoubtedly seek to purchase RMB-denominated reserves, if for no reason other than diversification. Geopolitical reasons may also help bolster the RMB's rise. Following economic sanctions against Russia in 2014 and the ruble's considerable slide against the dollar, many Russian corporations began looking to conduct trade in RMB instead of dollars—a move the Chinese support.[48] And in 2014, the BRICS countries (Brazil, Russia, India, China, and South Africa) established a $50 billion New Development Bank in Shanghai and an additional $100 billion liquidity reserve to rival the World Bank.[49]

The dollar will likely remain the world's largest reserve currency in 2045, but its status may be heavily eroded. According to the UK Ministry of Defense (MoD), "The Renminbi is

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43. Jeffrey Frankel, "The Latest on the Dollar's International Currency Status," VOX.com, December 6, 2013, http://www.voxeu.org/article/dollar-s-international-status.

44. IMF, "Currency Composition of Official Foreign Exchange Reserves (COFER)," accessed January 21, 2015, (n.24), http://data.imf.org/?sk=E6A5F467-C14B-4AA8-9F6D-5A09EC4E62A4; Society for Worldwide Interbank Financial Telecommunication (SWIFT), "Renminbi (RMB) Monthly Tracker 2014," November 2014, http://www.swift.com/products_services/renminbi_reports.

45. SWIFT, "RMB Now 2nd Most Used Currency in Trade Finance, Overtaking the Euro," December 3, 2013, http://www.swift.com/about_swift/shownews?param_dcr=news.data/en/swift_com/2013/PR_RMB_nov.xml.

46. Reinhart interview.

47. Ibid.

48. Jack Farchy and Kathrin Hille, "Russian Companies Prepare to Pay for Trade in Renminbi," CNBC, June 8, 2014, http://www.cnbc.com/id/101741727; Chen Aizhu and Huang Kai, "China Proposes Broadening Use of Yuan for Trade with Russia: Report," Reuters, December 21, 2014, http://www.reuters.com/article/2014/12/21/us-china-russia-idUSKBN0JZ02U20141221.

49. Jordan Totten, "BRICS New Development Bank Threatens Hegemony of U.S. Dollar," *Forbes*, December 22, 2014, http://www.forbes.com/sites/realspin/2014/12/22/brics-new-development-bank-threatens-hegemony-of-u-s-dollar/.

unlikely to replace the U.S. dollar as the pre-eminent reserve currency in the 2045 timeframe, but it may become a rival to it."[50] Another possible challenge to the dollar comes from the rise of stateless, virtual currencies, such as Bitcoin. According to the UK MoD's report, "States' monopoly on money is likely to be increasingly eroded by alternative currencies out to 2045."[51] One possible reason is because "alternative currencies may be able to bypass emergency capital controls or other measures taken by governments in the wake of financial crises."[52] In their assessment, the growth of these alternative currencies will constitute "the main shift in the financial landscape" out to 2045.[53] Even if digital currencies fail to undermine traditional state-backed money as a store of value, "there is vast potential in using [them] as a medium of exchange."[54] Digital currency "has the potential to be more transformative than anything we've seen before" and expands upon such innovations as crowdfunding, microlending, and new digital payment systems such as Square or Apple Pay.[55] Some have called this effect the "democratization of finance," and its growth has major implications for not just currency markets, but also other traditional power structures.

3. Power Diffusion

> Two great power shifts are occurring in this century: a power transition among states and a power diffusion away from all states to nonstate actors.[56]—Dr. Joseph S. Nye Jr.

> Traditional power structures are losing their monopolies on authority in many areas of human affairs.[57]—General Martin E. Dempsey, former Chairman of the Joint Chiefs of Staff

Since the Peace of Westphalia in 1648, the nation-state has held a preeminent position in defining international order. Nations have been the only political actors sufficiently capable of fielding large militaries or upholding international treaties. Yet this trend has begun to reverse recently, as international corporations, nongovernmental organizations, and transnational threat groups have gained a disproportionate ability to wage both war and peace on the world stage. While the nation-state will not soon cease to be the primary governing authority, this diffusion of power will greatly shape the FSE.

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50. UK MoD Development, Concepts, and Doctrine Center, *Global Strategic Trends—Out to 2045*, 5th ed. (London: MOD, 2014), 80, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/348164/20140821_DCDC_GST_5_Web_Secured.pdf.
51. Ibid., 78.
52. Ibid.
53. Ibid.
54. Greg Satell, "The Future of Money," *Forbes*, November 8, 2014, http://www.forbes.com/sites/gregsatell/2014/11/08/the-future-of-money/.
55. Ibid.
56. Joseph S. Nye Jr., *The Future of Power* (New York: PublicAffairs, 2011), xv.
57. Martin E. Dempsey, "The Bend of Power," *Foreign Policy*, July 25, 2014, http://www.foreignpolicy.com/articles/2014/07/25/the_bend_of_power_us_leadership_military_martin_dempsey.

Top 30 Global Entities by GDP or Revenue in 2014 (USD Billions)

Rank	*Entity*	*GDP/ Revenue*	*Rank*	*Entity*	*GDP/ Revenue*	*Rank*	*Entity*	*GDP/ Revenue*
1	United States	17,418.93	11	Canada	1,788.72	21	Nigeria	573.65
2	China	10,380.38	12	Australia	1,444.19	22	Sweden	570.14
3	Japan	4,616.34	13	Korea	1,416.95	23	Poland	546.64
4	Germany	3,859.55	14	Spain	1,406.86	24	Argentina	540.16
5	United Kingdom	2,945.15	15	Mexico	1,282.73	25	Belgium	534.67
6	France	2,846.89	16	Indonesia	888.65	26	Taiwan	529.55
7	Brazil	2,353.03	17	Netherlands	866.35	27	Norway	500.24
8	Italy	2,147.95	18	Turkey	806.11	28	**Wal-Mart**	485.65
9	India	2,049.50	19	Saudi Arabia	752.46	29	**Sinopec Group**	446.81
10	Russia	1857.46	20	Switzerland	712.05	30	Austria	437.12

Data Source: IMF, "World Economic Outlook Database"; "Global 500: 2015," *Fortune*, accessed August 20, 2015, http://fortune.com/global500.

NON-STATE ACTORS

As previously mentioned, economic strength is the backbone of military power, largely because it represents the means to fund a standing military. Yet many multinational corporations can match the sheer economic strength of nation-states. Two corporations (Wal-Mart Stores and Sinopec Group) rank among the top 30 global entities by output (GDP for countries, revenue for companies). When the list is expanded to the top 100 countries or companies, 39 corporations make the list. Adding subnational governments, such as states/provinces or cities/municipalities, would provide an even more eclectic ranking.

The wars in Iraq and Afghanistan saw the rise of private security contractors for both government organizations and corporations. These security contractors provide security consulting or training, risk analysis, physical protection of facilities, and mobile protection for personnel. Academi, formerly Blackwater, has historically received the vast majority of its contracts from government entities. But the company, according to *The Economist*, suggested that in the future it might generate half its revenue from corporations.[58] The United Nations estimates that the soldier-for-hire business is rapidly growing and will reach $244 billion by next year.[59] And as the threat of disruptive cyber attacks grows, business spending on security-related measures will continue to grow as well. Global cybersecurity expenditures in 2013 were an estimated $46 billion and remain one of the fastest growth areas of information-technology business spending.[60] As this trend continues, it becomes

58. "Bullets for Hire," *The Economist*, November 17, 2012. http://www.economist.com/news/international/21566625-business-private-armies-not-only-growing-changing-shape-bullets-hire.

59. Office of the High Commissioner for Human Rights, "Report of the Working Group on the Use of Mercenaries as a Means of Violating Human Rights and Impeding the Exercise of the Right of Peoples to Self-Determination to the 68th Session of the UN General Assembly, 20 August 2013," 7, http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N13/432/64/PDF/N1343264.pdf?OpenElement.

60. Samuel Rubenfeld, "Cybersecurity Spending Set to Rise to $46 Billion," *Wall Street Journal*, July 17, 2013, http://blogs.wsj.com/riskandcompliance/2013/07/17/cybersecurity-spending-set-to-rise-to-46-billion/.

ever clearer that the nation-state's recent monopoly on military power across both conventional and unconventional domains will erode further in the future.

Given a more interconnected world and access to increasingly advanced technologies, non-state actors will likely play a greater role in conflict by 2045. According to Nye, "For all the fashionable predictions of China, India, or Brazil surpassing the United States in the next decades, the greater threats may come from modern barbarians and nonstate actors."[61] Even more important, "Conventional wisdom has always held that the state with the largest military prevails, but in an information age it may be the state (or nonstates) with the best story that wins."[62] As Nye highlights, non-state actors are not new phenomena, but what are new are both the increasing frequency of intrastate conflict as well as increased lethality given new technologies, such as cyber weapons.[63] According to Dr. Matthew Burrows, principal author of the last three *Global Trends* documents, "Sadly for the future, the kind of destruction witnessed on 9/11 is the tip of the iceberg of what terrorists, insurgents, and states can do."[64]

Beyond military power, nongovernmental organizations (NGOs) and other charitable foundations have, in many respects, usurped governments in the role of combatting global ills, such as poverty, disease, and lack of essential services. The Bill and Melinda Gates Foundation, for example, provided $6.64 billion in grants and charitable contributions in 2012–2013; in contrast, the entire World Health Organization (WHO) operating budget during that time was only $3.96 billion.[65] International relief organizations such as Doctors Without Borders are often the first to respond to public health emergencies across the developing world. And multinational corporations may in many respects have better access to and knowledge of potential conflict areas than the U.S. Intelligence Community, especially when it comes to infrastructure or resources such as food, water, and energy.[66]

The ongoing power devolution means that in many locations, especially those most prone to crisis and instability in the future, even local national and subnational governments have an insufficient understanding of "ground-truth" and lack the ability to effectively influence events. Instead, religious groups, powerful business leaders, or even illicit actors like criminal networks or mafia may hold true legitimacy and power. It will be important for the U.S. military to understand these relationships and power structures in future interventions. And to build that awareness, DoD should look to those groups already possessing institutional knowledge, which in many cases means NGOs or multinational corporations.

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61. Nye, *The Future of Power*, xii.
62. Ibid., xiii.
63. Ibid., 26.
64. Matthew Burrows, *The Future, Declassified* (New York: Palgrave Macmillan, 2014), 4.
65. Bill and Melinda Gates Foundation data from 2013 and 2012 Consolidated Financial Statements, http://www.gatesfoundation.org/~/media/GFO/Who%20We%20Are/Financials/2013_FINAL%20GatesFoundation%20Program_FS.pdf; WHO budget data from its "Proposed Programme Budget 2014–2015," statement to the 66th World Health Assembly, April 19, 2013, 8, http://www.who.int/about/resources_planning/A66_7-en.pdf?ua=1.
66. Examples include Coca-Cola's water projects in Africa.

MULTI-/NON-POLARITY

The diffusion of power is also evident in the international order. The Cold War represented a bipolar world, as the two global superpowers—and their corresponding economic and social systems—clashed on the world stage. Following the collapse of the Soviet Union, the United States emerged as the sole global superpower, and the past three decades have been defined primarily through a lens of U.S. hegemony. But most now view that hegemony in decline. China, as the world's second-largest economy and military spender, has emerged as a counterbalance to the United States. Old international systems such as the G-7/G-8 have been supplanted by the G-20. While the United States may remain the predominant military, political, or cultural leader for some time, it is clear that in the coming decades, the United States must work within the confines of a much more crowded, nontraditional, international arena.

China immediately comes to mind when considering the state likely to displace the United States as global leader. But by 2045, India as well may rival the United States, according to a four-component power index consisting of GDP, population size, military spending, and technology, as reported by the National Intelligence Council (NIC).[67] The NIC concludes, "In a tectonic shift, by 2030, Asia will have surpassed North America and Europe combined in terms of global power."[68]

While many have argued that a new era of multipolarity is upon us, political scientist and author Ian Bremmer has suggested that the world is entering a new "G-Zero" phase. In Bremmer's opinion, the G-20 may have supplanted the G-7/G-8 following the financial crisis, but it will likely fail to effectively foster international collaboration given conflicting interests of its numerous members. According to Bremmer, the G-20 "includes members with such a broad divergence of economic and political values that it can only produce coherent, substantive solutions for problems that have already become crises—and only then when each of its most powerful members is threatened at the same moment."[69] As a result, Bremmer (writing with Dr. Nouriel Roubini in *Foreign Affairs*) believes that "the G-Zero era is more likely to produce protracted [economic and trade] conflict than anything resembling a new Bretton Woods."[70]

Some believe that states have become secondary sources of power in the twenty-first-century international system. Juan Zarate, CSIS senior adviser, argues, "In an increasingly interconnected world—where trade, financing, travel, and communications are fundamentally intertwined—the role of non-state, networked actors and systems—from corporations to influential Twitterati—often hold the keys to power and influence globally."[71] According

67. NIC, *Global Trends 2030*, 17.
68. Ibid., 16.
69. Ian Bremmer, "Welcome to the New World Disorder," *Foreign Policy*, May 14, 2012, http://www.foreignpolicy.com/articles/2012/05/14/welcome_to_the_new_world_order.
70. Ian Bremmer and Nouriel Roubini, "A G-Zero World," *Foreign Affairs*, March–April 2011, http://www.foreignaffairs.com/articles/67339/ian-bremmer-and-nouriel-roubini/a-g-zero-world.
71. Juan Zarate, "Can We Adapt to the Changing Nature of Power in the 21st Century?," in *2014 Global Forecast: U.S. Security Policy at a Crossroads*, ed. Craig Cohen, Kathleen Hicks, and Josiane Gabel (Washington, DC: CSIS, 2013), 59, https://csis.org/files/publication/131029_Cohen_GlobalForecast2014_WEB.pdf.

to Zarate, "It's not enough to say that power has shifted—we need to recognize that state-based power may no longer be central to exerting influence in this new environment." He goes on to argue that even though "classic state power still matters, a new national security model must take into account . . . the role of non-state networked actors . . . in parallel with classic state power."[72] He further suggests, "In the 21st century, the nation that galvanizes the majority of these new global voices will enjoy more power and exert more influence than has ever before been possible."[73]

While leading scholars disagree about the precise nature of power transfer or devolution in the future, the consensus is clearly that nation-states will have more difficulty exerting their will. Nye, in *The Future of Power*, describes the nature of power globally in the modern age as resembling a three-dimensional chessboard.[74] The top dimension is that of typical military hard power, in which the United States maintains unipolarity. The middle layer is one of economic strength, which is and has been multipolar for some time, with the United States, China, Japan, and Europe as current leaders. And, finally, the lowest dimension is the realm of transnational relations in which power is widely diffused. This level includes the global financial system, information networks, and even terrorist and other illicit non-state actors. This model seems appropriate for the present, but in the future, even traditional forms of hard and soft power wielded by governments may prove less influential. According to Burrows, "The losers [in the future] in many ways are governments and other established institutions. The future won't necessarily be kind to them."[75] One such reason, according to prominent author Moises Naim, is that traditional power is not just shifting—it is decaying.[76] Stemming from this power decay, Naim suggests that the future will see "a new kind of international politics"—wherein small states can veto larger states' actions, diplomats have less relevance, and "minilateral" coalitions of the willing form to accomplish shared objectives.[77] In such a world, the effectiveness of traditional forms of state power—military, economic, or even soft power—is diminished.[78]

4. Emerging and Disruptive Technologies

Technologies can be disruptive in two key ways. First, an emerging technology can itself be disruptive. Manned flight is one such example. Or second, a combination of existing technologies can be assembled or employed in a manner that proves disruptive. An illustrative example is the tank. The disparate technologies of the tank—armored plating or armored cars, tracks, and cannons—already existed. Yet putting them together created a weapon that would change the face of maneuver warfare.

72. Ibid., 61.
73. Ibid., 60.
74. Nye, *The Future of Power*, xv.
75. Burrows, *The Future, Declassified*, 7.
76. Moises Naim, *The End of Power* (New York: Basic Books, 2013), 1.
77. Ibid., 150–156.
78. Ibid., 141.

Whereas unmanned and autonomous vehicles and sensors receive much public attention and speculation concerning future battlefield implementation, various other technologies also hold the possibility of dramatically shaping the FSE.

ADVANCED COMPUTATION/ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) and "smart" machines have been the subject of public fascination since Isaac Asimov published his influential science fiction story collection *I, Robot* in 1950. For generations, technocrats, developers, and science fiction writers have argued that soon-to-be-developed AI will provide a great boon to humanity—or spell our destruction. But like cold fusion, these prognoses always seemed too rosy; with each passing decade the timeline for the development of artificial general intelligence (AGI), that is, human-equivalent intelligence, slipped further into the future. To many, the implications of a day when humanity will interact with not only AGI but also artificial super-intelligence (ASI), seem far-fetched. Yet recent decades have witnessed significant AI development, and society now relies heavily on AI systems for even its most basic functions. One precondition for the growth of AGI has been computational capacity, and Moore's Law notwithstanding, current systems are insufficient to support AGI—much less ASI. But the development of quantum computers threatens to upend the balance, possibly rendering even the most advanced encryption algorithms useless and providing a fertile environment for the growth of ASI.

Quantum computers leverage fundamentals of quantum mechanics, such as quantum superposition, in which a quantum bit (called a qubit) can hold the value of 0 and 1 simultaneously.[79] As a result of this quantum superposition, "n" qubits actually provides the equivalent information as 2^n classical bits. A quantum computer with 30 qubits, therefore, would be more powerful than a supercomputer; with 300 qubits, a quantum computer would be more powerful than all computers on the planet.[80] This is especially significant since quantum computers, unlike classical computers, can check many different possibilities in parallel, not just in rapid succession.[81] Currently only one company has a quantum computer on the market (Canadian firm D-Wave Systems), although some scientists argue that it is not a true quantum computer.[82] D-Wave Systems sold a $10 million version to Google, NASA, and the Universities Space Research Association in 2012. Furthermore, new players will likely begin spending additional R&D money on quantum computers as new financial incentives materialize. Google, IBM, Microsoft, and even governments have begun working on developing quantum computers. One reason is that there are myriad benefits for possessing a quantum computer—especially if you have the only one. For example, most current encryption technology (symmetric encryption, or AES, and

79. Veritasium, "How Does a Quantum Computer Work?," YouTube video, posted by "Veritasium," June 17, 2013, https://www.youtube.com/watch?v=g_IaVepNDT4.

80. Michelle Simmons, "Quantum Computation, Michelle Simmons, TEDxSydney," YouTube video, posted by "Tedx Talks," June 22, 2012, https://www.youtube.com/watch?v=cugu4iW4W54.

81. Ibid.

82. Hamish Johnston, "Is D-Wave's Quantum Computer Actually a Quantum Computer?," Physicsworld.com, June 20, 2014, http://physicsworld.com/cws/article/news/2014/jun/20/is-d-wave-quantum-computer-actually-a-quantum-computer.

asymmetric encryption, or RSA) leverages the advantage of computers' inability to conduct large factorization equations.[83] But against a quantum computer, all current public key encryption would arguably be useless.[84]

Given both the technology's relative infancy and the rate at which progress is occurring, it is impossible to provide an accurate timeline of when sufficiently advanced quantum computers will be created and employed. It may be within a decade. Alternatively, the difficulties of stabilizing and scaling the qubit entanglements may prove too difficult—or costly—for practical implementation. Yet given current investment and demand, it is likely that some sort of quantum computer will be developed by the year 2045. And this development will have major implications for the rise of more advanced AI systems.

Many corporations are currently developing AI systems, and it is possible that a breakthrough for AGI could be nearer than most think. Google, in an effort to build a better search experience, has established a "Quantum AI Lab Team" and has been rapidly acquiring AI start-ups, most notably with its purchase of DeepMind for more than $500 million. In fact, Google cofounder Larry Page in a 2006 conference suggested Google's goal is to "create the ultimate search engine that can understand anything . . . everything in the world."[85] An advanced version of Google—one that could understand user intent—would indeed be AI, according to Dr. Nick Bostrom, founding director of the Future of Humanity Institute (FHI) at Oxford. In his book *Superintelligence: Paths, Dangers, and Strategies* he argues that "if somebody *were* to succeed in creating an AI that could understand natural language as well as a human adult, they would in all likelihood also either already have succeeded in creating an AI that could do everything else that human intelligence can do, or they would be but a very short step from such a general capability."[86] So the question remains: When will we see the development of AGI? Bostrom aggregated a series of surveys polling experts in relevant fields, and the answer is alarming. The median estimate was of a 10 percent probability by 2022, 50 percent probability by 2040, and 90 percent probability by 2075.

Even if development of AGI provides myriad military, economic, or societal benefits, it may also create the possibility of conflict. According to Dr. Stuart Armstrong, research fellow at FHI, "If we have an AI, we're looking at a world of mass unemployment" as well as a world of great wealth concentrated in a few hands.[87] He suggests that such a scenario may require government intervention to provide some sort of protection for basic needs but argues that it is unclear at what threshold such intervention will be likely. "It's clear that if AI replaces 90 percent of human population's work, then you need some sort of government

83. Lamont Wood, "The Clock Is Ticking for Encryption," Computerworld.com, March 21, 2011, http://www.computerworld.com/article/2550008/security0/the-clock-is-ticking-for-encryption.html.

84. Joseph Cox, "Your Encryption Will Be Useless against Hackers with Quantum Computers," Motherboard.com, September 18, 2014, http://motherboard.vice.com/read/your-encryption-will-be-useless-against-hackers-with-quantum-computers.

85. James Barrat, *Our Final Invention: Artificial Intelligence and the End of the Human Era* (New York: Thomas Dunne Books, 2013), 40.

86. Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford: Oxford University Press, 2014), 14.

87. Stuart Armstrong, interview with author, January 21, 2015.

intervention to make a livable world." But what if only 40 percent of work is displaced, or if those jobs are displaced slowly? In support of Armstrong's theory, a 2013 study by two Oxford scholars estimated that 47 percent of American jobs are at high risk of automation in the future.[88]

ADDITIVE MANUFACTURING

> Just as nobody could have predicted the impact of the steam engine in 1750—or the printing press in 1450 . . . it is impossible to foresee the long-term impact of 3D printing. But the technology is coming, and it is likely to disrupt every field it touches.—"Print Me a Stradivarius," *The Economist*, February 10, 2011

Additive manufacturing (AM), also known as "3-D printing," produces three-dimensional (3-D) objects using a layering process and a digital model. It is "additive," as two-dimensional slides of a given thickness (for example, 0.5 mm) are printed on top of one another.[89] The earliest AM technology was developed in the 1980s, but it was not until the 2010s that 3-D printing costs dropped sufficiently for the technology to take off. In the past, AM products primarily consisted of layered plastic, but as the field advances, new materials are continually being used.

AM, a revolutionary jump in the trend of increasingly automated manufacturing, may prove a major disrupter for individuals, companies, entire industries—and even countries. The UK MoD suggests that AM "has the potential to transform the manufacturing industry, with performance and cost-effectiveness rapidly improving to the point where large-scale adoption for manufacturers is plausible well within the 2045 timeframe."[90] They further suggest that by 2045, "[AM] systems could be a common feature in the home" and produce "food, clothing, and even complex devices with mechanical and electronic components."[91] Yet AM's implications may well be even more profound. Take, for example, California biotech firm Organovo, which has begun selling replacement liver tissue. The firm, which can also print "everything from bone to blood vessels to heart tissue," recently partnered with the National Institutes of Health "to help scientists develop more reliable tools for bringing safer, more effective treatments to patients on a faster timeline."[92] It is likely that coupled with advances in the fields of synthetic biology, materials science, and nanotechnology, future AM systems will be able to produce entire replacement organs by 2045, if not much sooner.

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88. Carl Benedikt Frey and Michael A. Osborne, *The Future of Employment: How Susceptible Are Jobs to Computerisation?* (Oxford: Oxford Martin School, 2013), http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.

89. Create it REAL, "3D Printing Process," accessed July 17, 2014, http://www.createitreal.com/index.php/technology/process.

90. UK MoD, *Global Strategic Trends*, 68.

91. Ibid.

92. Signe Brewster, "Organovo Begins Selling 3D Printed Liver Tissue," Gigaom, November 18, 2014, https://gigaom.com/2014/11/18/organovo-begins-selling-3d-printed-liver-tissue/; Organovo Holdings, "Organovo Announces Collaboration with National Institutes of Health," press release, January 14, 2015, http://ir.organovo.com/news/press-releases/press-releases-details/2014/Organovo-Announces-Collaboration-with-National-Institutes-of-Health/default.aspx.

The AM revolution will likely provide numerous benefits in the future. As the technology advances, the cost of purchasing a 3-D printer will continue to decline, and the capability will proliferate. Businesses will be able to dramatically reduce overhead by eliminating the need to maintain excess inventories and ship both parts and finished goods long distances. Individuals, as well as corporations, will have increased opportunities for innovation and the development of new products. Cheap 3-D-printed houses—like those already being produced in China—may provide affordable housing for many living in poverty, especially in developing urban areas.[93] And the possibility of fabricated replacement organs may save countless lives.

Yet the proliferation of AM technology could have profound negative implications. One risk is of increasing an already growing trend in systemic unemployment. Countless manufacturing jobs, especially in developing countries, may be lost as consumers build products at home. According to the UK MoD, in poorer countries "large-scale automation of work could stall economic development, perhaps even reversing it."[94] Another very real risk is that of criminals, terrorists, or other non-state actors gaining the capability of 3-D printing advanced weapon systems. Defense Distributed, a "pending 501(c)(3) status nonprofit," disseminated plans for the first fully 3-D-printed gun in 2013.[95] In 2014, a University of Virginia research team created a 3-D-printed drone for the DoD capable of carrying a 1.5-pound payload,[96] and the Aerial Robotics Lab at Imperial College London successfully developed a semiautonomous rotor drone that carries its own 3-D printer.[97] While it is currently cheaper for nefarious groups to purchase traditionally produced weapons and drones, it is likely that in the future, costs will continue to decline for AM-produced weapons, while the sophistication of those weapons will increase.

The AM revolution will have significant implications for the defense community. The U.S. Navy already uses 3-D printers on deployed warships, and the U.S. Army is developing 3-D printers to create food for deployed troops.[98] U.S. Special Operations Command (USSOCOM) has also established an additive manufacturing facility and is actively expanding AM use in its logistics chain. According to Tony Davis, USSOCOM's director of science and technology, "We have a pretty tremendous logistics issue as we transition from a force focused on Iraq and Afghanistan to one focused globally again."[99] Building from an earlier

93. "Giant Chinese 3D Printer Builds 10 Houses in Just 1 Day," RT.com, April 29, 2014, http://rt.com/news/155220-3d-printer-houses-china/; "Chinese Firm 3D-Prints 5-Story House Using Construction Waste 'Ink,'" RT.com, January 22, 2015, http://rt.com/news/224423-china-3d-printer-house/.

94. UK MoD, *Global Strategic Trends*, 71.

95. Andy Greenberg, "Meet the 'Liberator': Test-Firing the World's First Fully 3D-Printed Gun," *Forbes*, May 5, 2013, http://www.forbes.com/sites/andygreenberg/2013/05/05/meet-the-liberator-test-firing-the-worlds-first-fully-3d-printed-gun/.

96. Jordan Golson, "A Military-Grade Drone That Can Be Printed Anywhere," *Wired*, September 16, 2014, http://www.wired.com/2014/09/military-grade-drone-can-printed-anywhere/.

97. "'Flying 3D Printer' Could Play Key Role in Emergencies," BBC, May 7, 2014, http://www.bbc.com/news/technology-27311292.

98. Marcus Weisberger, "The Defense Industry Is Expanding the Use of 3D Printing," *Defense One*, September 29, 2014, http://www.defenseone.com/technology/2014/09/defense-industry-expanding-use-3d-printing/95396/; Rick Docksai, "The Army Is Developing 3D Printers to Make Food," *Defense One*, July 31, 2014, http://www.defenseone.com/ideas/2014/07/army-developing-3d-printers-make-food/90284/.

99. Tony Davis, interview with author, August 1, 2014.

"shop in a box" concept, USSOCOM envisions a system where "instead of finding some scarce part and shipping it to wherever," forward-deployed operators could simply print replacement parts as needed.[100] In the future, AM could provide a revolutionary force multiplier for small SOF teams in remote environments.

Coupled with advanced robotics, future military applications of AM are limitless. In 2014 a team of Harvard and Massachusetts Institute of Technology (MIT) engineers designed the first self-assembling robots.[101] It is likely that in the not-too-distant future 3-D-printed robots may be capable of autonomous self-assembly and able to perform simple missions such as munitions delivery or surveillance. Once such a capability is possible, it is no longer required to produce drones at home and ship them abroad—or base them in an area controlled by friendly forces. While fielding drones in this manner may inhibit their recovery, ultimately it may provide significant cost savings. For another theoretical application, imagine SOF teams able to fly into a hostile country via commercial airline, link up at safe sites with prepositioned AM machines, and print all requisite material for their mission. Again, the implications for cost reduction—and enhanced security—are countless.

SYNTHETIC BIOLOGY AND PERFORMANCE ENHANCEMENT

Biotechnology and bioengineering is one of the fastest-growing technology sectors, and future advancements offer both considerable promise and risk. The mapping of the human genome, completed in 2003, has ushered a new age of research in the emerging field of synthetic biology.[102] Synthetic biology is an amalgam of existing research fields, notably biological engineering and biological technology, focused on the "design and construction of new biological parts, devices, and systems . . . [and] the re-design of existing, natural biological systems for useful purposes."[103]

It is difficult to predict the implications of advancements in the synthetic biology field, but one thing is certain: it will shape our future profoundly. Writing for the Center for American Progress's *Science Progress* journal, Denise Caruso suggests proponents "claim that the ability to create, manipulate and cheaply manufacture customized or unique life forms will produce many benefits across a wide range of applications, from medicine to energy generation and environmental remediation."[104] Yet Caruso argues these benefits ignore "an equally lengthy list of potential risks," such as the possibility of manufacturing new virulent pathogens as bioweapons. Another important set of risks, which she dubs

100. Ibid.

101. Sebastian Anthony, "Harvard & MIT Create First Self-Assembling Robots—the First Real Transformers," ExtremeTech, August 8, 2014, http://www.extremetech.com/extreme/187736-harvard-mit-create-first-self-assembling-robots-the-first-real-transformers.

102. James Kadtke and Linton Wells II, *Policy Challenges of Accelerating Technological Change: Security Policy and Strategy Implications of Parallel Scientific Revolutions* (Washington, DC: Center for Technology and National Security Policy, National Defense University, 2014), 38, http://ctnsp.dodlive.mil/files/2014/09/DTP106.pdf.

103. See Syntheticbiology.org, accessed February 4, 2015, http://syntheticbiology.org/.

104. Denise Caruso, "Synthetic Biology: An Overview and Recommendations for Anticipating and Addressing Emerging Risks," *Science Progress*, November 12, 2008, http://scienceprogress.org/2008/11/synthetic-biology/.

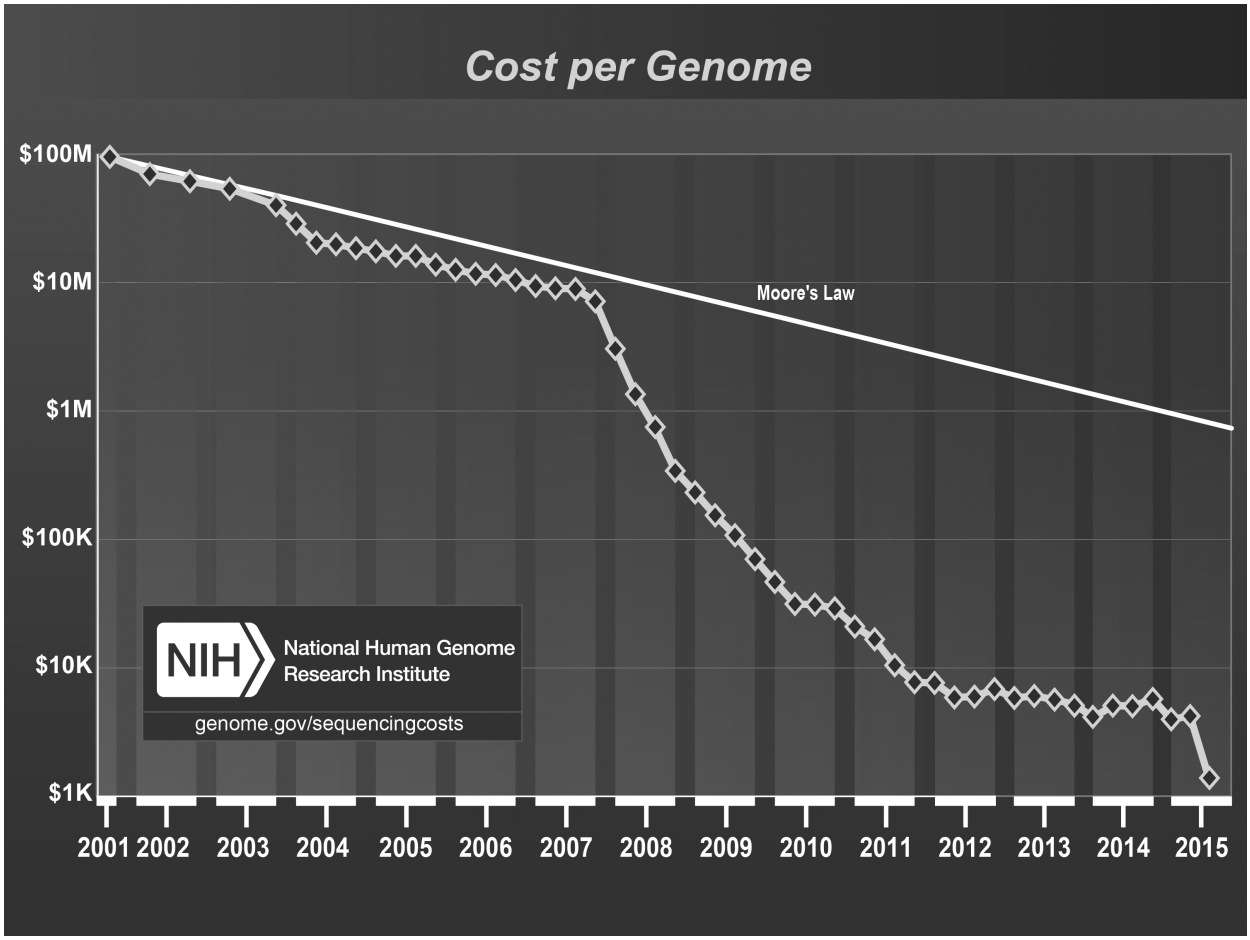

Image Source: National Human Genome Research Institute, "DNA Sequencing Costs," last updated October 02, 2015, http://www.genome.gov/sequencingcosts/.

"bioerror," stems from the unintended consequences of the technology—accidental release, mutation of "harmless" organisms into lethal ones, or the unknown effects of artificially created organisms on ecosystems and the environment. Dr. James Kadtke, special adviser on converging technologies at the National Defense University, mirrors Caruso's concerns.[105] While bioterrorism has been in the public sphere for decades, it has rarely been used because of its difficulty, according to Kadtke. Yet the accessibility of synthetic biology through companies like Cambrian Genomics, which allows customers to print DNA, coupled with a growing "bio hacking" community threatens to upend that balance. "If it's some guy doing it in his garage, there are zero containment controls."[106] To make the security challenge even greater, such a capability would allow for even "lone wolf" attackers to theoretically achieve large-scale effects without requiring coordination with or financial support from an overarching network.

105. James Kadtke, interview with author, January 13, 2015.
106. Ibid.

While future synthetic biology applications remain a subject of debate, developments over the short-term will have profound biomedical implications for the defense community. In 2014, the Defense Advanced Research Projects Agency announced the creation of a new biological technologies office. Some of the new office's goals will be to "improve the health and well-being of service members through products such as neural interfaces and advanced prosthetics . . . harnessing biological systems to create products that will surpass chemical and manufactured solutions . . . [and] seek to apply biological complexity at scale, examining biological systems across spatial, physical, and temporal scales."[107]

Examples of advances in the biomedical field abound. The Gates Foundation, for example, is backing a biotech company currently developing a wirelessly controlled medical implant, which will continuously provide medicine to the host and may need replacing as infrequently as every 16 years.[108] The company, MicroCHIPS, has been testing the device for osteoporosis patients, but the Gates Foundation hopes to use the technology to enable more effective birth control measures in the developing world. Given that the device links wirelessly to another device, data encryption and security will clearly be a concern. Coupling advances in biotechnology with other emerging technologies, such as nanotechnology, will produce even further advancements. In the future, it will be possible to implant "microscopic robots in your circulatory system that keep track of your blood pressure, detect nascent heart disease and identify early-stage cancer."[109]

Synthetic biology may also provide an avenue for future weapons development. Take, for example, DNA-targeted bioweapons—specifically designed to infect or kill a particular individual. "If you're more and more interested in precision strike, this is a precision strike avenue," suggests Scott Aughenbaugh, CSIS's deputy director of strategic futures.[110] Aughenbaugh believes that even non-state actors will have such a capability by 2045.

ROBOTICS

While a class of unmanned aerial vehicles (UAVs) known as remotely piloted vehicles (RPVs) has been used in combat operations since World War II, drones capable of executing missions with little to no human interaction are much newer.[111] Drones for battlefield surveillance began to see development in the 1990s, and the Clinton administration began using them in Afghanistan to hunt Osama bin Laden after al Qaeda attacked two U.S.

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107. Joey Cheng, "New Biotech Office to Integrate Biology into National Defense," *Defense Systems*, April 1, 2014, http://defensesystems.com/articles/2014/04/01/darpa-biotechnology-office.aspx.

108. Daniel Cooper, "Future Contraceptives Will Let Women Remote-Control Their Fertility," Engadget .com, July 7, 2014, http://www.engadget.com/2014/07/07/wireless-implant-microchips-gatesfoundation/.

109. Eric Schmidt and Jared Cohen, *The New Digital Age: Reshaping the Future of People, Nations and Business* (New York: Knopf, 2013), 25.

110. Information for this paragraph from Scott Aughenbaugh, interview with author, January 15, 2015.

111. Lexi Krock, "Time Line of UAVs," *NOVA*, November 2002, http://www.pbs.org/wgbh/nova/spiesfly/uavs .html.

embassies in Africa in 1998.[112] Following the terrorist attacks of September 11, 2001, armed Predators began flying combat operations over Afghanistan, and the U.S. military has included UAVs as an integral part of all operations since. By 2013, 31 percent of all planes in the U.S. military's inventory were drones, up from only 5 percent in 2005.[113] And combat drones are no longer just in the air. According to P. W. Singer, when U.S. forces invaded Iraq in 2003, there were zero robot systems on the ground, but by the end of the U.S.-led "surge," there were thousands.[114] According to a recent CSIS report, "The most significant advances or changes to existing force structure involving substation of unmanned systems in the near term will likely come on the ground, at sea, and undersea."[115]

Future advances in the field of robotics may prove even more incredible. In July 2012, for example, a student at Bar-Ilan University in Israel was able to control a robot at the Béziers Technology Institute in France simply using his thoughts.[116] The Israeli student was in an fMRI (functional magnetic resonance imaging) machine, which scans neural activity by mapping blood flow in the brain. The robot had a camera on its head, and the student within the fMRI machine was able to watch in near-real time and manipulate the movement of the robot walking around a room. Such examples illuminate the possibilities of more advanced neural-controlled robotics in the future. These avatars have a range of practical implications, from enabling "locked in" trauma patients to interact with the world around them, to allowing robots to work in hazardous environments, such as biological- or radiological-contaminated areas, to even the possibility of replacing human soldiers on the battlefield.

While a pioneer, the U.S. military is no longer the sole player in semiautonomous drone development. According to a recent RAND Corporation report, more than 70 countries have acquired UAVs, and 23 countries are developing armed UAVs.[117] Sam Brannen, who investigated robotics issues at CSIS, suggests that in as early as 5 to 10 years, every country in the world could have access to armed drones.[118] One significant implication of the proliferation of armed drones is whether they will be used as the United States has

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112. Mark Bowden, "How the Predator Drone Changed the Character of War," *Smithsonian Magazine*, November 2013, http://www.smithsonianmag.com/history/how-the-predator-drone-changed-the-character-of-war-3794671/?no-ist.

113. Spencer Ackerman and Noah Shachtman, "Almost 1 in 3 U.S. Warplanes Is a Robot," *Wired*, January 9, 2012, http://www.wired.com/2012/01/drone-report/.

114. Peter Singer, *Wired for War: The Robotics Revolution and Conflict in the Twenty-First Century* (New York: Penguin Press, 2009), 32.

115. Samuel J. Brannen, *Sustaining the U.S. Lead in Unmanned Systems: Military and Homeland Considerations through 2025* (Washington, DC: CSIS, 2014), 11, http://csis.org/files/publication/140227_Brannen_UnmannedSystems_Web.pdf.

116. Liat Clark, "Student Controls Robot with His Mind from 2,000 km Away," *Wired*, July 6, 2012, http://www.wired.co.uk/news/archive/2012-07/06/mind-control-robot-avatar.

117. Lynn E. Davis, Michael J. McNerney, James Chow, Thomas Hamilton, Sarah Harting, and Daniel Byman, "Armed and Dangerous?: UAVs and U.S. Security," RAND, 2014, http://www.rand.org/content/dam/rand/pubs/research_reports/RR400/RR449/RAND_RR449.pdf.

118. Patrick Tucker, "Every Country Will Have Armed Drones within 10 Years," *Defense One*, May 6, 2014, http://www.defenseone.com/technology/2014/05/every-country-will-have-armed-drones-within-ten-years/83878/.

used them. As Philip Alston, former UN special rapporteur on extrajudicial, summary, or arbitrary executions, has argued, "If other states were to claim the broad-based authority that the United States does—to kill people anywhere, anytime—the result would be chaos."[119] And the risks to geopolitical stability of an arms race in weaponized drones are yet unknown.[120]

Most of the drones mentioned above are semiautonomous—meaning a human operator makes most, if not all, decisions. But there are often significant tactical advantages for autonomy, and future unmanned systems will likely be increasingly autonomous. According to Brannen, "The most significant advance in unmanned systems over the next decade is likely to be the incorporation of autonomy."[121] One reason is the cost associated with human operators and crew. A single Predator pilot's salary, for example, can easily range more than $100,000 annually. Another reason is that semiautonomous drones must remain in contact with the operator, which provides an opportunity for signal jamming or spoofing. Or perhaps an autonomous system or AI would simply perform better, especially in hazardous environments.

The U.S. military has already made significant headway in the development of autonomous fighting vehicles. In 2013, the Northrop Grumman X-47B autonomous drone conducted both a takeoff and landing from an aircraft carrier without the aid of a pilot. And in another test, an Air Force bomber launched an experimental missile capable of independently selecting and engaging its target.[122] Yet future advancements in robotics may make the drones of today seem archaic. According to Brannen, "We're really like in the stone age on [drone use]."[123] He suggests that within the next decade there will be a massive adoption of commercial RPVs and that self-driving autos are "five or six years from hitting the mainstream"—an unbelievable feat since the technology was initially developed only a few years ago. Brannen also believes that in the future, swarming low-cost UAVs may prove an effective method of overwhelming A2/AD defenses.[124] And Daniel Suarez, former technology consultant and author of several influential novels about the risks posed by advanced technology, argues, "Very soon drones will tell humans what to look at. Not the other way around."[125]

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119. Jonathan Masters, "Targeted Killings," CFR Backgrounders, Council on Foreign Relations, May 23, 2013, http://www.cfr.org/counterterrorism/targeted-killings/p9627.

120. Paul Scharre, "What Is Autonomy?," 20YY Warfare Initiative, Center for a New American Security, February 2014, http://www.cnas.org/research/us-defense-policy-and-military-operations/20yy-warfare-initiative.

121. Brannen, *Sustaining the U.S. Lead in Unmanned Systems*, 5.

122. John Markoff, "Fearing Bombs That Can Pick Whom to Kill," *New York Times*, November 11, 2014, http://www.nytimes.com/2014/11/12/science/weapons-directed-by-robots-not-humans-raise-ethical-questions.html?_r=1.

123. Samuel Brannen, interview with author, January 19, 2015.

124. Brannen, *Sustaining the U.S. Lead in Unmanned Systems*, 8.

125. Daniel Suarez, "The Kill Decision Shouldn't Belong to a Robot," TEDGlobal 2013, June 2013, http://www.ted.com/talks/daniel_suarez_the_kill_decision_shouldn_t_belong_to_a_robot#t-265615.

NANOTECHNOLOGY AND MATERIALS SCIENCE

Perhaps no other emerging technology will prove as disruptive in the future as nanotechnology. Nanotechnology—"science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers"—enables the manipulation of individual atoms and molecules.[126] The implication of nanoscience and nanomanufacturing are arguably limitless. The U.S. National Nanotechnology Initiative (NNI), established in 2000, is an interagency group that helps coordinate and report on nanotechnology development across the federal government. According to the NNI, "Almost all high-performance electronic devices manufactured in the past decade use some nanomaterials."[127] It further estimates that nanotechnologies will have a $2.4 trillion impact on the global economy in 2015 alone. Future applications of nanotechnology cover every sector of the economy and society—electronics, construction, medicine, food, and even defense.

Nanotechnology's profound implications are based on not only the ability to build at increasingly smaller scales but also an ability to create composite or new materials. Kadtke and Dr. Linton Wells II, in a paper for the National Defense University, outline seven specific components and impact areas for nanotechnology: composites and hybrid materials, smart materials, nanomaterials, nanoelectronics, nanosensors, biomedical nanotechnology and nanomedicine, and nanomachines and nanomanufacturing.[128] According to the NNI, "Today's scientists and engineers are finding a wide variety of ways to deliberately make materials at the nanoscale to take advantage of their enhanced properties such as higher strength, lighter weight, increased control of the light spectrum, and greater chemical reactivity than their larger-scale counterparts."[129] Amazingly, manufacturing at the nanoscale enables engineers and scientists to leverage the effects of quantum mechanics to "literally fine-tune a material property of interest" or even replicate nanoscale biological principles such as molecular self-assembly or self-organization.[130] According to Dr. K. Eric Drexler, a leading scholar in nanotechnology, "Large scale, high-throughput atomically precise manufacturing [APM] is the heart of advanced nanotechnology, and in the coming years it has the potential to transform our world."[131] In Drexler's opinion, "What computer systems have done for processing information, APM systems will do for processing matter . . . Where the digital revolution opened the door to a radical abundance of information products, the APM revolution will open the door to a radical abundance of physical products."[132]

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126. U.S. National Nanotechnology Initiative (NNI), "What Is Nanotechnology?," Nano.gov, accessed June 29, 2015 http://www.nano.gov/nanotech-101/what/definition.

127. NNI, "Frequently Asked Questions," Nano.gov, accessed February 9, 2015, http://www.nano.gov/nanotech-101/nanotechnology-facts.

128. Kadtke and Wells, *Policy Challenges of Accelerating Technological Change*, 56–60.

129. NNI, "What Is Nanotechnology?"

130. NNI, "What's So Special about the Nanoscale?," Nano.gov, accessed June 29, 2015, http://www.nano.gov/nanotech-101/special.

131. K. Eric Drexler, *Radical Abundance: How a Revolution in Nanotechnology Will Change Civilization* (New York: PublicAffairs, 2013), xi.

132. Ibid., xii.

While much of the prognosis on nanotechnology and its implications sounds like science fiction, examples of the technology's military applications abound. One noteworthy product in this area is USSOCOM's Tactical Assault Light Operator Suit (TALOS), often referred to as the "Iron Man Suit." While TALOS is years away from full operational capability, the idea is to merge lightweight armor (using advanced composite materials) with sensors to provide the wearer enhanced situational awareness. Another practical application deals with stealth and camouflage. Nanotechnology could provide new applications of stealth through its properties "for creating low weight, high strength structures, and coatings with a scope of altering their reflection/absorption/scattering characteristics of electromagnetic radiation in visible, infrared, and microwave regions."[133] Carbon nanotubes, for example, are not only "the blackest known material" but also "absorb a broad spectrum of light—from radio waves through visible light through the ultraviolet—almost perfectly."[134] Israeli company Nanoflight reportedly completed successful testing and evaluation of carbon nanotube paint in 2010, and British company Surrey NanoSystems recently created a new "super-black" material called Vantablack, which absorbs "99.96% of incident radiation, believed to be the highest-ever recorded," according to the company's press release.[135] And future applications of nanotechnology may well provide new, unforeseen military uses.

Like other emerging technologies, nanotechnology poses risks as well as promise. While the "gray goo" scenario—self-replicating nanobots consuming the world—undoubtedly crosses some people's minds, the real risks of nanotechnology are much more pedestrian. The long-term health implications of widespread nanotechnology use, or the inhalation or digestion of nanoparticles, is unknown. Nanoparticles released into the atmosphere or environment could "constitute a completely new class of non-biodegradable pollutant."[136] Nanosensors, if widely proliferated in the future, could represent a major privacy concern. And, according to Kadtke, new nanomaterials and composites have never been experienced before, so it may be impossible to determine the long-term health and environmental effects of these creations.[137]

5. Connectedness

By 2025, the majority of the world's population will, in one generation, have gone from having virtually no access to unfiltered information to accessing all of the

133. S. R. Vadera and Narendra Kuman, "Nanotechnology and Nanomaterials for Camouflage and Stealth Applications," Nanowerk, January 30, 2015, http://www.nanowerk.com/spotlight/spotid=38899.php.

134. Katherine Bourzac, "Nano Paint Could Make Airplanes Invisible to Radar," *MIT Technology Review*, December 5, 2011, http://www.technologyreview.com/news/426276/nano-paint-could-make-airplanes-invisible-to-radar/.

135. Clay Dillow, "New Stealth Nano-Paint Turns Any Aircraft into a Radar-Evading Stealth Plane," *Popular Science*, July 14, 2010, http://www.popsci.com/technology/article/2010-07/stealth-paint-turns-any-aircraft-radar-evading-stealth-plane; Surrey NanoSystems, "British Breakthrough in World's Darkest Material Launched at Farnborough International," July 9, 2014, http://www.surreynanosystems.com/news/19/.

136. Michael Berger, "Nanotechnology Risks—the Real Issues," Nanowerk, April 16, 2007, http://www.nanowerk.com/spotlight/spotid=1781.php.

137. Kadtke interview.

> world's information through a device that fits in the palm of the hand.—Eric Schmidt and Jared Cohen[138]

Over the past two decades, the Internet has driven a trend of growing interconnectedness globally that has impacted cultures, populations, and societies in countless ways. At the turn of the century, fewer than 400 million people globally had access to the Internet in their home; now that number is more than 3 billion and climbing.[139] According to the United Nations' International Telecommunications Union (ITU), cellular coverage has reached 93 percent globally, meaning "almost every person on the globe lives within reach of a mobile-cellular signal."[140] Furthermore, through its Connect 2020 agenda, the ITU seeks to expand internet household penetration to 55 percent globally by 2020 (up from 43.6 percent currently).[141]

In 2014, the Pew Research Center concluded a study on "Digital Life in 2025," canvassing 2,558 technology experts on their predictions about how increased connectivity will alter society in the future. Pew's findings and conclusions suggest the establishment of a "global, immersive, invisible, ambient networked computing environment"; augmented reality enhancements through wearable or implantable technologies; disruption of twentieth-century business models; and "tagging, databasing, and intelligent analytical mapping of the physical and social realms."[142] Some experts suggested that "The spread of the 'Ubernet' will diminish the meaning of borders, and new 'nations' of those with shared interests may emerge and exist beyond the capacity of current nation-states to control."[143] Other, more pessimistic, respondents concluded that the future may prove more contentious (or even violent) as inequality expands and privacy erodes.[144]

In response to growing individual empowerment and the devolution of traditional power structures, however, governments and corporations may try to reassert themselves in the digital arena. Authoritarian regimes in particular may use the Internet as a tool to monitor, track, and crack down on dissident populations. Even worse, these regimes may infiltrate and attempt to subvert or coopt nascent pro-democracy or social movements, reducing peoples' faith in the value of online engagement. Such activities may ultimately undermine or constrain social connectedness.

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138. Schmidt and Cohen, *The New Digital Age*, 4.

139. Internet Live Stats, "Internet Users," accessed February 10, 2015, http://www.internetlivestats.com/internet-users/.

140. International Telecommunications Union (ITU), *Measuring the Information Society Report 2014* (Geneva: ITU, 2014), 3, http://www.itu.int/en/ITU-D/Statistics/Documents/publications/mis2014/MIS2014_without_Annex_4.pdf.

141. ITU, "Connect 2020 Agenda," accessed February 10, 2015, http://www.itu.int/en/connect2020/Pages/default.aspx.

142. Janna Anderson and Lee Rainie, *Digital Life in 2025* (Washington, DC: Pew Research Center, 2014), 5, http://www.pewinternet.org/files/2014/03/PIP_Report_Future_of_the_Internet_Predictions_031114.pdf.

143. Ibid., 8.

144. Ibid., 9.

Whether increasing digital connectivity globally will prove a net positive or negative for countries and societies has yet to be determined. But undoubtedly, this connectivity will fundamentally shape the FSE.

INTERNET OF THINGS AND BIG DATA

The Internet of Things (IoT) describes the system of devices, protocols, and applications of an increasingly interconnected world. Many think of IoT as simply the devices connected to the Internet. And while certainly part of the IoT, that description fails to capture either the IoT's breadth or implications. McKinsey & Company suggests that the IoT represents how "the physical world itself is becoming a type of information system."[145] The IoT ultimately encompasses not only all the devices connected to the Internet—from computers, to phones, to "smart" appliances or wearables—but also the unprecedented amounts data that these devices collect about the world around us.

The IoT already permeates every sector of the economy. In 2008, the number of devices connected to the Internet exceeded the number of people on earth.[146] General Electric CEO Jeff Immelt has suggested that the IoT, which he described as the "Industrial Internet," could add up to $10–$15 trillion to global GDP over 20 years.[147] The U.S. Federal Trade Commission (FTC) assesses that the number of devices connected to the Internet currently stands at 25 billion and will double to 50 billion by 2020.[148] The UK MoD suggests that while linear projections indicate that by 2040 there will be more than 95 billion devices connected to the Internet (or more than 10 devices per person on the planet), that number may underestimate the growth.[149] They suggest that decreasing costs of digital devices may result in exponential growth, resulting in a staggering 50 trillion connected devices by 2045.

Along with the growth in connected devices, the amount of data created has been growing exponentially for years—and will continue to do so. According to IBM, 2.5 quintillion bytes of data are created every day, "so much that 90% of the data in the world today has been created in the last two years alone."[150] Accurate predictions on the rate of growth in data creation and storage in the future are difficult. According to EMC Corporation, the "digital universe"—the amount of data created annually—is doubling in size every two years and will reach 44 zettabytes by 2020.[151] Interestingly, according to EMC, metadata

145. Michael Chui, Markus Loffler, and Roger Roberts, "The Internet of Things," *McKinsey Quarterly*, March 2010, http://www.mckinsey.com/insights/high_tech_telecoms_internet/the_internet_of_things.

146. CISCO, "The Internet of Things" infographic, 2001, http://share.cisco.com/internet-of-things.html.

147. GE Reports, "Analyze This: The Industrial Internet by the Numbers & Outcomes," October 7, 2013, http://www.gereports.com/post/74545267912/analyze-this-the-industrial-internet-by-the.

148. FTC, *Internet of Things: Privacy & Security in a Connected World*, Staff Report (Washington, DC: FTC, 2015), http://www.ftc.gov/system/files/documents/reports/federal-trade-commission-staff-report-november-2013-workshop-entitled-internet-things-privacy/150127iotrpt.pdf.

149. UK MoD, *Global Strategic Trends*, 57.

150. IBM, "What Is Big Data?," accessed February 10, 2015, http://www-01.ibm.com/software/data/bigdata/what-is-big-data.html.

151. EMC Corporation (with research and analysis by International Data Corporation), "The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things," IDC, April 2014, http://www.emc.com/leadership/digital-universe/2014iview/index.htm.

(data about data) is "the fastest-growing subcategory of the digital universe."[152] They also conclude that "emerging markets will surpass mature markets by 2017" in the proportion of total data created.[153]

The rise of the IoT and Big Data has profound implications for both the defense community and society in general. Nearly every sector of the economy will be impacted: from health care to manufacturing to transportation—and especially finance and information technology. Two of the major outgrowths of Big Data are better abilities to track (people, things, behavior, and so on) and to predict. Already corporations are using data gleaned from consumer purchases and online behaviors to better tailor and market products and services to individuals. Political parties are also able to use such data to conduct "microtargeting" of individual voters. As the IoT continues to spread, such ability to track will be improved. Even more alarming is the ability to predict. According to one study, with sufficient prior data, "it is possible to predict [the] location of a wide variety of hundreds of subjects even years into the future and with high accuracy."[154] From location data of specific individuals to consumer behaviors and even the outcomes of more complex interactions (such as pandemics), predictive analytics offers remarkable possibilities to corporations and governments. Intel Corporation, for one, describes such prescriptive analysis as the "next-generation [of] big data intelligence."[155] According to Intel, automated analytics algorithms, "such as machine learning," enable predictive models to adjust and increase accuracy over time—and even "generate new algorithms as needed."[156] Given that by some estimates only 0.5 percent of all data created is ever analyzed, such advancements in computation will have major implications.[157] Coupled with advances in computer processing and AI, the predictive power of Big Data analytics will continue to increase in the decades to come.

Growth of Big Data and the IoT also give rise to significant challenges and threats in the future. Storage of data is one key challenge—in terms of not only the physical space and architecture but also the ability to rapidly transmit data to support analytics. Network and cybersecurity is another major concern. With the growth of the IoT and Big Data, the cyber domain will become an increasingly important consideration for the U.S. national security community. According to EMC, 52 percent of the data that needs protection (such as corporate financial data, medical records, and other personally identifiable information [PII]) is

152. Ibid.

153. Ibid.

154. Adam Sadilek and John Krumm, "Far Out: Predicting Long-Term Human Mobility," Association for the Advancement of Artificial Intelligence, 2012, http://research.microsoft.com/en-us/um/people/jckrumm/Publications%202012/Sadilek-Krumm_Far-Out_AAAI-2012.pdf. For further information on this subject, refer to Patrick Tucker, "The Naked Future: What Happens in a World That Anticipates Your Every Move" (keynote address at the 2014 CA Technologies Government Summit, October 20, 2014, Washington, DC), http://nsp.performedia.com/cagovsummitonline/gallery.

155. Intel Corporation, "Predictive Analysis 101: Next-Generation Big Data Intelligence," March 2013, http://www.intel.com/content/dam/www/public/us/en/documents/best-practices/big-data-predictive-analytics-overview.pdf.

156. Ibid.

157. Antonio Regalado, "The Data Made Me Do It," *MIT Technology Review*, May 3, 2013, http://www.technologyreview.com/news/514346/the-data-made-me-do-it/.

currently not protected.[158] This trend touches on perhaps the most important issue: privacy. As wearables and other devices in the IoT proliferate and continue to gather more PII, the challenge of securing increasingly larger data sets will only grow, and privacy concerns will mount. Consider, for example, the implications of combining what formerly seemed benign data sets. Data from fitness watches coupled with ancestry or genealogical data may provide insurers insight into life expectancies of individuals. Or how "smart home" appliance information coupled with GPS data found in nearly all new automobiles may give insight into when a house is unoccupied. Another important concern of the Big Data environment is the concept of filter bubbles and discrimination. Algorithms using past data provide digital users unique, custom experiences online, creating a "filter bubble" effect, where content, advertisements, and even news is filtered for each individual. While there are undoubtedly some benefits to this practice, there are also significant downsides, such as exacerbating political and cultural differences in societies, or even inadvertently price discriminating against certain groups of consumers. Most corporate audiences laud the future of Big Data and IoT, but its long-term societal implications remain uncertain.

SOCIAL AND COMMUNITY NETWORKS

Mention social networking, and undoubtedly one of the first things to come to mind is Facebook. Since its debut in 2004, Facebook amassed nearly 1.4 billion monthly active users by the end of 2014—with approximately 82.4 percent of its daily users outside the United States and Canada.[159] Yet Facebook was not the first digital social network: Myspace preceded it by nearly a year and maintained a lead in global unique visitors until May 2008.[160] While there are likely countless reasons for Facebook's success over Myspace, one compelling justification is its ability to better form groups within the network. According to one study, Facebook's implementation of Open Application Program Interface (API)—the ability to share data across websites or applications and a key component of Web 2.0—"transformed Facebook one-to-one communication network into a group forming network."[161] This transition theoretically enabled Facebook to shift from Metcalfe's Law, which states that the value of a network is proportional to the users of the network squared, to Reed's Law, which suggests that in group-forming networks, the utility scales exponentially.[162]

Such group-forming behavior is an important characteristic of digital social media and has profound implications for social and community networks broadly. In *Here Comes Everybody: The Power of Organizing without Organizations*, author Clay Shirky outlines how

158. EMC Corporation, "The Digital Universe of Opportunities," infobrief, Slide 13.

159. Facebook, "Company Info," accessed February 10, 2015, http://newsroom.fb.com/company-info/.

160. Mike Musgrove, "Facebook Passes Myspace with Global Boost," *Washington Post*, June 24, 2008, http://www.washingtonpost.com/wp-dyn/content/article/2008/06/23/AR2008062302094.html.

161. Gwangjae Jung and Byungtae Lee, "How Did Facebook Outspace Myspace with Open Innovation? An Analysis of Network Competition with Changes of Network Topology," *PACIS 2011 Proceedings*, 2011, http://aisel.aisnet.org/pacis2011/88.

162. David P. Reed, "That Sneaky Exponential—beyond Metcalfe's Law to the Power of Community Building," blog, n.d., http://www.reed.com/dpr/locus/gfn/reedslaw.html.

modern information technology has profoundly altered society's ability to connect, mobilize, and affect change. He argues that modern technology allows anybody to have a much larger public profile and visibility than in the past, "enables new kinds of group forming," and allows these groups to wield tremendous power and influence in areas typically excluded to them.[163] Historically, according to Shirky, group formation and management was difficult and costly. It took time and money to establish a group, and for most large organizations, significant effort had to be expended to manage the entity. Yet modern technology has "collapsed," in Shirky's terms, the barriers of group formation.[164] He suggests that while it is difficult to control these decentralized groups, since the economic incentives of group formation remain high (and the cost low), increasing numbers of people are aggregating into groups to accomplish countless goals.

Historically, "communities" to a large extent were bound by geographic proximity. Yet for many, digital media has fundamentally altered the meaning of community. Today communities form completely online around a shared goal, identity, value, or interest. For many, these online social groups fulfill a need for connection and trust.[165] For others, "the relative anonymity of Internet communication encourages self-expression and facilitates the formation of relationships based on shared values and beliefs."[166] This anonymity of online interaction "enables an individual to experiment with different virtual identities and explore what it is like to experience those identities in the social world."[167] Such experimentation and redefining of personality is an important characteristic of one pitfall of online social networking—the recruitment and radicalization of disenfranchised groups.

The Internet's influence on radicalization has been well documented, and the trend is only increasing as more people gain connectivity and more of our lives moves online. In one 2013 RAND study on online radicalization, the authors determined that the Internet enhances opportunities for radicalization through increased connectivity "with like-minded individuals from across the world 24/7."[168] Additionally, the study concluded that the Internet not only acts as an "echo chamber," confirming existing beliefs, but also provides an opportunity for communication with unsavory individuals that a potential recruit would avoid in the real world.[169] According to some estimates, more than 15,000 fighters have flocked to join the Islamic State fighting in Syria, motivated at least in part by

163. Clay Shirky, *Here Comes Everybody: The Power of Organizing without Organizations* (New York: Penguin Press, 2008), 11–21.

164. Ibid., 22.

165. Linda S. L. Lai and Efraim Turban, "Groups Formation and Operations in the Web 2.0 Environment and Social Networks," *Group Decision and Negotiation* 15, no. 5 (September 2008): 400.

166. Jillianne R. Code and Nicholas E. Zaparyniuk, "Social Identities, Group Formation, and the Analysis of Online Communities," in *Handbook of Research on Social Software and Developing Community Ontologies*, ed. Stylianos Hatzipanagos and Steven Warburton (New York: Information Science Reference, 2009), 90.

167. Ibid., 101.

168. Ines von Behr, Anaïs Reding, Charlie Edwards, and Luke Gribbon, *Radicalisation in the Digital Era: The Use of the Internet in 15 Cases of Terrorism and Extremism* (Cambridge: RAND Europe, 2013), xii, http://www.rand.org/content/dam/rand/pubs/research_reports/RR400/RR453/RAND_RR453.pdf.

169. Ibid., 26–27.

online recruiting efforts.[170] In the coming decades, disenfranchised individuals will find increasingly more opportunities to connect with such unsavory actors abroad.

The future of social and community group formation is certainly unclear. For all the impact Facebook has had on digital group formation, many of the youngest generation (later Millennials and the emerging Generation Z) have begun to shift toward alternative, more individualistic social networking sites such as Instagram or Snapchat.[171] Growing up in an environment where many inherited Facebook profiles from birth, this youngest generation may ultimately revert the trend and seek more private online activities. Additionally, the impact of online social networking on important sociocultural factors such as civic engagement is unknown. Harvard University professor Dr. Robert Putnam popularized the notion of social capital in his 2000 book *Bowling Alone* and noted that most measures of civic engagement had been notably declining over the past few decades.[172] Some may attribute the growth of online activity with such a decline in social capital and disengagement from the local community. Yet according to some research, digital social networking, in many respects, actually bolsters real-world community engagement. For example, according to a 2010 Pew Research study, "Controlling for demographics and other types of internet use, compared with other internet users a Facebook user who visits the site multiple times per day is two and a half times more likely to have attended a political rally or meeting, 57% more likely to have tried to convince someone to vote for a specific candidate, and 43% more likely to have said they voted or intended to vote."[173] Furthermore, Pew Research determined that regular, active Facebook users were also significantly more trusting of others—a key component of social capital.[174]

Although the exact nature of how digital communities will evolve over the coming decades is unclear, they will likely remain—and perhaps grow—in importance.[175]

GOVERNANCE CHALLENGES

Radical connectivity has already begun to strain traditional governance structures, and this divergence will only grow in the decades to come. In one sense, increased connectivity has helped enable power devolution, weakening traditional institutions such as governments. According to Nicco Mele, author and digital consultant, "The nation-state may not be

170. Somini Sengupta, "Nations Trying to Stop Their Citizens from Going to Middle East to Fight for ISIS," *New York Times*, September 12, 2014, http://www.nytimes.com/2014/09/13/world/middleeast/isis-recruits-prompt-laws-against-foreign-fighters.html?_r=0.

171. Jennifer Van Grove, "Why Teens Are Tiring of Facebook," CNET, March 2, 2013, http://www.cnet.com/news/why-teens-are-tiring-of-facebook/.

172. For more information, refer to Robert D. Putnam, "Bowling Alone: The Collapse and Revival of American Community," http://bowlingalone.com/.

173. Keith N. Hampton, Lauren Sessions Goulet, Lee Rainie, and Kristen Purcell, *Social Networking Sites and Our Lives: How People's Trust, Personal Relationships, and Civic and Political Involvement Are Connected to Their Use of Social Networking Sites and Other Technologies* (Washington, DC: Pew Research Center, 2011), 41, http://www.pewinternet.org/files/old-media//Files/Reports/2011/PIP%20-%20Social%20networking%20sites%20and%20our%20lives.pdf.

174. Ibid., 33.

175. Kathleen Hicks, comment to the author, July 22, 2015.

dead yet . . . but it is losing its cultural and political force."[176] But more importantly, radical connectivity redefines the relationship between the citizen and the state in important ways. According to Schmidt and Cohen, authors of *The New Digital Age*, in the future "citizen participation will reach an all-time high as anyone with a mobile handset and access to the Internet will be able to play a part in promoting accountability and transparency," which "will empower people to police the police in a plethora of creative ways."[177] Mele, however, portrays a less utopian future. While he suggests that crowd-sourced journalism, and even investigations, may grow in the future, such digital media will likely fail to replicate traditional journalism's role in identifying corruption, especially in local governments.[178] And while increased participation in government is undoubtedly a positive for most societies, Mele also warns "radical connectivity also paves the way for a dangerous populism to take hold of our political system."[179] Such populism may give rise to fringe candidates or parties, such as the ultranationalist movements currently gaining favor across Europe.

The drivers of increased connectivity and power devolution may suggest a weakening of traditional governance structures, but this transition may prove incredibly turbulent—and violent. Schmidt and Cohen predict some governments, especially authoritarian ones, will fight to reassert their sovereignty and control. "Some governments will consider it too risky to have thousands of anonymous, untraceable and unverified citizens" online and will crack down on Internet freedom.[180] In fact, increased connectivity may even work to the advantage of some authoritarian regimes. With greater proportions of their populations online and creating digital personas, authoritarian regimes will have an increased capability of surveilling and targeting dissident populations. "Data-mining software and 'deep packet inspection' technologies make it easy to automate surveillance through the Internet service providers and mobile carriers of all unencrypted Internet traffic no matter what service is being used or where it is based."[181] According to Evgeny Morozov, author of *The Net Delusion: The Dark Side of Internet Freedom*, the danger from authoritarian regimes is "not just using the internet to monitor you and crack down. In the case of China and Russia we are seeing very active attempts at propaganda—basically identifying sensitive conversations, or sensitive forums or threads on blogs and trying to hijack them."[182] But even if social media alone "will not light [the] spark" of revolution, it does help create "a new kind of citizen: networked, unafraid, and ready for action. These citizens will transform their countries whether a revolution takes place or not."[183]

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176. Nicco Mele, *The End of Big: How the Internet Makes David the New Goliath* (New York: St. Martin's Press, 2013), 27.
177. Schmidt and Cohen, *The New Digital Age*, 34.
178. Mele, *The End of Big*, 36–52.
179. Ibid., 64.
180. Schmidt and Cohen, *The New Digital Age*, 33.
181. Rebecca MacKinnon, *Consent of the Networked: The Worldwide Struggle for Internet Freedom* (New York: Basic Books, 2012), 39–40.
182. John D. Sutter, "When the Internet Actually Helps Dictators," CNN, February 22, 2011, http://www.cnn.com/2011/TECH/web/02/22/authoritarian.internet.morozov/.
183. Emily Parker, *Now I Know Who My Comrades Are: Voices from the Internet Underground* (New York: Sarah Crichton Books, 2014), 285.

Radical connectivity may have tipped the scales in favor of the people against authoritarian regimes, but it also enables revolutionaries and insurgents of many flavors. According to Shirky, "Digital networks have acted as a massive positive supply shock to the cost and spread of information, to the ease and range of public speech by citizens, and to the speed and scale of group formation."[184] This effect allows "insurgents to play by different rules than incumbents."[185] Yet, Shirky notes that while commonly referred to as "the dictator's dilemma," it is more accurately described as "the conservative dilemma," as "it applies not only to autocrats but also to democratic governments and to religious and business leaders."[186]

Another important possibility in the future is for groups to form online, virtual states. "While not as legitimate or useful as actual statehood," these virtual governments could manifest a distinct online presence, where "sympathetic engineers" could build online applications and databases to facilitate the delivery of real-world services.[187] Such digital governments could even develop unique virtual currencies, or use an existing one such as Bitcoin, and conduct their own foreign policy.[188] Although such an idea may seem farfetched, in 2014 Estonia became the first country in the world to offer digital "e-Residency" to anyone who could pass a background check. According to the country's e-Estonia website, "Estonia is proudly pioneering the idea of a country without borders."[189] Estonia, one of the least-populous countries in Europe, hopes to attract 10 million foreigners to the program by 2025.[190]

To CSIS's Aughenbaugh, regimes must embrace the challenge of governing in a changing world or risk irrelevance—or worse, extinction. At the macro level, Aughenbaugh sees many opportunities for state fragmentation in the future. Geography has driven sovereignty and by extension governance for generations, but increasingly geography must compete with other factors given the impact of radical connectivity. Aughenbaugh believes that when looking at the future of governance structures, one must consider population patterns, ideological systems, and even relationship and community identification.[191] As populations grow and migrate and communities develop across traditional geographic boundaries, governments will be tested on whether they can maintain a shared identity, and shared goals, among their public. Especially given an increasing "filter bubble" effect, populations categorized by geographical borders will grow increasingly fractured and

184. Malcolm Gladwell and Clay Shirky, "From Innovation to Revolution," *Foreign Affairs*, March–April 2011, http://www.foreignaffairs.com/articles/67325/malcolm-gladwell-and-clay-shirky/from-innovation-to-revolution.

185. Ibid.

186. Clay Shirky, "The Political Power of Social Media," *Foreign Affairs*, January–February 2011, http://www.foreignaffairs.com/articles/67038/clay-shirky/the-political-power-of-social-media.

187. Schmidt and Cohen, *The New Digital Age*, 101–102.

188. Ibid., 102.

189. E-Estonia.com, "Estonian E-Residency," accessed August 1, 2015, https://e-estonia.com/e-residents/about/.

190. Nabeelah Shabbir, "Estonia Offers E-Residency to Foreigners," *Guardian*, December 26, 2014, http://www.theguardian.com/world/2014/dec/26/estonia-offers-e-residency-to-world-what-does-it-mean.

191. Scott Aughenbaugh, interview with the author, January 15, 2015.

isolated along ideological, ethnic, and religious lines. As a result, Aughenbaugh sees the potential for many current states to fracture: Sudan "will not be the last."[192]

6. Geopolitics

While radical connectivity is changing the nature of how we interact with each other and the world around us, and conventional authorities are losing their monopoly on power, geopolitics remains a potent driver of the future. From international regimes to resources and even ideological systems, geopolitical competition will fundamentally shape the security environment in which the U.S. military will operate in the future.

IDEOLOGICAL SYSTEMS

Since the fall of the Berlin Wall, the world has seen significant advancements of democracy over totalitarian or authoritarian forms of government. According to Naim, "In 1977, a total of eighty-nine countries were ruled by autocrats; by 2011, the number had dwindled to 22. Today, more than half the world's population lives in democracies."[193] Many see this trend as both inevitable and irreversible. But if history is a useful guide, world governance systems ebb and flow—typically based on the characteristics of the global distribution of power. According to Brookings Institution senior fellow Robert Kagan, "Every international order in history has reflected the beliefs and interests of its strongest powers, and every international order has changed when power shifted to others with different beliefs and interests."[194] Kagan argues that in an international system with a single global (democratic) hegemon, not only do liberal democracy and free markets spread, but also conflict is diminished. "Contrary to what one often hears, multipolar systems have historically been neither particularly stable nor particularly peaceful."[195]

If Kagan's theory is correct, then an erosion of a U.S.-dominated international system will increase the likelihood of conflict in the future and may give rise to more authoritarian governance structures. According to the NIC, "How the U.S. evolves over the next 15–20 years—a big uncertainty—will be among the most important variables in the future shape of the international order."[196] By 2030, in fact, the NIC assesses China as a close second in proportion of global power. Many academics and pundits already view authoritarianism as more efficient than democracy. Take, for example, Thomas Friedman's 2009 column in the *New York Times* arguing that political gridlock in Washington, DC was worse than a one-party autocracy. According to Friedman, "One-party autocracy certainly has its drawbacks. But when it is led by a reasonably enlightened group of people, as China is today, it can also have great advantages."[197] Even influential *Foreign Policy* magazine

192. Ibid.
193. Naim, *The End of Power*, 5–6.
194. Robert Kagan, *The World America Made* (New York: Knopf, 2012), 5.
195. Ibid., 83.
196. NIC, *Global Trends 2030*, 101.
197. Thomas L. Friedman, "Our One-Party Democracy," *New York Times*, September 9, 2009, http://www.nytimes.com/2009/09/09/opinion/09friedman.html.

suggests that it is wrong to assume "that democratic governments are less corrupt and provide better services to their citizens than autocracies."[198] Dr. Azar Gat, writing in *Foreign Affairs*, sees authoritarianism's rise buoyed by an embrace of capitalist systems, as opposed to communism. According to Gat, "If any factor gave the liberal democracies [in the twentieth century] their edge, it was above all the existence of the United States rather than any inherent advantage."[199] China's continued rise, aided by cooperation with an increasingly authoritarian Russia, "could then be regarded by many as an attractive alternative to liberal democracy."[200]

In many ways, modern technology provides an advantage for authoritarian regimes that their predecessors did not have. According to a report by the Carnegie Endowment for International Peace, "Contrary to assumptions, different types of authoritarian regimes may be able to control and profit from the Internet."[201] The paper's authors conclude, "Through a combination of reactive and proactive strategies, an authoritarian regime can counter the [democratic] challenges posed by Internet use and even utilize the Internet to extend its reach and authority."[202] According to Christopher Walker, executive director of the International Forum for Democratic Studies at the National Endowment for Democracy, "Today's leading authoritarian regimes are turning 'containment' on its head, using massive resources and coordinated political efforts to chip away at the rules-based institutions that have served as the glue for the post–Cold War liberal order . . . and reshaping the way the world thinks about democracy."[203]

Another important ideological system that will gain in prominence over the coming decades is Islamism. According to John Custer, retired U.S. Army major general, one of the greatest trends shaping the security environment in the future is the rise of nationalism and religion.[204] In Custer's opinion, arbitrary borders drawn across much of the former European colonial territories have, following the collapse of the Soviet Union, given rise to a dual threat of tribal-ethnic nationalism and a greater emphasis on religion across the Muslim world. According to Custer, these trends have only been exacerbated by U.S. military involvement in the region since 9/11—as well as increased sectarian conflict in places such as Iraq, Syria, and Yemen. "Future conflict over the next fifteen years [will come from] the diaspora from Afghanistan and Syria," he predicts.[205] The Arab Spring in partic-

198. Joshua E. Keating, "A Better Dictator," *Foreign Policy*, April 23, 2012, http://foreignpolicy.com/2012/04/23/a-better-dictator/.

199. Azar Gat, "The Return of Authoritarian Great Powers," *Foreign Affairs*, July–August 2007, http://www.foreignaffairs.com/articles/62644/azar-gat/the-return-of-authoritarian-great-powers.

200. Ibid.

201. Shanthi Kalathil and Taylor Boas, "Summary," in *The Internet and State Control in Authoritarian Regimes: China, Cuba, and the Counterrevolution*, Working Paper No. 21 (Washington, DC: Carnegie Endowment for International Peace, 2001), http://carnegieendowment.org/files/21KalathilBoas.pdf.

202. Ibid.

203. Christopher Walker, "Christopher Walker: Authoritarian Regimes Are Changing How the World Defines Democracy," *Washington Post*, June 13, 2014, http://www.washingtonpost.com/opinions/christopher-walker-authoritarian-regimes-are-changing-how-the-world-defines-democracy/2014/06/12/d1328e3a-f0ee-11e3-bf76-447a5df6411f_story.html.

204. John Custer, interview with the author, January 22, 2015.

205. Ibid.

ular challenged authoritarian regimes across parts of the Muslim world and, in some states, gave a boost to political Islamism, most notably in Egypt with the Muslim Brotherhood's brief period of rule. And worryingly, a 2014 RAND Corporation analysis concludes that the number of both Salafi-jihadist groups and individuals has increased consistently in the past quarter century, with a marked increase since 2011.[206] Additionally, the number of attacks conducted globally by al Qaeda and its affiliates has increased dramatically since 2009.[207] The author concludes that weakening governance, expanding network reach, and even "growing popular support for the Salafi-jihadist ideology" may all contribute to this trend.[208] And while the Islamic State may represent the most notable Salafi-jihadist threat currently, just as the Islamic State usurped leadership from al Qaeda, perhaps in the future alternate, more virulent Salafi-jihadist groups may arise. According to Dr. Kathleen Hicks, director of the CSIS International Security Program, "The future is likely to include some kind of enduring Salafi challenge to the West."[209]

RESOURCES AND RESOURCE MANAGEMENT

The quest for control of strategic resources has always been a critical component of geopolitics. In the future, as the world's population balloons to an estimated 9.4 billion by 2045, that competition will grow more acute. Perhaps the three most important strategic resources will be energy, water, and food, especially given their interdependence. Water is critical for crop irrigation as well as energy generation—from hydropower to cooling thermal power plants and extracting fossil fuels such as shale gas.[210] Exacerbated by the effects of climate change, the competition over these scarce resources may lead to increased conflict. In April 2014, Jim Yong Kim, World Bank president, stated, "Fights over water and food are going to be the most significant direct impacts of climate change in the next five to 10 years."[211]

Food

Food security will be a major concern across much of the developing world in the future. A set of complementary factors—growing population, climate change, less arable land, and increasing wealth effects—will significantly increase global food demand. According to a report produced for the NIC by Chatham House, demand for staple crops will grow 1–1.5 percent annually to 2040.[212] Global food prices will rise, and price volatility will

206. Seth G. Jones, *A Persistent Threat: The Evolution of al Qa'ida and Other Salafi Jihadists* (Santa Monica, CA: RAND, 2014), 27, http://www.rand.org/content/dam/rand/pubs/research_reports/RR600/RR637/RAND_RR637.pdf.

207. Ibid., 35.

208. Ibid., 43–47.

209. Kathleen Hicks, comment to the author, July 22, 2015.

210. World Bank, "Thirsty Energy: Securing Energy in a Water-Constrained World," August 29, 2013, http://www.worldbank.org/en/topic/sustainabledevelopment/brief/water-energy-nexus.

211. Larry Elliott, "Climate Change Will 'Lead to Battles for Food', says Head of World Bank," *Guardian*, April 3, 2014, http://www.theguardian.com/environment/2014/apr/03/climate-change-battle-food-head-world-bank.

212. Office of the Director of National Intelligence (ODNI), *Natural Resources in 2020, 2030, and 2040: Implications for the United States* (Washington, DC: ODNI, 2013), https://www.hsdl.org/?view&did=746656.

increase, especially for crops used for biofuels. Technological innovation may help to boost production to meet some of the demand growth. Yet, according to the UN Food and Agriculture Organization (FAO), the growth rate globally in yields of the major cereal crops is steadily declining.[213] The FAO estimates that "just satisfying the expected food and feed demand will require a substantial increase of global food production of 70 percent by 2050."[214]

The impacts of climate change will also be particularly felt in terms of food security. "No other sector is more climate sensitive," argues the FAO.[215] While some studies already estimate decreased cereal yields due to climate change, these effects will only grow by 2045.[216] Extreme weather events such as floods, droughts, tornadoes, extreme high-water levels, and heat waves will only increase, reducing arable land and disrupting crop yields.[217] Although increased atmospheric carbon dioxide (CO_2) levels may actually help boost some crop yields, this effect may not offset other impacts.[218] Of especial concern is that climate change will not uniformly impact global food production. Sub-Saharan Africa, already the least food secure region, is expected to be the most impacted.[219]

Paradoxically, while global food prices may rise by as much as 100 percent by 2045 and some regions may be less food secure, the ill effects of overeating will be felt across much of the globe. Currently, nearly 35 percent of U.S. adults are obese, and annual medical costs related to obesity are nearly $150 billion.[220] According to a recent study by researchers from Duke University, obesity prevalence in the United States will increase by 33 percent, while rates of "severe" obesity will grow 130 percent, by the year 2030.[221] Compared with holding obesity levels constant from 2010, these increases will cost an additional $549.5 billion in health care expenditures, "further hinder[ing] efforts for healthcare cost containment."[222] Yet this problem is not simply one of the United States or developed world. Over a third of all adults globally are obese or overweight, and rates across the developing world are increasing faster than in the developed, due to changes in diet, such as increased consumption of meats, fats, and sugar.[223] In fact, already far more people (65 percent) globally live in countries where risks from excess weight kill more people than risks from

213. UN Food and Agriculture Organization (FAO), "How to Feed the World in 2050," October 2009, 2, http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf.

214. Ibid., 8.

215. FAO, "Climate Change and Bioenergy Challenges for Food and Agriculture," October 2009, 1, http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Climate.pdf.

216. ODNI, *Natural Resources in 2020, 2030, and 2040*, 66.

217. Ibid., 67.

218. FAO, "Climate Change and Bioenergy Challenges," 3–4.

219. Ibid., 4.

220. U.S. Centers for Disease Control and Prevention (CDC), "Adult Obesity Facts," September 9, 2014, http://www.cdc.gov/obesity/data/adult.html.

221. Eric A. Finkelstein, Olga A. Khavjou, Hope Thompson, Justin G. Trogdon, Liping Pan, Bettylou Sherry, and William Dietz, "Obesity and Severe Obesity Forecasts through 2030," *American Journal of Preventative Medicine* 42, no. 6 (June 2012): 563–570.

222. Ibid.

223. Sharada Keats and Steve Wiggins, "Executive Summary: Future Diets: Implications for Agriculture and Food Prices," Overseas Development Institute (ODI), January 2014, 1, http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8773.pdf.

being underweight.[224] By some estimates, more than a billion adults will be obese by 2030.[225] This trend will only increase by 2045.

Water

Water is one of the most important strategic resources, and access to potable water is a significant positive determinant of health, education, and economic development. According to the World Bank, "At least 700 million people lack access to safe drinking water. Poor sanitation, water, and hygiene lead to about 675,000 premature deaths annually."[226] Yet an increasing global population "will require approximately 50% more water in 2050."[227] Additionally, given increased energy demands, water consumption by the energy sector will increase 85 percent by 2035 alone.[228]

A 2012 report by the Office of the Director of National Intelligence (ODNI) concluded that, "absent more effective management of water resources," water shortages "will hinder the ability of key countries to produce food and generate energy, posing a risk to global food markets and hobbling economic growth."[229] Combined with other risks such as poverty and weak institutions, water scarcity can "contribute to social disruptions that can result in state failure."[230] Furthermore, using "water as a weapon or to further terrorist objectives also will become more likely" by the middle of the next decade.[231] Regions with the greatest increase in water stress in the future include the Middle East and much of South and Southwest Asia as well as North and East Africa. The Amu Darya and Brahmaputra River Basins, in Central and South Asia, respectively, are particularly at risk.[232] In fact, the Organization for Economic Cooperation and Development (OECD) estimates that without new policies, by 2050 more than 40 percent of the global population will live "in river basins experiencing severe water stress."[233]

Implications of water scarcity on the FSE become particularly significant when combined with other risks. The NIC assesses that water and arable land scarcity, particularly in sub-Saharan Africa, South Asia, and parts of the Middle East, will "increase the risks of intrastate conflict," when considering the "disproportionate levels" of young, possibly

224. WHO, "Obesity and Overweight," fact sheet no. 311, updated January 2015, http://www.who.int/mediacentre/factsheets/fs311/en/.

225. Harvard School of Public Health, "Adult Obesity," accessed January 20, 2015, http://www.hsph.harvard.edu/obesity-prevention-source/obesity-trends/obesity-rates-worldwide/.

226. World Bank, "Water Overview," last updated April 10, 2015, http://www.worldbank.org/en/topic/water/overview#1.

227. Ibid.

228. World Bank, "Thirsty Energy: Securing Energy in a Water-Constrained World," last updated January 20, 2015, http://www.worldbank.org/en/topic/sustainabledevelopment/brief/water-energy-nexus.

229. ODNI, *Global Water Security* (Washington, DC: ODNI, February 2012), iii, http://www.dni.gov/files/documents/Special%20Report_ICA%20Global%20Water%20Security.pdf.

230. Ibid.

231. Ibid.

232. Ibid., v.

233. OECD, "Water Chapter of the OECD Environmental Outlook to 2050: The Consequences of Inaction," March 2012, http://www.oecd.org/env/indicators-modelling-outlooks/waterchapteroftheoecdenvironmentaloutlookto2050theconsequencesofinaction.htm.

unemployed, men.[234] According to the NIC, water may ultimately cause more strife "at both the intrastate and interstate levels" than any other resource.[235] Increased urbanization may also further exacerbate water shortages. Urban residents typically have much better access to potable water and improved sanitation than people in rural areas do. But that is not necessarily the case in urban slums. According to the United Nations, "Those who suffer the most of these water-related challenges are the urban poor, often living in slum areas or informal settlements following rapid urban growth."[236] This trend is especially concerning, given that the global slum population is projected to grow to approximately 2 billion people by the year 2030.[237]

Without some sort of technological breakthrough, water rationing, scarcity, and conflict is likely across much of the developing world in the future. Desalinization is one possible solution, yet the process is currently prohibitively expensive for much of the world and also leads to potential environmental concerns.

Energy

Given population and economic growth across the developing world, global energy demand will increase 37 percent by 2040, according to the International Energy Agency (IEA), with much of the demand led by China and India.[238] Natural gas demand will grow by more than 50 percent, greater than any other fossil fuel source, and the IEA sees an "increasingly flexible" global trade system in liquefied natural gas.[239] Yet fossil fuels' contribution to global energy needs will likely decline through a combination of increased reliance on renewables as well as efficiency gains. The IEA believes fossil fuels will drop from a recent 68 percent proportion of global energy to 55 percent by 2040. Half of the growth in global energy production will likely come from renewables, according to the IEA.

Yet the IEA's projections may prove conservative. For example, the IEA projects solar power will grow by only 18 percent by 2040. One major limitation in solar power has been its expense—both in installation and in storage. But advances in batteries and storage "would make using renewable energy sources much more practical," according to the UK MoD.[240] It concludes that this type of advanced storage will be "in common use by 2045," reducing conventional energy requirements and enabling a growth in renewables.[241] One possible method of development is through the application of nanoengineering and quan-

234. NIC, *Global Trends 2030*, 63.
235. Ibid., 66.
236. UN Department of Economic and Social Affairs (UNDESA), "International Decade for Action 'WATER FOR LIFE' 2005–2015," accessed January 19, 2015, http://www.un.org/waterforlifedecade/water_cities.shtml.
237. Rasna Warah, "The Challenge of Slums: Global Report on Human Settlements 2003," Global Policy Forum, 2003, https://www.globalpolicy.org/component/content/article/211/44579.html.
238. IEA, "*World Energy Outlook 2014* Factsheet," November 11, 2014, 3, http://www.worldenergyoutlook.org/media/weowebsite/2014/141112_WEO_FactSheets.pdf.
239. IEA, *World Energy Outlook 2014: Executive Summary*, 2, http://www.iea.org/publications/freepublications/publication/WEO_2014_ES_English_WEB.pdf.
240. UK MoD, *Global Strategic Trends*, 25.
241. Ibid.

tum mechanics. According to the NNI, "Nanoengineered batteries, fuel cells, and catalysts can potentially use enhanced reactivity at the nanoscale to produce cleaner, safer, and more affordable models of producing and storing energy."[242]

Other likely reasons for future diversification into alternative energy include a global desire to reduce carbon emissions, government subsidies, and the desire to create "green jobs." Furthermore, much of current energy production is threatened by geopolitical risks, in such places as Russia, Venezuela, and the Middle East. One only needs to look as far as Russia's threatening to cut off gas shipments to Eastern Europe to see why global leaders will likely seek opportunities to reduce their reliance on foreign energy sources and possible disruptions.

There may be some data to support such a theory. According to the U.S. Energy Information Administration (EIA), while renewables may still make up a fraction of total domestic energy needs by 2040, generating capacity will grow 52 percent. And while they assess wind power as the largest share of renewable capacity, solar "leads the growth," growing 600 percent.[243] Even ExxonMobil assesses that growth on an annualized basis of solar/wind/biofuels as a category will outpace any other form of energy through 2040.[244] In fact, ExxonMobil assesses that by 2040 "natural gas, nuclear and renewables are expected to deliver more than 70 percent of the world's electricity."[245] And two reports by the IEA suggest that through concerted effort by policymakers, solar power could become the largest source of electricity by 2050, with much of that development in China and India.[246]

A shifting resource environment will undoubtedly create winners and losers, which will have major geopolitical implications. Regimes whose budgets rely on exporting fossil fuels will be the clearest losers—such as Russia, Iran, and Venezuela, for example.[247] Other countries may be at risk, especially of internal economic volatility, as oil- and gas-producing regions may lose jobs and face increased unemployment. Yet governments have the opportunity to adapt, if they act. Texas, for example, leads the United States not only in oil production but also in wind power capacity, according to the American Council on Renewable Energy (ACORE).[248] Indonesia, the third-largest geothermal energy producer after the United States and the Philippines, possesses the world's largest geothermal reserves

242. NNI, "What's So Special about the Nanoscale?"

243. EIA, *Annual Energy Outlook 2014* (Washington, DC: EIA, 2014), MT-19, http://www.eia.gov/forecasts/archive/aeo14/pdf/0383%282014%29.pdf.

244. ExxonMobil, *The Outlook for Energy: A View to 2040* (Irving, TX: ExxonMobil, 2014), 57, http://cdn.exxonmobil.com/~/media/Reports/Outlook%20For%20Energy/2015/2015-Outlook-for-Energy_print-resolution.pdf.

245. Ibid., 37.

246. IEA, "How Solar Energy Could Be the Largest Source of Electricity by Mid-Century," press release, September 29, 2014, http://www.iea.org/newsroomandevents/pressreleases/2014/september/how-solar-energy-could-be-the-largest-source-of-electricity-by-mid-century.html.

247. José Luis Cordeiro, interview with the author, January 9, 2015.

248. ACORE, *The Outlook for Renewable Energy in America: 2014* (Washington, DC: ACORE, 2014), 8, http://www.acore.org/files/pdfs/ACORE_Outlook_for_RE_2014.pdf.

and currently has dozens of projects under development to increase production.[249] And while the United States is one of the leading global oil producers, it is by far the largest oil consumer. So diversification into other energy sources—in the short term liquefied natural gas, and in the long term renewables—will actually provide a boost for the U.S. economy.[250]

Dr. José Luis Cordeiro, energy adviser for the Singularity University, calls this effect the "democratization of energy."[251] Greater reliance on renewables will allow countries, states, and even communities to generate a greater percentage of their electricity and power needs closer to home. And that will have an impact of further reducing energy requirements, as there will not be as great of a need to ship fossil fuels over far distances. If current predictions hold true, by 2045 greater segments of the global population will have access to electricity, helping alleviate poverty and providing essential services in much of the developing world.

Yet the tremendous growth in population and higher living standards in the developing world may strain global energy requirements, especially if such a rosy prognosis does not come to pass. Africa's energy needs, for example, are particularly acute. Currently, the IEA estimates that 620 million people in sub-Saharan Africa do not have access to electricity, "and for those that do have it, supply is often insufficient, unreliable and among the most costly in the world."[252] Given the region's massive population and economic growth, energy demand will increase by around 80 percent by 2040. Yet the IEA estimates that 530 million will still lack electricity.

INTERNATIONAL ALLIANCES AND REGIMES

In a global order without a clear hegemon—a multi- or non-polar world—international regimes will take on a much more prominent role in geopolitics. Yet the structure, nature, and power of those regimes are uncertain. The G-7, for example, encompassed the world's seven largest economies at the time of its formation. But the rise of the developing world saw the G-20 overtake the G-7/G-8 as the predominant international economic forum following the 2007–2009 financial crisis. Military regimes, such as NATO, have likewise seen their power and influence erode. Lacking a clear military threat (until perhaps a recent revanchist Russia), most NATO countries have allowed their defense budgets to slip below the required 2 percent of GDP target, and significant political divisions among members appeared following the 2003 Iraq war.

Many existing regimes will remain in place in the future, if for no reason other than inertia, yet their relevance remains in question. According to Malia Du Mont, former director of strategy in the Office of the Under Secretary of Defense for Policy, "Those alliances

249. Indonesia-Investments, "Geothermal Energy," accessed January 14, 2015, http://www.indonesia-investments.com/business/commodities/geothermal-energy/item268.

250. Cordeiro interview.

251. Ibid.

252. IEA, *World Energy Outlook 2014: Executive Summary*, 6.

aren't powerful in-and-of themselves."[253] In her opinion, they will only retain relevance "insofar as their members maintain their power." Brannen sees the mutual defense portion of alliances as increasingly less credible to both allies and adversaries in the future. He suggests, for example, that it will be difficult for the United States to maintain that it is willing to trade "NYC for Tokyo or LA for Seoul."[254]

Future regimes will increasingly acknowledge the role that emerging countries play not only in the global economy but also in solving both regional and global issues. The G-20's ascendency is one such example. Yet there are others, such as the United Nations' ITU, which has begun playing a larger role in Internet governance. Or take, for example, the new Asian Infrastructure Investment Bank, seen by many as a competitor to the existing World Bank and the first multilateral institution led by China.[255]

But perhaps the most pressing challenges of the next 30 years cannot be solved by states alone. Cities, for example, may play a greater role in international regimes. "Responsible for about 70 per cent of global greenhouse gas emissions, cities can play a critical role in reducing these emissions," according to the United Nations.[256] The C40 Cities Climate Leadership Group (C40), formed in 2005, now consists of 70 member cities globally. The C40 contains 1/12th of the global population and produces 18 percent of global GDP.[257] As the global population increasingly urbanizes, cities will undoubtedly play a greater role in tackling tough global problems like climate change.

The expanded role of non-state actors and institutions also threatens the viability of existing multilateral regimes. Currently, cities or international corporations have little opportunity to participate in international regimes, but that must change in the future. One possible solution is through the advent of—or expanded employment of existing—regimes focused on single issues, such as the environment or economy. According to Du Mont, "Other multi-lateral institutions . . . economic-focused institutions . . . may have an easier time incorporating non-state actors" than traditional political regimes.[258] Aughenbaugh concurs with this assessment, suggesting that many international institutions (NATO or the UN Security Council, for example) have too many countries with varying interests to effectively collaborate on challenging issues. In his opinion, "It's really difficult to operate in a one-veto-kill environment."[259]

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253. Malia Du Mont, interview with the author, January 22, 2015.

254. Brannen interview.

255. "China-Led AIIB Development Bank Holds Signing Ceremony," BBC, June 29, 2015, http://www.bbc.com/news/world-asia-33307314; Huey Fern Tay, "Asian Infrastructure Investment Bank: Australia Sixth Biggest Shareholder in China Bank," ABC News, June 29, 2015, http://www.abc.net.au/news/2015-06-29/australia-sixth-biggest-shareholder-in-new-china-investment-bank/6580682.

256. United Nations, "Climate Summit 2014: Catalyzing Action: Action Areas/Summit Announcements," accessed January 29, 2015, http://www.un.org/climatechange/summit/action-areas/.

257. C40 Cities, "C40 Cities," accessed January 29, 2015, http://www.c40.org/cities.

258. Du Mont interview.

259. Aughenbaugh interview.

Instead, regional governance structures or multilateral institutions will likely hold greater influence in the future. According to the NIC, "Economic trends, especially the likely growth of intraregional trade, point to greater regional integration" as "global multilateral institutions will struggle to keep up with the rapid diffusion of power."[260] Examples of such regional structures range from the European Union to the Gulf Cooperation Council and the Association of Southeast Asian Nations.

260. NIC, *Global Trends 2030*, 57–58.

3 Conclusion

Individually, the aforementioned drivers will have a profound impact on the FSE. But ultimately, the confluence of these drivers—and how each evolves over time—will determine the nature of future conflict. Each reader will make his or her own assessment of what this means for the U.S. military, but I will leave you with a few parting thoughts. Please note that a major global catastrophe—such as a natural disaster, social unrest, or financial collapse—would compromise this assessment. (And while those events may seem low probability, they should also be considered.)

Technological advancements may most readily capture the reader's imagination, and many future technologies seem like science fiction or may not yet even be imagined. This driver, perhaps more than any other, is the greatest wild card. Over the near term, the technologies that will have the greatest impact have likely already been developed. Some are still in the testing and evaluation phase, whereas others remain in their operational infancy (such as robotics). The "confidence interval" of technological assessments is particularly large, and accurate predictions are especially difficult. Yet even as new technologies proliferate within society, they will not be evenly distributed, creating winners and losers at all levels. This driver may also play the greatest role in shaping conflict in the future—for better or worse. New advanced weapon platforms—such as drones, precision munitions, direct energy weapons, nanoweapons, or even AI—may render current operational concepts, tactics, and weapon systems woefully outdated. Moreover, the U.S. military will likely employ new military occupations, weapons, and even entire units (such as the new Cyber National Mission Force) by 2045.[1] But technology also holds the promise of helping avoid conflict in the future. As food, water, and energy demand grows significantly over the coming decades, technological advancements can prevent shortages and ensuing conflict.

Demographic changes will also play an important role in determining the nature of future warfare. The global population will grow by 2 billion over the next 30 years, with all net growth occurring in urban areas. These urban areas are growing increasingly complex, dense, and interdependent, especially in "megacities" of 10 million or more

1. The Cyber National Mission Force, "the U.S. military's first joint tactical command with a dedicated mission focused on cyberspace operations" was activated by U.S. Cyber Command in January 2014. For more information, refer to General Keith B. Alexander's statement before the Senate Committee on Armed Services, February 27, 2014, http://www.defenseinnovationmarketplace.mil/resources/Cyber_Command_Alexander_02-27-14.pdf.

people. To make matters worse, most of these megacities (and the broader urbanization trend) are disproportionally located along coastlines and in regions particularly threatened by climate change. It is likely that population-centric warfare in dense urban areas will remain one of the most frequent (and complex) challenges of the coming decades. And the U.S. military may need to fundamentally reexamine how it operates in the future urban environment.

The global population is also aging at an unprecedented rate. Typically, an aging population decreases the likelihood of conflict. But expanding automation in both the manufacturing and services sector—coupled with a possible "revolution" in additive manufacturing—may lead to a large-scale "robotification" of jobs, increasing unemployment, especially among younger, less-skilled workers. This effect, coupled with a declining payer-to-payee ratio for age-related entitlement programs, may cause social instability. These same social programs, if left unchanged, will boost debt loads globally in the coming decades, constraining defense-related expenditures. And since personnel costs—especially those related to healthcare—represent one of the largest DoD outlays, it is likely that the U.S. military in the future will be a much smaller force.

The future offers promise for much of the global population. Living standards and life expectancy are expected to increase globally, as are personal incomes, access to technology, literacy rates, and many other standards of development. Barring unforeseen catastrophe, this trend will likely continue, as technological promise provides myriad benefits for societies. This increasingly connected global citizenry will shape group formation across defined geographic borders and may fundamentally alter both local and national politics. But this effect also contributes to an ongoing devolution of power globally and will constrain options for military use as well as the effectiveness of typical hard power. And while global GDP growth is expected to continue, the economic center of gravity will continue to shift further to the east and may challenge existing international regimes and alliances.

Fundamentally new security paradigms may also emerge in the future. Cybersecurity is rapidly becoming one of the foremost military dimensions, and the growth of the IoT and Big Data will only exacerbate this trend. As the number of devices proliferates and more components of the nation's critical infrastructure become digital, the possibility of widespread disruption or destruction will increase. And as people's digital footprints grow, the debate about privacy will only become more contentious.

As the role and influence of non-state actors continue to expand in the future, national governments will have to confront a diminished ability to control geopolitical events. The proliferation of disruptive technologies will further challenge existing power structures, whether economic, military, or political. NGOs and multinational corporations may own the resources—or access—most needed for operational success. And the spread, reach, and capability of malign threat groups—or individual actors—will vex conventional military forces and may fundamentally alter traditional concepts of deterrence.

Given the range of these risks, and the diffuse, growing asymmetric nature of the threat in the FSE, the U.S. military must prioritize efforts to mitigate future crises as well as help build a global resiliency to respond to conflict or disasters once they occur. The FSE is one in which the United States cannot deploy large numbers of forces to combat every problem. It is also not one in which the United States can abdicate global leadership and let nations disintegrate or international regimes decay. Otherwise, the United States will risk humanitarian crises on an unprecedented scale—or the evolution of transnational threats that will truly represent an existential risk to the nation.

The challenges facing the U.S. military, combined with looming constraints on national security budgets, are daunting. In the face of these challenges and an unknown future, defense officials must choose between preparing for a nebulous, "broad array of threats and opportunities"[2]—or trying to identify the regions and types of conflict most likely in the coming decades. According to General (Retired) Dempsey, "Innovation is the military imperative and the leadership opportunity of this generation. It's a fleeting opportunity."[3]

Time will tell if the U.S. military seizes the opportunity.

2. DoD, *Quadrennial Defense Review 2014*, 3.
3. Ibid., 64.

About the Author

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