



J U N E
2 0 1 4

Creative Disruption *Technology, Strategy and the Future of the Global Defense Industry*

By Ben FitzGerald and Kelley Saylor

Foreword by the Honorable William J. Lynn III
and ADM James Stavridis, USN (Ret.)



Center for a
New American
Security

Acknowledgements

We would like to thank our colleagues at CNAS for their support of the project and their critical feedback on the report. In particular, we are grateful to Michael Horowitz for his substantive guidance and expertise in developing the project's surveys, to Shawn Brimley and Dafna Rand for their editorial guidance and to Liz Fontaine and JaRel Clay for their media and publication assistance.

This project would not have been possible without the leadership of the Creative Disruption Task Force co-chairs, Bill Lynn and ADM Jim Stavridis, USN (Ret.), nor without the intellectual vision of the project steering committee: Denis Bovin; ADM Giampaolo Di Paola, ITA N (Ret.); Geoff Hoon; ACM Angus Houston, AC AFC (Ret.); Linda Hudson; Brett Lambert; Senator Joe Lieberman; Ellen Lord; James Murdoch; Sean O'Keefe; and Bob Work.

We also benefited tremendously from the insights and expertise of the Creative Disruption working group: CDR Clay Beers, USN; Marty Bollinger; Chris Bowie; Jonathan Caverley; Pierre Chao; August Cole; Steve Cortese; Frank Finelli; Stephen Greene; Steve Grundman; MG Kevin Kennedy, USAF (Ret.); Larry Korb; Peter Levin; Joe Militano; Carlo Musso; Mark Mykityshyn; Pete Newell; James Peddell; Ben Riley; Russ Rumbaugh; Pat Ryan; Neill Sciarrone; Andrew Shapiro; Zach Sherman; and Tom Thornhill.

Readers should note that some of the steering committee and working group participants are affiliated with organizations that support CNAS financially. CNAS maintains a broad and diverse group of more than one hundred funders including private foundations, government agencies, corporations, and private individuals, and retains sole editorial control over its ideas, projects and products. A complete list of our financial supports can be found on our website at <http://www.cnas.org/content/cnas-supporters>.

The views expressed in this report are those of the authors alone, who are solely responsible for any error of fact, analysis or omission.

TABLE OF CONTENTS

Foreword	5	Appendix A: Survey I	31
I. Introduction	7	Appendix B: Survey II	34
II. Trends in Technology, Strategy and Business	9	Appendix C: Survey III	38
III. Disruptive Effects	15		
IV. Recommendations: Success and Failure in the 21st Century	21		
V. Conclusion	25		

J U N E 2 0 1 4

Creative Disruption

Technology, Strategy and the Future of the Global Defense Industry

By Ben FitzGerald and Kelley Sayler

Foreword by the Honorable William J. Lynn III and ADM James Stavridis, USN (Ret.)

About the Authors

Ben FitzGerald is a senior fellow and director of the Technology and National Security Program at the Center for a New American Security.

Kelley Sayler is a research associate at the Center for a New American Security.



CREATIVE DISRUPTION: TECHNOLOGY, STRATEGY AND THE FUTURE OF THE GLOBAL DEFENSE INDUSTRY

By Ben FitzGerald and Kelley Saylor

Foreword by the Honorable William J. Lynn III and ADM James Stavridis, USN (Ret.)

J U N E 2 0 1 4

Creative Disruption

Technology, Strategy and the Future of the Global Defense Industry



FOREWORD

By the Honorable William J. Lynn III
and ADM James Stavridis, USN (Ret.)

Google's recent acquisition of Boston Dynamics, a DARPA-funded organization that develops some of the world's most innovative robots, served the Pentagon with an unsettling notice: the center of gravity in cutting edge, military applicable research is shifting abruptly away from the defense establishment to relatively new commercial firms with loads of cash to invest. This is just one example of a broader trend in which commercial and international firms are taking the lead in what once was the technological province of the Department of Defense (DOD). As the world becomes increasingly globalized, such trends are likely to produce even greater disruptive effects.

Indeed, globalization is an inevitable force of change, erasing boundary lines not just between countries but between industries as well. It suggests a borderless world in which China could make iPhones or the leading U.S. auto export could be a BMW made in South Carolina. Such trends will present economic and technological risks to state and non-state actors alike. Cyber crime and attacks, proliferating weapons of mass destruction, black market arms, sophisticated smuggling methods and a range of other capabilities provide unparalleled power and influence to illegitimate regimes, crime syndicates and super-empowered individuals. This ever-growing range of threats, further expanded by traditional state-based threats, constitutes a significant challenge to the United States and its allies.

Globalization also blurs boundaries between defense and commercial industries, vastly diluting the sources of technological innovation and placing them well beyond the control of any individual government or entity. For the United States, the question hanging in the balance is whether or not the domestic defense industry can pull out of the cul-de-sac it now finds itself in – one in which it is chasing a declining share of a market with fewer funds allocated for the research and development of tomorrow's technologies. Unfortunately, there is little reason for optimism. Independent research and development (IRAD)

spending by the top U.S. defense companies dropped by one-third as a percentage of sales from 1999 to 2012.¹ Today, there are no defense companies among the Top 20 industrial research and development spenders worldwide.² In fact, the IRAD budgets of the top five U.S. defense contractors combined still would not put defense on the Top 20 list.

No one doubts that globalization, declining post-war defense budgets and the increased pace of technological change are combining to reshape the defense industry. For generations, the Pentagon has been a technology exporter to the commercial sector of transformational capabilities such as the Global Positioning System (GPS) and the Internet. Today, DOD is increasingly becoming an importer of the technological advances taking place all around the world, from information technology and 3-D manufacturing to autonomous vehicles and synthetic biology. Information technology alone has had a profound impact on national security, enabling soldiers to use smartphones to obtain real-time surveillance from drones and to coordinate with fellow troops via text messaging.

Such swift and dynamic change will become increasingly disruptive if not properly managed. A central question of this project is thus whether the Pentagon and the U.S. defense industry are adapting fast enough to the pace of technological change or just hunkering down with short-term policies to maintain an archaic status quo. While previous adjustments in the defense industry have been successfully managed with direct input and guidance from the government, many of the resulting mechanisms – from acquisition to regulatory policy – are now standing in the way of industry's ability to adapt.

The defense industry is moving too slowly to adjust to current trends in the technology and security

environments. The short-term financial focus on keeping stock prices high through share repurchases and increasing dividends has thus far deferred more substantial integration of and investments in next-generation technologies. The Pentagon and the defense industry must take a far more active role in shaping their own intertwined futures. To harness change, the U.S. defense establishment must increase spending on research and development and leverage the world's best technology, especially from commercial firms and from nations that train and fight alongside our own armed forces.

To address these issues, the Center for a New American Security established the Task Force on Technology, Strategy and the Global Defense Industry and asked us to act as co-chairs. We were pleased to serve given the critical need to consider these three subjects together rather than as separate disciplines. In a hat tip to the economist Joseph Schumpeter, we adapted the concept of creative destruction and called the project Creative Disruption.

We assembled an impressive cast of experts from a range of backgrounds to participate on the task force. Their names can be found in the acknowledgements section of this report. Based on a series of fascinating meetings and innovative research methods, the CNAS team, led by Ben FitzGerald and Kelley Saylor, drew out a number of important insights into the critical trends and predictable disruptions impacting technology, strategy, and business, and formulated clear recommendations for both government and industry.

We endorse these findings, recommend this report and ask that those with a stake in maintaining competitive advantage for the U.S. and its allies continue to think and act creatively to improve our future strategic circumstance.

1. Zachary Fryer-Biggs and Marcus Weisberger, "U.S. Giants Skimp on Research, Development," *Defense News*, August 19, 2013, <http://www.defensenews.com/apps/pbcs.dll/article?AID=2013308190005>.

2. Strategy&, "The Global Innovation 1000: Top 20 R&D Spenders 2005-2013," *Strategyand.com*, <http://www.strategyand.pwc.com/global/home/what-we-think/global-innovation-1000/top-20-rd-spenders-2013>, Accessed May 20, 2014.

I. INTRODUCTION

By Ben FitzGerald and Kelley Sayler

In the years to come, the convergence of emerging trends in the technological, geopolitical and business environments threatens to profoundly disrupt the global defense industry. These trends are pulling governments and the industries that support them in multiple directions to an extent that calls into question the underlying strategic basis of military technological advantage, as well as the broader ecosystem of defense research and development (R&D), acquisition and sustainment.

Although the major powers of the 20th century still retain privileged access to advanced military capabilities in sufficient quantities to achieve their national priorities in the short term, the medium- and long-term pictures look decidedly more ominous. The challenges that lie ahead are a result of holding on too long to previously successful strategies, structures and methods that are ill-suited to current needs. Continued failure to collectively adapt the military industrial ecosystem to the current and emerging environment will leave the defense industry, and the governments that it supports, at risk of irrelevance, catastrophic failure or both. The need for reform is particularly potent in the West, where declining defense budgets are beginning to force difficult trade-offs between strategic priorities and competing capabilities.

In the case of the United States, the prevailing character of the military industrial environment remains heavily influenced by the middle and final years of the Cold War. The adoption of the so-called offset strategy in the late 1970s helped to use U.S. technological superiority to counterbalance Soviet advantages in mass and created a paradigm in which innovation was sponsored – and controlled – by the U.S. government.¹ This highly successful strategy helped to equip U.S. and allied forces with advanced technologies while creating positive externalities for broader technological innovation, business growth and employment. However, the drawdown following the end of the

Cold War saw significant consolidation within the defense industry, as well as the exit of many commercial businesses. This decline left a smaller cadre of defense-specific firms optimized for producing next-generation military capabilities and exporting these systems to allies through foreign military sales.

The geopolitical, business and technology environments of today and the future are very different from those of the Cold War and its immediate aftermath. National governments must now invest in capabilities to address an ever-increasing set of plausible contingencies as both state and non-state actors gain access to a wider range of both traditional and emerging technologies in both the physical and cyber domains. Furthermore, all of this must be achieved in an era of shrinking defense budgets, which are often dwarfed by the revenues of major commercial technology companies, and shifting sources of innovation, which have accelerated the democratization of technology and diluted governmental control.²

Indeed, the structures, from acquisition regulations to arms control, that supported the innovation and management of previously successful defense-industrial regimes – and denied new technologies to adversaries – now act as impediments in the geopolitical and business environment of the 21st century. Although creative destruction (i.e., the process in which new structures automatically replace and destroy older ones) would have likely materialized within a less regulated system, ongoing government support of the existing paradigm, whether explicit or tacit, has instead created an environment in which clear trends will impact unmoving business and regulatory structures. This will in turn cause predictable and significant disruption.

In the absence of an effective strategy and supporting paradigm to address the requirements of the evolving business and security environments,

Creative Disruption Survey Series

In conjunction with this project, the Center for a New American Security conducted a series of three surveys of national security professionals. The results of these surveys represent a range of perspectives in government, industry and academia, and are intended to provide an illustrative sense of prevailing opinions on emerging trends in technology, strategy and business. A full compendium of the survey results can be found in the appendices.

both governments and the defense industry will continue to make decisions that serve short-term requirements but increase strategic risk. These entities must therefore shift from their current defensive crouch to a forward-leaning posture that takes advantage of, and mitigates against, the major trends of the 21st century. Despite myriad advantages, opportunities and good intentions from those in government and industry, such innovation appears decidedly unlikely. Any future loss of military technological advantage will thus be as much the result of a collective failure to adapt as of structural trends in technology, strategy and business.

II. TRENDS IN TECHNOLOGY, STRATEGY AND BUSINESS

The Changing Technology Environment

Recent years have witnessed dramatic changes in the global technology environment as a result of acceleration in both the pace of technological development and the rate of diffusion. From processing power and big data analytics to unmanned systems, robotics and synthetic biology, technology is advancing rapidly.

Indeed, more information is being digitized and “datafied” than ever before, with digital information now representing 98 percent of all stored information, up from 25 percent in the year 2000.³ Cloud computing, data integration and analytic suites are also advancing rapidly. Together, these developments in information technology are revolutionizing approaches to national security and military operations.

Similarly, global inventories of unmanned systems are continuing to expand, with profound implications for the future of warfare and R&D investments. At least 11 countries currently operate an ever-expanding array of drones – numbering well over 800 by conservative estimates. And this number entirely excludes the arsenals of China, Russia and Turkey, for which no data is available.⁴

Growth in these systems shows no signs of slowing. From 2002 to 2010, for example, the U.S. arsenal of unmanned aerial vehicles (UAVs) alone increased more than 40-fold.⁵ And as advanced robotics and complementary technologies like autonomy and miniaturization mature and the socialization of unmanned systems continues, a steady increase is likely in the number, diversity and use of such systems.⁶

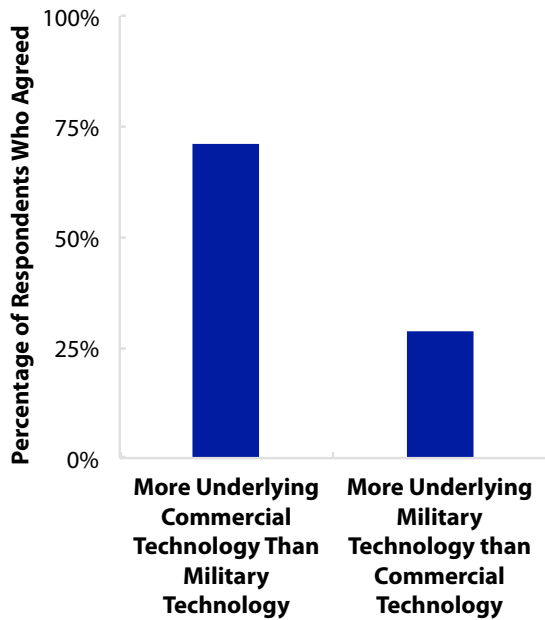
Advanced manufacturing is also beginning to influence the technology environment by increasing the speed, adaptability and customization of production, while simultaneously decreasing

cost and, in some cases, material waste.⁷ For the traditional defense-industrial base, advanced manufacturing enables rapid prototyping as well as compressed – and more frequent – acquisition cycles. However, given the commercial availability and relative affordability of related tools such as computer-aided design software and 3-D printers, non-state actors can also benefit by, for example, using open-source designs to manufacture untraceable weapons and component parts.⁸

To be sure, the defense industry is more commercial, more global, and more financially complex than at any time in our history – and this will be more true tomorrow than it is today. This changing technology environment is a result not only of developments in the technologies themselves but also of the changing nature of technological innovation. During the Cold War, innovation was largely driven by investments from the military and domestic defense industry and produced technologies specifically designed for defense purposes. By contrast, innovation today is increasingly driven by the commercial sector and produces technologies that must be adapted for defense purposes after production (see Figure 1).⁹ This shift is a result of several factors, including the expansion of dual-use technologies – which provide attendant incentives for commercial investment – as well as commercial industry’s ability to readily adapt to and integrate emerging technologies.¹⁰

Furthermore, the current downturn in defense spending, comparatively modest market opportunities for traditional defense firms relative to commercial businesses, and increase in the number of income-oriented shareholders have dampened enthusiasm for the types of investments needed to sustain innovation.¹¹ Today, the combined market capitalization of the “Big Five” defense firms – Boeing, Lockheed Martin, General Dynamics, Raytheon and Northrop Grumman – is approximately half that of Apple, which could buy the two largest firms, Boeing and Lockheed Martin, with

FIGURE 1: IN 2030, WHAT WILL DRIVE KEY DEVELOPMENTS IN MILITARY TECHNOLOGY?



Source: Center for a New American Security Creative Disruption Survey I, January 2014.

its cash on hand.¹² This position has left defense firms reluctant to jeopardize the support of their investors by allocating cash to fund independent R&D, thereby increasing the influence of commercial R&D as a source of innovation.¹³

The rate of diffusion and the types of adopters for a given technology – both of which are likely to vary as a function of the financial intensity and organizational capital required for adoption – also affect current trends in the technology environment.¹⁴ For example, the low financial intensity and organizational capital needed to adopt cyber capabilities result in comparatively low barriers to entry. For this reason, all interested parties (ranging from major militaries to minor militaries to non-state actors) are likely to adopt cyber capabilities. In contrast, the high financial intensity and organizational capital required to adopt a technology like directed energy will likely limit

its diffusion to both state and non-state actors, thereby limiting the technology’s impact on the broader technology environment.

Differing moral constraints and societal values will also influence the rate and nature of technological diffusion. As seen in the case of the U.S. active denial system (a heat-emitting crowd-control tool that has been termed a “pain ray” by some human rights groups), moral concerns can limit the use of certain technologies in the field.¹⁵ Such concerns could similarly affect the diffusion of sensitive technologies like human performance modification or bioweapons. This would give a military advantage to those actors that are not constrained by similar moral considerations or societal values.

These trends in technology are interacting with concurrent trends in the strategic environment. Increases in the commercial availability of a number of emerging technologies, for example, have lowered barriers to entry and generated substantial second-mover advantages on cost, thereby contributing to the growing empowerment of individuals, non-state actors and state-based militaries. Discussing one example of this phenomenon, Peter W. Singer observed that “the investments to create satellite navigation and the Internet may have originally come out of DARPA, but now any terrorist group can pinpoint targets with GPS devices they buy off Amazon.com.”¹⁶ As a growing share of such innovative technologies are developed outside of the Department of Defense, the department must develop effective ways to access and leverage these technologies.

When considered together, these trends call into question the ability of a singular military to sustain a meaningful technological advantage while avoiding cost-imposition strategies.

The Changing Strategic Environment

In addition to dynamic technology trends, the evolving strategic environment is characterized

The evolving strategic environment is characterized by a greater diffusion of power and a more rapid decision cycle than existed during the Cold War.

by a greater diffusion of power and a more rapid decision cycle than existed during the Cold War. At the same time that access to disruptive technologies is increasing, demographic pressures – including rapid urbanization and unstable youth bulges – have increased the potential for explosive conflicts and have generated hybrid adversaries that pair these technologies with irregular tactics to achieve outsized effects.¹⁷ As the National Intelligence Council concluded in its assessment of such trends, “individuals and small groups will have greater access to lethal and disruptive technologies (particularly precision-strike capabilities, cyber instruments and bioterror weaponry), enabling them to perpetrate large-scale violence – a capability formerly the monopoly of states.”¹⁸

Increased access to communications technologies and social media platforms will further contribute to the empowerment of individuals by improving coordination efforts among dispersed actors and enabling otherwise distributed threats to converge. In addition, these technologies can be used to enhance terrorist recruitment efforts, resulting in an expansion of terrorist networks and an increase in the self-radicalization of terrorists.¹⁹

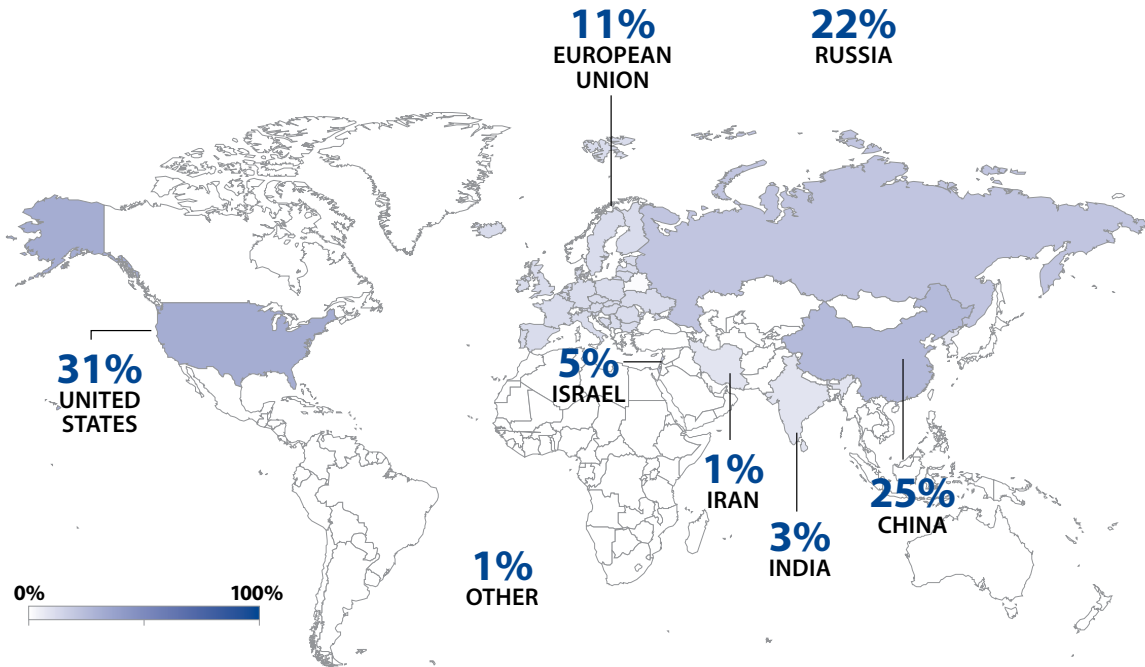
Communications and information technologies could have a number of other influences on the security environment at the state level by expanding human interactions within and across national

boundaries.²⁰ These technologies could aid in social mobilization during periods of civil unrest, as they are often credited with having done during the Arab Spring.²¹ They could also accelerate the decision cycles of national governments, heightening the potential for misunderstanding during tense periods or increasing pressure for immediate – and potentially destabilizing – action in the event of a conflict. The convergence of these trends could thus expand the sources, nature and magnitude of future conflicts, which suggests the need for adaptable structures capable of responding to a growing range of contingencies.

In the years to come, the strategic environment will also be influenced by shifts in the national and regional distribution of global defense spending. Although U.S. defense spending continues to represent a substantial portion of the global total – nearly 40 percent in 2012 – its net percent change in spending since the 2008 financial crisis was a modest 0.1 percent. In contrast, Chinese and Russian defense spending increased by 43.5 percent and 31.2 percent, respectively, over the same period, whereas spending by Germany (-4.3 percent), the United Kingdom (-9.1 percent) and Italy (-21.5 percent) precipitously declined.²² These changes elevated Russia over the UK in terms of total defense spending, leaving it behind only the United States and China, and placed China on pace to surpass the combined spending of the UK, France and Germany by 2015.²³ If current trends continue, they could result in shifts in the military balance of power or embolden previously restrained states to undertake more provocative military campaigns (see Figures 2 and 3).

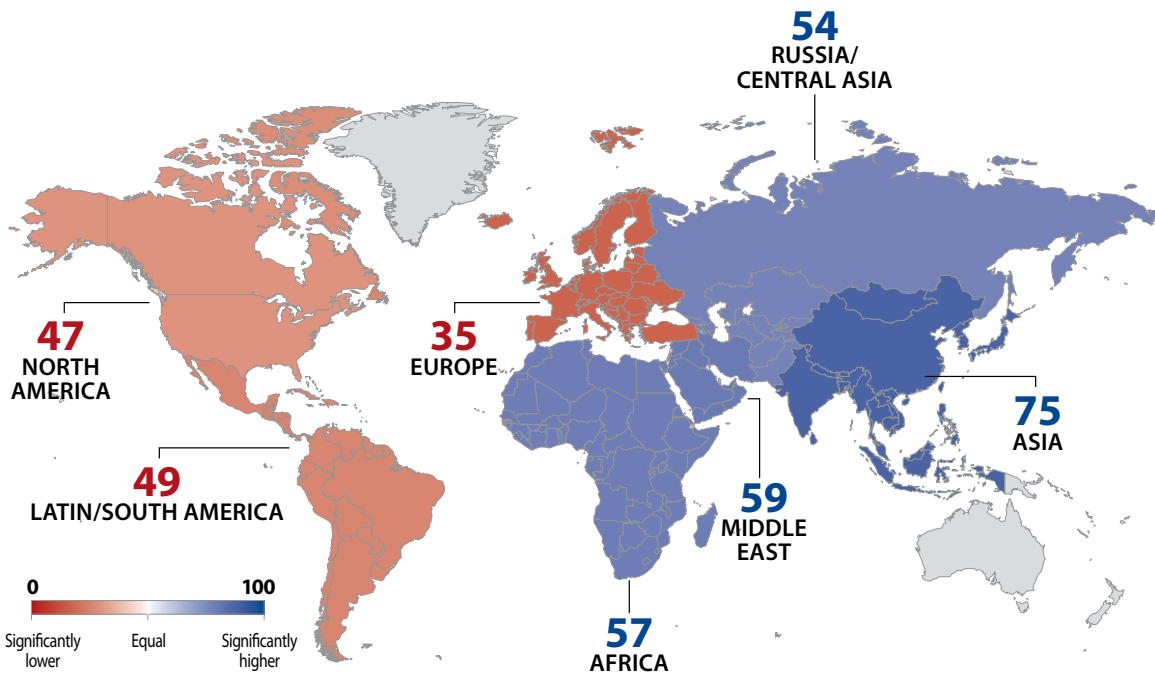
Regional shares of military expenditures are also changing. From 2002 to 2012, the shares of Africa and the Middle East marginally increased (by less than 1 percent each); however, East Asia’s share climbed by over 3 percent, reflecting a real increase of \$126 billion in constant 2011 prices.²⁴ More dramatically, Western Europe’s military expenditures

FIGURE 2: PERCEIVED TOP ARMS EXPORTERS IN 2030



Source: Center for a New American Security Creative Disruption Survey I, January 2014.

FIGURE 3: PERCEIVED COMPARATIVE LEVEL OF ACQUISITION SPENDING IN 2030



Source: Center for a New American Security Creative Disruption Survey I, January 2014.

declined by over 8 percent from 2002 to 2012, reflecting a real decrease of \$13 billion in constant 2011 prices.²⁵

This distribution of expenditures is largely mirrored in the global defense industry market, which is dominated by U.S. firms, 42 of which are among the Stockholm Military International Peace Research Institute's Top 100 arms-producing and military service companies for 2012.²⁶ Defense firms in other nations, however, are becoming increasingly competitive. Driven by domestic sales, the six Russian firms included in the Top 100 saw their arms sales increase by approximately 28 percent in 2012. And although Chinese firms are not included in the Top 100 because of a lack of reliable sales data, analysts estimate that 9 or 10 Chinese firms would be in the Top 100, with between 4 and 6 firms in the Top 20.²⁷

When taken as a whole, the share of sales of firms outside of North America and Western Europe, which together still account for 86 percent of total global sales, rose by 14 percent in 2012 alone.²⁸ Given that defense-industrial procurement remains a mostly national endeavor, Western firms are likely to see a continued decline in their share of global sales if military expenditure trends hold.²⁹ Several factors could magnify this effect, including a lack of cost competitiveness (particularly for countries that have no need or ability to employ advanced capabilities), the desire to avoid the human rights obligations that often accompany Western arms exports, and the existence of regulatory barriers to emerging markets and technologies.³⁰

The Unchanging Governmental Environment

In the face of significant strategic and technological change, departments of defense have shown little interest in strategically meaningful reform. Not only do they follow the precepts of a decades-old strategy, they still rely on that strategy's

concomitant institutional constructs. Despite the possible impact of these institutional barriers on future innovation and competitiveness, they seem unlikely to undergo any significant changes by 2030 and, at any rate, will continue to exist in some form for the foreseeable future. In the case of Western defense regulations, such as the United States' International Traffic in Arms Regulation and the European Union's Code of Conduct on Arms Exports, the expressed intent of national governments to use export controls to bolster regional stability, limit access to sensitive technologies and uphold international obligations suggests that they will remain involved in regulation, likely in a similar capacity as they are today.³¹

Indeed, ongoing efforts have focused on rebalancing the emphasis of Western export controls between economic and security priorities, and countless studies have concluded that existing controls inhibit innovation and competitiveness and are ill-suited for both a globalized defense market and a rapidly changing security environment.³² Nonetheless, enthusiasm at the national level for comprehensive reform has been minimal.

The rigidity of existing regulatory barriers will thus inevitably come into conflict with emerging technologies. For example, the Missile Technology Control Regime, originally established in 1987 to regulate ballistic and cruise missiles, constrains the exports of UAVs – particularly those with ranges of more than 300 km and payloads of more than 500 kg, such as the MQ-1 Predator, MQ-9 Reaper and RQ-4 Global Hawk.³³ These restrictions provide advantages to those countries that do not adhere to them, including China, Iran and Israel, the last of which has surpassed the United States to become the world's largest exporter of UAVs.³⁴ Despite this, there are no indications that such regulations will be amended in the near term to accommodate emerging technologies or to establish more efficacious guidelines.³⁵

Government involvement in research and development will additionally hold important consequences for the future of defense technology, as there is a demonstrated positive correlation between rate of innovation and R&D intensity (the ratio of R&D to gross domestic product).³⁶ Current leaders in total R&D intensity across business, government, academia and other organizations include Israel, South Korea and Finland, although the United States continues to make the single largest investment in R&D.³⁷

Overall, however, both U.S. and European Union shares of global R&D spending are dwindling, with America's share declining from 37 percent in 2001 to under 30 percent in 2011 and the EU's share declining from 26 percent to 22 percent over the same period. As with broader military expenditures, these shares are shifting to South and East Asia, which accounted for 34 percent of R&D spending as of 2011 (up from 25 percent in 2001).³⁸ In its examination of these trends, the National Research Council concluded that they "are indicative not only of the growing importance that nations are placing on R&D, but also of prospective challenges to U.S. technological leadership."³⁹

Trends in independent research and development (IRAD), or research and development that is funded by business, will also impact future sources of innovation. There appears to be a growing disparity in IRAD investment trends between commercial firms and traditional defense firms. For the latter, aversion to risk and uncertainty over market signals have led to a decline in IRAD investments. This is particularly true in the United States, where the IRAD spending of top defense firms fell as a percentage of sales to 2.3 percent in 2012 from approximately 3.5 percent in 2000.⁴⁰ For commercial firms, however, the injunction is clear: Innovate or die, and they have responded by investing accordingly.⁴¹ If left unchanged, this state of affairs will gradually

shift innovation to the commercial sector and undermine the competitiveness of traditional defense firms.

Finally, bureaucratic inertia and institutional politics also contribute to the intransigent governmental environment, with vested interests and constituencies, as well as entrenched organizational structures, forming a protective layer around incumbent programs.⁴² These conditions favor the status quo and additionally increase the difficulty of ending poorly performing programs or investing in new alternatives. Often, incumbent programs are further buttressed by a reluctance to forfeit potential returns on sunk costs, particularly when those costs are substantial.⁴³ This focus on short-term political and financial expediency adds to long-term risk, potentially resulting in the fielding of substandard systems, undermining competitiveness and threatening sustained military superiority.

III. DISRUPTIVE EFFECTS

The convergence of these trends in technology, strategy and the global defense industry will generate several disruptive effects in the years to come. Although the exact manifestation of these effects may vary between countries depending on structural and strategic contexts, they will present national governments with similar risks and opportunities. Given the potential for variance, the following section will explore these effects within a U.S. context.

Structure of the Industry and Implications

As a result of the 1990s downturn in defense spending, the defense industry initiated a series of consolidations that increased the disparity between commercial and defense-specific firms. Defense suppliers prior to this time were mostly subsidiaries of multi-industrial companies that derived less than 20 percent of their revenues from government purchases. The downturn prompted many of these companies to divest themselves of their defense units.⁴⁴ This, in turn, increased the difficulty of transferring commercial innovations to the defense sector.⁴⁵

At the same time, traditional defense firms consolidated, ultimately leaving only three then-prime contractors in the United States.⁴⁶ Many of the defense firms that remained after consolidation divested of their commercial units, with only a third of firms retaining significant commercial businesses. These defense-unique firms now derive approximately 80 percent of their revenues from government purchases.⁴⁷ Furthermore, the trend toward bifurcation shows no signs of reversal, with efforts at commercial diversification by defense firms since the 1990s almost universally ending in failure.⁴⁸

The continued bifurcation of industry holds consequences for competitiveness and the future of defense acquisitions. The high barriers to entry for platform development give a strong advantage to prime defense contractors, which are positioned to

exploit both large-scale production capacity and a unique knowledge of the military customer.⁴⁹ As a result, competition for major systems is effectively closed to commercial firms. In the case of rapid acquisitions and the incorporation of emerging technologies, however, commercial firms have the edge.⁵⁰ This trend is broadly consistent with Clayton Christensen's observations on innovation: "Established firms tend to be good at improving what they have long been good at doing, and ... entrant firms seem better suited for exploiting radically new technologies."⁵¹ Despite this, DOD is, in the words of one observer, "still paying dinosaurs to disrupt" and has done little to cultivate relationships with commercial firms.

Given the agility and adaptability needed to navigate the complex strategic environment of the future, DOD will increasingly need to access technology originating from both the commercial and defense sectors (see Table 1). The department is not currently well positioned to do so, nor is it clear that DOD recognizes the unsustainability of its current approach.

Indeed, despite the predictable disruption that will arise from the proliferation of commercial technologies with defense applications, DOD has demonstrated a repeated inability to preemptively institute comprehensive change in the way it does business and has thus far failed to ease the entry of commercial firms into its defense market. Current acquisition processes often include cumbersome reporting standards and require the abdication of intellectual property rights, both of which inhibit commercial crossover into the defense space.

Commercial firms may also have concerns about the public relations impact of partnering with a military customer. These concerns have been well-documented with regard to the use of commercial information technologies in government surveillance – a practice that has been roundly criticized by human rights groups with the intent

of impacting non-defense sales. For example, activist Norman Solomon has argued that Amazon’s cloud computing contract with the CIA means that it “is responsible for keeping the CIA’s secrets and aggregating data to help the agency do its work ... including drone strikes.”⁵² Although this is a particularly extreme characterization, it nonetheless illustrates the public relations problem facing commercial firms.

Many commercial firms are also reluctant to partner with a military customer because of concerns about the ownership of intellectual property rights. DOD’s failure to resolve such concerns will have increasingly grave consequences for its ability to leverage innovative technologies. In this regard, Google’s recent purchase of Boston Dynamics, a commercial robotics company with strong links to the Defense Advanced Research Projects Agency (DARPA), is instructive. Although Google has stated that it will honor all existing development contracts signed by Boston Dynamics with DARPA, Google has also signaled that it is unlikely to enter into any new contracts with the agency.⁵³ This development highlights the necessity of developing effective policy instruments to manage emerging trends and ensure continued access to critical technologies and major sources of innovation.

Concerns about intellectual property rights are driving a similar phenomenon among international defense firms, which are often more amenable to partnering with each other than with the U.S. government. Indeed, European defense firms have a demonstrated history of collaborating across national borders to share production risk and navigate the challenges posed by increased competition and declining budgets.⁵⁴ Although the size of the U.S. market has largely insulated it from many of these competitive pressures, economic and business trends suggest that this situation is unlikely to hold over the long term. Unfortunately, however, U.S. acquisition culture and regulatory

TABLE 1: TECHNICAL NEEDS FOR NATIONAL MILITARIES

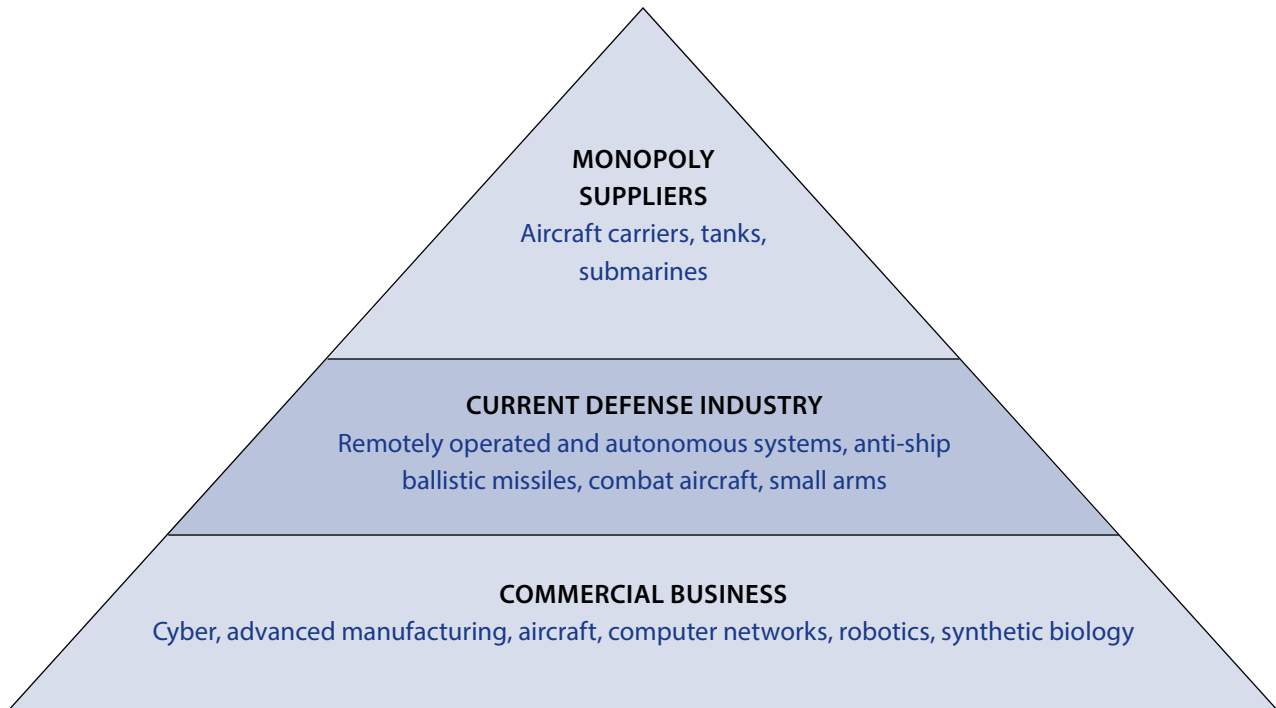
	SUSTAINING TECHNOLOGY/ CAPABILITY	DISRUPTIVE TECHNOLOGY/ CAPABILITY
UNIQUELY MILITARY	Aircraft carriers, tanks, submarines, remotely piloted aircraft	Autonomous surveillance/ strike platforms, anti-ship ballistic missiles
ADAPTED FOR MILITARY USE	Cargo planes, helicopters, small arms, computer networks	Cyber, advanced manufacturing, robotics, synthetic biology

Note: This chart is intended to be illustrative, based on estimated operational effects and existing concepts of operations, and is therefore subject to change. The authors would like to thank Mike Horowitz, Russ Rumbaugh and Pat Ryan for their contributions to this taxonomy.

structures are not optimized for such collaboration and, in the absence of reform, could lead to a significant loss in competitiveness.

In addition, there is evidence that existing acquisitions processes in the United States have generated an aversion within DOD to procuring commercial products with potential military applications.⁵⁵ Over the long term, the convergence of these trends will constrain DOD’s ability to access and leverage commercial technology at a time when more and more innovation is emanating from the commercial sector. Indeed, a survey of defense experts by the Center for a New American Security found that 71 percent of these experts believe that future innovation is more likely to be derived from commercial technologies than from purely defense technologies.⁵⁶

TABLE 2: NOTIONAL FUTURE DEFENSE INDUSTRY STRUCTURE AND CAPABILITIES PRODUCED



Note: This chart describes a hypothetical future defense industry structure with candidate technologies produced. Technology development would almost certainly take place across different business types. The authors would like to thank Marty Bollinger for articulating this structure.

Experts largely agree on the types of reform that would be required to address some of these challenges. Of the 16 major studies on acquisition reform since 1986, the majority “arrived at most of the same findings and made similar recommendations.”⁵⁷ Nonetheless, meaningful reform has thus far remained elusive. And although it is possible that developments in the strategic environment could prompt a re-evaluation of current policies, such a result is far from certain. The exigencies of more than 12 years of war may have resulted in incremental improvements in DOD’s ability to engage non-traditional suppliers – and notably led to the 2009 creation of the Rapid Fielding Initiative – but even they left the underlying acquisition structures largely intact and poorly situated to leverage commercial technologies.

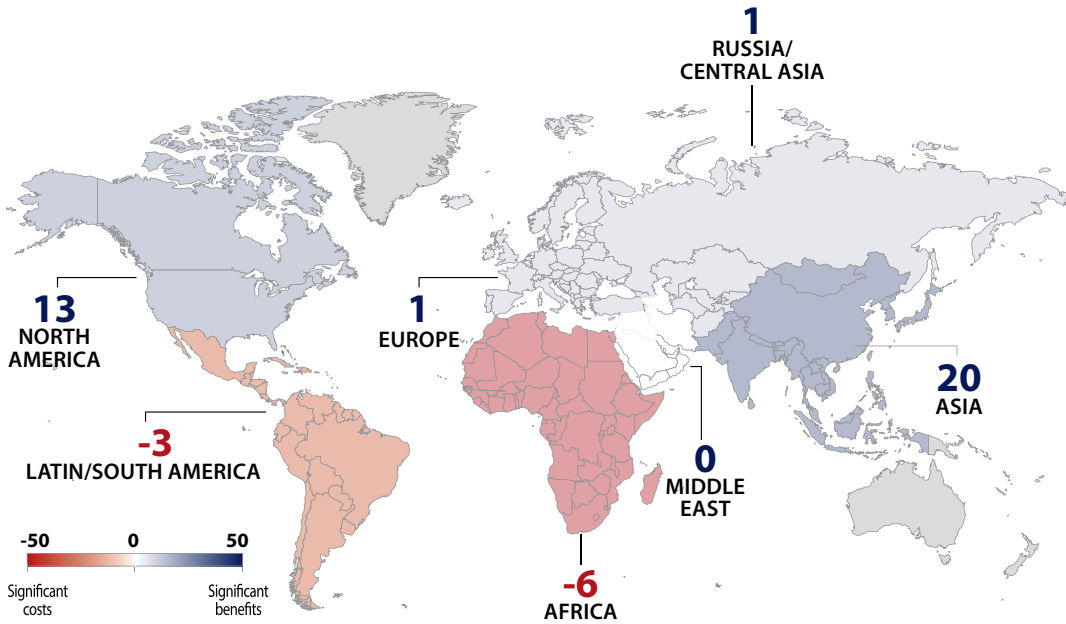
Failure to adapt to a primarily commercial technology environment means missing the opportunity

to capitalize on rapid technology transitions and privately funded R&D and additionally creates the real risk that military technology will be outdated and inferior to that which is available on the open market to friend and foe alike (see Table 2). Thus, in the continued absence of reform, the bifurcation of the defense industry – which has only widened since its emergence in the 1990s – presents a growing impediment to DOD’s ability to obtain the most innovative and impactful technologies and could eventually affect its ability to accomplish key strategic objectives.

Implications of Changing Power Dynamics

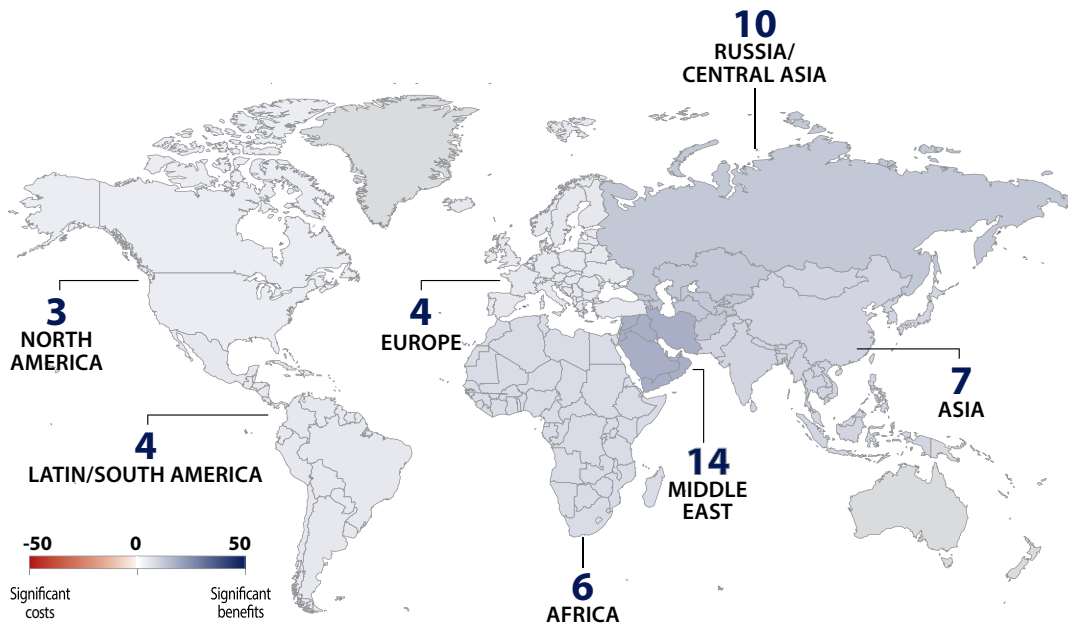
The aforementioned trends – in national military spending, accessibility of disruptive technology and the broader strategic environment – could also result in changes in existing power dynamics.⁵⁸ Indeed, at a time when U.S. and allied defense

FIGURE 4: BY 2030, NATIONAL MILITARIES IN WHICH GEOGRAPHIC REGIONS WILL DERIVE THE MOST MILITARY BENEFIT OR FACE THE MOST MILITARY COSTS FROM EMERGING TECHNOLOGIES?



Source: Center for a New American Security Creative Disruption Survey II, February 2014.

FIGURE 5: BY 2030, NON-STATE ACTORS IN WHICH GEOGRAPHIC REGIONS WILL DERIVE THE MOST MILITARY BENEFIT OR FACE THE MOST MILITARY COSTS FROM EMERGING TECHNOLOGIES?



Source: Center for a New American Security Creative Disruption Survey II, February 2014.

budgets are declining, some U.S. competitors have dramatically accelerated defense investments and embarked on aggressive programs of military modernization focused on the acquisition of asymmetric capabilities. In the case of China, for example, sizable increases in defense spending over the past decade have fueled the country's development of advanced anti-access/area denial capabilities, which could in turn provide it with a strategic advantage in the event of a conflict and ultimately lead to a shift in the balance of power.⁵⁹

At the same time, the proliferation and accessibility of disruptive technologies will continue to enhance the stature of individuals, non-state actors and minor military powers (see Figures 4 and 5). Early indicators of this can be seen in Hezbollah's acquisition of UAVs, which it has used to infiltrate Israeli airspace – a feat that likely could not be accomplished with conventional aircraft.⁶⁰ Further highlighting the implications of such a development, Yochi Dreazen has written that “drones represent the next evolution of warfare-by-remote-control, when weaponized robotic planes give terrorist groups de facto air forces.”⁶¹ It seems clear that these dynamics will lead to the democratization of the tools of violence with attendant consequences for national security and the stability of the international system.

In this way, the convergence of trends in technology and security will affect the balance of power among all players in the international system – state and non-state alike. Moreover, the evolving diversification and amplification of threats will have a substantial impact on state-based capability development, which will need to prepare for a growing range of contingencies – from the conventional to the highly asymmetric. This difficulty will be compounded by concomitant reductions in U.S. and allied defense budgets. If major powers fail to recognize and plan for this state of affairs – and there is little evidence to suggest that they are doing so – they will find themselves increasingly

vulnerable to a diverse set of actors and potentially powerless to effect desired outcomes in the event of a conflict.

Risks of Unidentified Hollowness

Trends in technology and industry will also influence the ability of defense firms to recruit and retain high-level talent. In the years to come, the U.S. defense industry will face numerous challenges arising from the aging of its workforce, 18.5 percent of which will be eligible for retirement in 2017.⁶² This impending wave of retirement – which will result in a substantial loss of human capital – is set to hit at the same time that declining defense budgets and defense downsizing are decreasing the appeal of the industry among both current and rising talent.⁶³ Indeed, in the case of the latter, an *Aviation Week* survey found that “60% of students at universities favored by aerospace and defense employers said they had considered a career in the industry in 2013, down from 72% in 2012 and the lowest in four years.”⁶⁴

As the sources of innovation continue to shift to the commercial sector – with attendant implications for the respective compensation packages on offer – defense firms will face an increasingly competitive talent market. This competitiveness will be heightened by the aggressive talent management practices of some commercial firms.⁶⁵ For example, many Silicon Valley businesses use so-called “acqui-hires” – in which firms are acquired primarily for their talent – to access and corner limited, high-demand skill sets. Google's recent acquisition of Boston Dynamics and other robotics companies is widely viewed as an example of this strategy.

Such pressures could, in turn, give rise to unidentified hollowness within the defense-industrial base. In the case of human capital, for example, the defense industry may successfully recruit a sufficient number of workers but may find that those workers lack the optimal skill set or performance

record, ultimately leading to a further deterioration of industry-driven innovation. These dangers are similarly present within the supplier base and support contractors and, if left unidentified, threaten to hamstring DOD in the event of unforeseen crisis and to undermine the very foundations of national security.⁶⁶

Political and Regulatory Interference Handicaps the Defense Industry

Given the budgetary constraints that will remain in place for the foreseeable future, the United States and similarly situated nations will have to make tradeoffs in the capabilities that they continue to invest in and produce. In addition to making wise investment decisions, these nations will be forced to assess how future capabilities will be developed. In theory, governments could provide clear demand signals to industry and allow commercial innovation and competition to naturally produce the best solutions. To date, however, the process of creative destruction has not held for the defense industry. Archaic regulatory barriers, distributive politics and entrenched interests have combined to forestall necessary change and protect favored capabilities. Worse, governments use these methods of intervention in an attempt to effect desired outcomes in the absence of a clearly defined strategy.

Congressional politics have been particularly pernicious in minimizing the creative destruction that would otherwise arise under conditions of austerity. Indeed, members of Congress, sensitive to the re-election imperative, are loath to support capability reductions that could negatively impact their constituencies, regardless of the military utility of those capabilities. This phenomenon has played out most recently in response to the Air Force's efforts to divest itself of the A-10 ground-attack aircraft. Despite the service's assessment that the A-10's capabilities is now duplicated by other aircraft and that divestiture could thus enable the procurement of newer capabilities that could diminish overall

strategic risk, a coalition of affected lawmakers has strongly resisted any changes in the current program.⁶⁷ Lawmakers similarly disregarded service preferences by promoting upgrades to the M1 Abrams tanks despite the opposition of the U.S. Army.⁶⁸

The final outcome of this particular battle remains to be seen. However, one thing is clear: The absence of strategic direction is driving short-term, politically expedient behaviors in government and industry. This state of affairs is not sustainable, and as defense budgets continue to decline, the strategic and monetary costs of artificially preventing creative destruction will become increasingly apparent. In the years to come, it will be critical for the United States to adopt a more strategic approach – as well as the requisite political will – to identify the capabilities it should develop on its own, divest itself of or work with partners to achieve. It cannot continue to do everything.

IV. RECOMMENDATIONS: SUCCESS AND FAILURE IN THE 21ST CENTURY

In the 21st century, the competitiveness of national governments will be determined by their ability to manage the disruptive effects arising from interactions in the technology, security and business environments. Macro trends in these environments will inevitably lead to a diminution in the traditional sources of competitive advantage that were the hallmarks of 20th-century powers. However, this is not to suggest that 20th-century powers will necessarily face defeat nor that they will be inherently uncompetitive. In fact, these powers – with their uniquely high levels of access to intellectual property, capital, commercial markets and highly trained military personnel – remain exceptionally well placed to succeed.

To remain competitive, governments will need to align themselves with, rather than resist, prevailing trends. For the United States, such alignment will require a guiding strategy that, in contrast to that of the Cold War, will not have the benefit of a large, existential threat as an organizing principle. This strategy will need to provide the context within which DOD and its industry partners can develop capabilities for a rapidly evolving range of contingencies. These capabilities will necessarily be developed by widely different sources using a variety of methods to achieve appropriate levels of quality, cost and timeliness.

Such requirements, in turn, imply a new paradigm for defense acquisition to support strategic objectives, minimize risk and maintain access to innovation. To achieve those aims, the new paradigm must be multi-modal, agile and capable of leveraging a wide range of organizations (large or small, commercial or specializing in defense, domestic or international). This paradigm is ambitious, but it is fundamental to maintaining technological competitiveness and is well within the realm of the possible.

A wide range of actors will thus need to demonstrate bold leadership and a willingness to invest in long-term strategic initiatives in support of vital objectives, regardless of popularity or adverse political pressures.

To date, however, there has been little recognition that disruptive trends in technology, security and business are occurring, let alone that significant change will be required to adapt to them. Indeed, if national governments are to maintain competitiveness in the face of a rapidly changing strategic environment, they cannot afford to cling to outmoded paradigms, processes and structures. Likewise, elected officials, policymakers and defense industry leaders can no longer afford to employ expedient but short-sighted approaches at the detriment of competitiveness and sustainability. A wide range of actors will thus need to demonstrate bold leadership and a willingness to invest in long-term strategic initiatives in support of vital objectives, regardless of popularity or adverse political pressures.

In this spirit, we propose several necessarily high-level recommendations to help business leaders and policymakers navigate the complexities of the emerging strategic, business and technological environments.

Develop an Acquisition Strategy for the 21st Century

Today's approach to acquisition remains rooted in the precepts of a decades-old paradigm. While the technological offset strategy developed in the

late 1970s served the United States well during the last decades of the Cold War, it was not designed for today's strategic environment nor can it easily accommodate emerging asymmetric threats – including cyberweapons, biological weapons and low-technology weapons from non-state actors – or satisfactorily leverage the growing number of commercially and internationally produced technologies. Indeed, the United States and other major powers cannot afford to continue to address the challenges of the 21st century with 20th-century approaches. Although comprehensive reform is highly unlikely, developing an appropriate strategic framework would create the conditions for positive, incremental change across the defense ecosystem.

At a minimum, this paradigm needs to replicate the successes of the offset strategy by effectively equipping U.S. forces, imposing costs on adversaries, generating positive economic externalities and strengthening alliance relationships and partnerships. It will also need to foster the agility needed to respond to unanticipated shifts in strategic priorities and the strategic environment. This will necessarily involve engaging business, domestic and international equities in a manner that encourages both innovation and collaboration. The strategy will also need to recognize that DOD will, on balance, have a greater need to access externally developed technologies – that is, those originating from international or commercial firms – than in the past. The task of crafting such a strategy will be daunting but will be essential to maintaining competitiveness and, for the United States, preserving military superiority.

Undertake Reform to Update Defense Structures

In support of this new strategy, DOD will need to implement numerous incremental reforms in a variety of areas. Although past efforts to introduce such reforms have been well documented, they have not yet come close to achieving necessary

outcomes. The future success of reform will therefore require a shift in mindset – from managing the defense-industrial base, as currently conceived, to creating a permissive environment for a broader industrial base that can support defense needs. Specifically, DOD should implement the following changes:

ACQUISITION REFORM

The need for acquisition reform is widely acknowledged and has been extensively studied both inside and outside of DOD.⁶⁹ Moreover, there is a general consensus on the types of reform that are necessary. What is needed, then, is not further study, but rather strong leadership and a commitment to instituting the actions that have already been identified. The British experience with implementing through-life costing demonstrates that this type of reform – even if flawed – is possible, despite political, cultural and financial challenges.⁷⁰

In addition to easing the participation of international and commercial firms in the defense space and implementing more effective mechanisms for acquiring international and commercial technologies, DOD will need to recognize that its uniform model for acquiring a diverse range of capabilities and services is a vestige of a bygone era. Over the past 13 years of war, the department has – by necessity – utilized a number of more rapid, agile acquisition processes – via the Joint Improvised Explosive Device Defeat Organization, Rapid Fielding, the Rapid Equipping Force, etc. – that were better suited to its needs. In the future, DOD will need to identify the type of process that is most appropriate for the given circumstance and tailor its approach accordingly. Furthermore, it will need to establish methods of translating innovative concepts and prototypes into viable and enduring capabilities.

Finally, DOD will need to demonstrate realism and restraint in the requirements generation process. To this end, it must conduct a candid assessment of

essential needs and limit capability requirements to those needs. In the past, the department has often insisted on a comprehensive but costly solution when a partial solution at a substantial cost savings would be adequate to meet essential needs. It can no longer afford to do so.

IMPROVED COMMUNICATION TO THE MARKET

Once essential needs are established, DOD will then need to better communicate its intentions with both defense and commercial firms. For defense firms, DOD will need to increase visibility into the requirements process and convey its program agenda and priorities in a timely manner. Such measures will help industry identify the areas to which it should direct investments, thereby reassuring investors and providing support for further investments.⁷¹ For commercial firms, DOD will need to clearly convey market opportunities and identify potential points of commercial entry. As an example of this, Australia's Roadmap for Network Centric Warfare explicitly sought to transmit the government's demand signal to industry.⁷² DOD should replicate this approach on a broader scale.

IMPROVED ENGAGEMENT WITH COMMERCIAL FIRMS

In the past, DOD has often implemented policies that make it more, not less, difficult for commercial firms to do business with the department; however, this approach is counterproductive for all parties.⁷³ As the commercial sector becomes an increasing source of innovative technologies, DOD will need to better engage commercial firms and improve its means of leveraging these technologies for the warfighter.

INTELLECTUAL PROPERTY REFORM

DOD will need to update regulations concerning the transfer, ownership and protection of intellectual property (IP) to reflect the demands of today's business environment. Existing intellectual property regulations, enacted during the height of

the Cold War, continue to be useful within certain contexts but are now much more of an impediment to the government's ability to access innovative technology or collaborate with potential partners. Indeed, as a DOD white paper concluded, "many commercial companies may refuse to do business with the Government because they believe that they will be forced to give up their IP rights under a traditional Government contract."⁷⁴ Despite DOD's recognition of the problem, however, it has failed to enact meaningful reform. And as the sources of innovation continue to shift to the commercial sector, this failure will become increasingly problematic.

REGULATORY REFORM

Declining revenues and increased competition point logically to increased collaboration throughout the global defense industry, as is seen in many European projects, including the "nEUROn" UAV technology demonstrator.⁷⁵ For this reason, the Departments of Defense, State and Commerce will need to make greater headway in adjusting both import and export controls to enable greater international collaboration and expand technology-sharing agreements with U.S. partners and allies. Although there have been positive developments in this area – including the recent revisions to the U.S. Munitions Import List, which removed import controls on select defense articles – substantial opportunities remain for better aligning U.S. regulations with trends in the technology, security and business environments.

Increase Defense Industry Innovation

Despite the critical need for government leadership to improve the strategic context in which defense industry operates, recent history provides little hope for optimism. At the same time, the responsibility for reform and innovation does not rest solely with government. The defense industry will play a critical role in crafting a business environment that can adapt to rapidly changing trends in the technological and strategic environments and efficiently

produce premier defense capabilities.

To date, however, the defense industry has been more focused on short-term risk mitigation than on long-term strategic thinking, as is evident in its preference for buying back shares – for the purpose of raising stock prices – rather than investing in innovative technologies or exploring alternative business strategies. Although shareholders and investors have rewarded this approach, it threatens to undermine the long-term competitiveness of the defense industry.⁷⁶ Instead, defense industry and industry leaders should adopt the following approaches:

LEAD AND INVEST

Industry chief executive officers and other leaders will need to demonstrate leadership with their boards and shareholders to make the case for bolstering long-term competitiveness through investments in innovative technologies, rather than simply responding to short-term market pressures. Industry leadership should additionally explore alternative business strategies, including mergers and acquisitions, that may present short-term risk but provide greater stability, greater potential for growth synergies and broader corporate sustainability over the long run.

EXPLORE MARKET ADJACENCIES

The defense industry, particularly so-called second-tier businesses with more commercial opportunities and structures, should explore market adjacencies. Rather than focusing solely on transferring defense technology to commercial markets, as was attempted with limited success in the 1990s, these businesses should explore the opportunity to act as a conduit between the commercial sector and defense markets.

DESIGN FOR AND AROUND REGULATIONS

In the absence of meaningful regulatory reform, defense businesses should explore the extent to which export compliance and other regulatory

requirements can be incorporated directly into the design of systems, particularly for those systems intended to be exported to growing markets in developing nations. An example of this approach can be seen in Textron's AirLand Scorpion, built entirely from commercially available and off-the-shelf components that should be export compliant with little to no alteration.⁷⁷

EXPLORE EFFECTIVE INTERNATIONAL COLLABORATION

Current U.S. efforts at international collaboration have seen both successes and set-backs. However, if the defense industry is to remain competitive in the future, it will need to explore more effective means of partnering with international firms. The formation of MBDA, a transnational company with operations in the United States and several European countries, provides one potential model for such efforts.⁷⁸

With such collaboration, however, comes public concern about outsourcing, domestic job loss and economic decline. Industry will thus need to actively work to allay these concerns by promoting domestic manufacturing of those defense articles developed by international consortia, offering community job training and instituting other innovative programs. Such concerns have complex origins and are not easily addressed – often giving rise to acute political pressures. Yet it will be essential for industry to explore opportunities to socialize alternative models of business.

Broadly speaking, although much of the impetus for reform in the defense industry is tied to government action, this should not preclude proactive innovation and creative competition from businesses.

V. CONCLUSION

Inertia, inability to adapt and a conscious desire to cling to the familiar methods of past success have positioned 20th-century powers and their defense industries for significant, predictable disruption in the face of 21st-century strategic, business and technological trends. It is unclear when exactly these trends will collide, but the leading indicators of peril are coming into focus as defense budgets decline.

This ominous outlook need not be the future we create for ourselves. The governments and businesses in question retain the tools to access the intellect, capital and technology necessary for success. Their success – or failure – will rest on the ability of departments of defense to develop clear and flexible strategies for maintaining military superiority, as well as on the ability of industry to build on these strategies using innovative models and methods. Critically, these strategies must also be supported with appropriate, agile bureaucratic and governance processes.

Unfortunately, the current defense climate, particularly in the United States, suggests that neither a recognition of the impending danger nor a willingness to implement the requisite reforms is near at hand or even likely. Indeed, rather than improving certainty for business, simplifying regulations and allowing market forces to ensure competitiveness, DOD and Congress are attempting to effect success through regulation and oversight – precisely the wrong focus of effort. In the absence of change, the loss of strategic and technological advantage in the coming years will not simply be due to intractable macro trends but to a willful failure to adapt.

ENDNOTES

1. For the classic articulation of the offset strategy, see William J. Perry, "Desert Storm and Deterrence," *Foreign Affairs*, 70 no. 4 (Fall 1991), 66-82.
2. For example, in 2013, the combined defense budgets of France and the United Kingdom were roughly equivalent to Hewlett-Packard's annual revenue. See Stockholm Military International Peace Research Institute (SIPRI), "SIPRI Military Expenditures Database (2014)," sipri.org, http://www.sipri.org/research/armaments/milex/milex_database (Accessed May 7, 2014); and Hewlett Packard, "HP Reports Fourth Quarter and Fiscal 2013 Results," HP.com, <http://h30261.www3.hp.com/phoenix.zhtml?c=71087&p=irol-newsarticle&ID=1880346>.
3. Kenneth Neil Cukier and Viktor Mayer-Schoenberger, "The Rise of Big Data," *Foreign Affairs*, 92 no. 3 (May/June 2013).
4. Simon Rogers, "Drones by Country: Who Has All the UAVs?" Datablog on TheGuardian.com, August 3, 2012, <http://www.theguardian.com/news/datablog/2012/aug/03/drone-stocks-by-country/>.
5. Jeremiah Gertler, *U.S. Unmanned Aerial Systems*, R42136 (Congressional Research Service, January 2012).
6. One example of the developments to come can be seen in the experiments being conducted by researchers at the University of Pennsylvania's GRASP Laboratory with swarms of nano quadrotors. "Towards a Swarm of Nano Quadrotors," Youtube.com, February 3, 2012, <https://www.youtube.com/watch?v=UQzuL60V9ng>. See also Michael C. Horowitz, "The Looming Robotics Gap," *ForeignPolicy.com*, May 5, 2014, http://www.foreignpolicy.com/articles/2014/05/05/the_looming_robotics_gap_us_military_technology_dominance.
7. Chris Anderson, *Makers: The New Industrial Revolution* (New York: Crown Business, 2012).
8. See Aaron Martin and Ben FitzGerald, "Process Over Platforms: A Paradigm Shift in Acquisition Through Advanced Manufacturing" (Center for a New American Security, December 2013); and Gabrielle Jonas, "Now You Can 3-D Print Your Guns in Metal," *Newsweek*, December 5, 2013.
9. National Research Council, *Avoiding Surprise in an Era of Global Technology Advances* (Washington: National Academies Press, 2007), 13.
10. Ibid.
11. The rise of income-oriented shareholders has, in turn, pushed defense companies to "to generate shareholder value by buying back shares and returning earnings to shareholders in the form of dividends" rather than making long-term investments. Erich Fischer and Randy Starr, "2014 U.S. Defense Industry Perspective," (Strategy&, December 20, 2013).
12. Emily Chasan, "Apple Now Holds 10% of All Corporate Cash: Moody's," CFO Journal blog on wsj.com, October 1, 2013, <http://blogs.wsj.com/cfo/2013/10/01/apple-now-holds-10-of-all-corporate-cash-moodys/>.
13. Zachary Fryer-Biggs, "DOD Wants Innovation, Firms Want Less Risk," *DefenseNews*, February 9, 2012, <http://www.defensenews.com/article/20120206/DEFREG02/302060005/DoD-Wants-Innovation-Firms-Want-Less-Risk>.
14. Michael C. Horowitz, *The Diffusion of Military Power* (New York: Princeton University Press, 2010).
15. Jacey Fortin, "Active Denial System: Microwave Weapon Safe for Military Use?" *International Business Times*, March 12, 2012, <http://www.ibtimes.com/active-denial-system-microwave-weapon-safe-military-use-video-423916>.
16. P.W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century* (New York: Penguin Books, 2009), 263.
17. National Intelligence Council, *Global Trends 2030: Alternative Worlds*, NIC 2012-001 (December 2012).
18. Ibid.
19. Scott Shane and James Dao, "Investigators Study Tangle of Clues on Fort Hood Suspect," *The New York Times*, November 14, 2009, <http://www.nytimes.com/2009/11/15/us/15hasan.html?pagewanted=all>; and Ines von Behr, Anais Reding, Charlie Edwards and Luke Gribbon, "Radicalization in the Digital Era: The Use of the Internet in 15 Cases of Terrorist Extremism," RR-453-RE (RAND Corporation, November 2013).
20. U.S. Army Training and Doctrine Command, *The U.S. Army Concept for the Human Dimension in Full Spectrum Operations 2015-2024*, TRADOC PAM 525-3-7 (June 11, 2008), <http://www.tradoc.army.mil/tpubs/pams/p525-3-7.pdf>.
21. Richard A. Lindsey, "What the Arab Spring Tells about the Future of Social Media in Revolutionary Movements," *Small Wars Journal*, July 29, 2013, <http://smallwarsjournal.com/jrnl/art/what-the-arab-spring-tells-us-about-the-future-of-social-media-in-revolutionary-movements>.
22. International Institute for Strategic Studies, "The Military Balance 2014: The Annual Assessment of Global Military Capabilities and Defence Economics" (February 2014).
23. Angelo Young, "Global Defense Budget Seen Climbing in 2014; First Total Increase since 2009 as Russia Surpasses Britain and Saudi Arabia Continues Its Security Spending Spree," *International Business Times*, February 6, 2014, <http://www.ibtimes.com/global-defense-budget-seen-climbing-2014-first-total-increase-2009-russia-surpasses-britain-saudi>.
24. During this period, global military expenditures increased by 42 percent – from \$1.2 trillion to \$1.7 trillion in constant 2011 dollars.
25. SIPRI, "SIPRI Military Expenditures Database (2014)."
26. Sam Perlo Freeman and Pieter D. Wezeman, "The SIPRI Top 100 Arms-Producing and Military Services Companies, 2012," (SIPRI, January 2014), 2.

27. Ibid. There is, however, an important distinction in the nature of the exports that comprise these sales. For example, although the share of Chinese arms exports increased from 2 percent to 6 percent between 2009 and 2013, this increase was driven by the comparatively low costs of Chinese defense articles, rather than by the sophistication of the technology. Thus, the shift in sales shares does not necessarily signal a shift in the sources of technological innovation. Zhang Yiwei, "China No. 4 in Global Arms Sales," *Global Times*, March 18, 2014, <http://www.globaltimes.cn/content/849186.shtml>.
28. Peter Apps, "As West Cuts, Global Defense Industry Balance Shifts," Reuters, February 12, 2014, <http://mobile.reuters.com/article/idUSBREA1B18N20140212?irpc=932>.
29. For example, in 2009, the United States, Germany, Italy and France all spent over 98 percent of their procurement dollars on domestically supplied defense articles. Scott Miller, "Remarks at the Federated Defense Launch" (Center for Strategic and International Studies, Washington, December 16, 2013).
30. See Zachary Keck, "Western Defense Companies Face Grim Future," *The Diplomat*, June 12, 2013, <http://thediplomat.com/2013/06/western-defense-companies-face-grim-future/>; Yiwei, "China No. 4"; and Peter Doerrie, "Africa Is Arming Faster Than Any Other Continent," War Is Boring blog on Medium.com, April 16, 2014, <https://medium.com/war-is-boring/82fcd8576966>.
31. See Department of State, "Overview of U.S. Export Control System," [state.gov](http://www.state.gov/strategictrade/overview/), <http://www.state.gov/strategictrade/overview/> (Accessed on May 7, 2014); and European Union External Action, "Arms Export Control," [europa.eu](http://eeas.europa.eu/non-proliferation-and-disarmament/arms-export-control/index_en.htm), http://eeas.europa.eu/non-proliferation-and-disarmament/arms-export-control/index_en.htm.
32. Pierre Chao, "Toward a U.S. Export Control and Technology Transfer System for the 21st Century" (Center for Strategic and International Studies, May 2008), 8-9.
33. Samuel J. Brannen, "Sustaining the U.S. Lead in Unmanned Systems: Military and Homeland Considerations through 2025" (Center for Strategic and International Studies, February 2014).
34. Kelvin Chan, "Curbs Shut U.S. Drone Makers Out of Export Markets," Associated Press, February 13, 2014, <http://news.yahoo.com/curbs-shut-us-drone-makers-export-markets-075835575--finance.html>.
35. Similarly, 3-D printing can substantially accelerate prototyping and parts replacement – and has already been used in such a capacity by the amphibious assault ship USS *Essex* – but the potential of the technology is constrained by an outmoded, sluggish certification and qualifications processes. An alternative model, suggested by RADM Paul Verrastro, would establish an "approved database of design drawings that you can simply download . . . [and print] . . . knowing it can meet the specifications." Sydney J. Freedberg, Jr., "'Throw a Frag Grenade' into Acquisition or 'Do No Harm:' Navy Struggles with Innovation," *Breaking Defense*, April 10, 2014.
36. National Science Board, *Research and Development, Innovation, and the Science and Engineering Workforce*, NSB-12-03 (July 2012).
37. National Science Foundation, *Science and Engineering Indicators 2014*, NSB 14-01 (February 2014), <http://www.nsf.gov/statistics/seind14/>.
38. Ibid.
39. It is important to note, however, that such trends could reverse in response to a strategic shock or other unforeseen change in the strategic environment. Quoted in National Research Council, *Avoiding Surprise*, 11.
40. This picture is more promising in Europe, where top defense firms like BAE and Finmeccanica spend more than 10 percent on R&D. Note: Due to differing accounting standards, this figure reflects funding sources that are not included in the U.S. figure. Zachary Fryer-Biggs and Marcus Weisberger, "U.S. Giants Skimp on Research, Development," *Defense News*, August 19, 2013, <http://www.defensenews.com/apps/pbcs.dll/article?AID=2013308190005>.
41. Fryer-Biggs, "DOD Wants Innovation, Firms Want Less Risk."
42. See James R. Kurth, "Why We Buy the Weapons We Do," *Foreign Policy*, 11 (Summer 1973).
43. For an example of this type of argument, see Steve Kosiak and Barry Watts, "U.S. Fighter Modernization Plans" (Center for Strategic and Budgetary Assessments, June 2007).
44. Marty Bollinger, "Back to the Future in Global Defense" (Booz & Company, January 2014).
45. John R. Harbison, Thomas S. Moorman, Jr., Michael W. Jones and Jikun Kim, "U.S. Defense Industry Under Siege – An Agenda for Change" (Booz Allen Hamilton, 2000).
46. Leslie Wayne, "The Shrinking Military Complex; After the Cold War, the Pentagon Is Just Another Customer," *The New York Times*, February 27, 1998, <http://www.nytimes.com/1998/02/27/business/shrinking-military-complex-after-cold-war-pentagon-just-another-customer.html?pagewanted=all&src=pm>.
47. Bollinger, "Back to the Future in Global Defense."
48. Ibid.
49. Peter Dombrowski and Eugene Gholz, *Buying Military Transformation: Technological Innovation and the Defense Industry* (New York: Columbia University Press, 2006).
50. Marty Bollinger, "Back to the Future in Global Defense."
51. Clayton Christensen, *The Innovator's Dilemma: The Revolutionary Bestseller that Changed the Way We Do Business* (New York: HarperBusiness, 2000), 35.
52. Quoted in Christopher Zara, "Amazon-CIA Cloud Contract Is a Recipe for Big Brother Hell, Warn Privacy Activists," *International Business Times*, February 25, 2014. See also Brendan Sasso, "Google to Obama: Leave Us Out of Your Spying Fight," *Defense One*, April 9, 2014.

53. Grant Turnbull, "Don't Be Evil: Inside Google's Acquisition of Boston Dynamics," *Army Technology*, January 29, 2014; and Mike Hoffman, "Google Buys Pentagon's Robotics Lab," *Defense Tech*, December 16, 2013.
54. Amy Svitak, "Collaboration Is Essential for Europe's A&D Industry," *Aviation Week & Space Technology*, October 28, 2013.
55. Zachary Fryer-Biggs, "Group Warns of Aversion to Buying Commercial Products," *Defense News*, January 27, 2014.
56. See Appendix A for further information about this survey.
57. J. Ronald Fox, "Defense Acquisition Reform 1960-2009: An Elusive Goal" (U.S. Army Center of Military History, 2011).
58. For more on the potential effects of these trends on sustained U.S. technological dominance, see Shawn Brimley, Ben FitzGerald and Kelley Saylor, "Game Changers: Disruptive Technology and U.S. Defense Strategy" (Center for a New American Security, September 2013).
59. Chinese military expenditures continue to rise, reaching an estimated \$135 billion to \$215 billion in 2012, up from approximately \$33 billion in 2000. See Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2013* (May 2013), 3.
60. Similarly, North Korea has reportedly used UAVs to infiltrate South Korean air space. See Yochi Dreazen, "The Next Arab-Israeli War Will Be Fought with Drones: Hezbollah, Weaponized Robots, and a Future That's Already Here," *The New Republic*, March 26, 2014; and Jung Sung-ki, "North Korea's Drones Prompt Seoul to Seek Radars," *Defense News*, April 14, 2014.
61. Dreazen, "The Next Arab-Israeli War."
62. Claire Zillman, "America's Defense Industry Is Going Gray," *money.cnn.com*, November 12, 2013, <http://management.fortune.cnn.com/2013/11/12/aerospace-worker-shortage/>.
63. See Zachary Fryer-Biggs, "Job Cuts Scare Off Would-be Workers," *Defense News*, October 21, 2013; and Zachary Fryer-Biggs, "Firms Struggle to Keep Talent in Downturn," *Defense News*, July 15, 2012.
64. Zillman, "America's Defense Industry Is Going Gray."
65. CB Insights, "The Rise of the Acqui-hire: Breaking Down Talent Acquisitions," blog at cbinsights.com, January 9, 2014, <http://www.cbinsights.com/blog/tech-acquihire-report>.
66. The authors would like to thank Marty Bollinger for this insight.
67. See Halimah Abdullah, "Congress Prepares To Defend Districts from Defense Cuts," *CNN.com*, February 26, 2014, <http://www.cnn.com/2014/02/26/politics/congress-defense-cuts/>; and Sara Sorcher and Stacy Kaper, "In Defense Budget Hunger Games, What's on Congress's Wish List?" *The National Journal*, March 20, 2014, <http://www.nationaljournal.com/defense/in-defense-budget-hunger-games-what-s-on-congress-s-wish-list-20140320>.
68. Richard Lardner, "Abrams Tank Pushed by Congress Despite Army's Protests," *HuffingtonPost.com*, April 28, 2013, http://www.huffingtonpost.com/2013/04/28/abrams-tank-congress-army_n_3173717.html.
69. For a history of these efforts, see Fox, "Defense Acquisition Reform." See also David Barno, Nora Bensahel, Jacob Stokes, Joel Smith and Katherine Kidder, "The Seven Deadly Sins of Defense Spending" (Center for a New American Security, June 2013).
70. National Audit Office of the United Kingdom, *Ministry of Defence Through-Life Management*, HC 698 Session 2002-2003 (May 21, 2003).
71. Early reports indicate that the Pentagon is in the process of producing the third iteration of its Better Buying Power Initiative, known as BBP 3.0, and that this version may introduce greater transparency in contracting. See Sydney J. Freedberg, Jr., "Pentagon Readies New Acquisition Fixes: Will They Work?" *Breaking Defense*, April 23, 2014.
72. Sue Bushell, "Defence Details Plans for Network Centric Warfare," *CIO.com*, October 18, 2005, http://www.cio.com.au/article/141474/defence_details_plans_network_centric_warfare/.
73. See Zachary Fryer-Biggs, "Group Warns of Aversion."
74. Office of the Under Secretary of Defense for Acquisitions, Technology and Logistics, *Intellectual Property: Navigating through Commercial Waters, Version 1.1* (October 15, 2001).
75. See Chris Pocock, "Neuron UCAV Makes Its Maiden Flight," *AINonline.com*, December 7, 2012, <http://www.ainonline.com/aviation-news/ain-defense-perspective/2012-12-03/neuron-ucav-makes-its-maiden-flight>.
76. "Time to Change," *Aviation Week and Space Technology*, 176 no. 13 (April 2014), 52-53.
77. Doug Cameron, "Is the U.S. Ready for a Cut-Rate Jet Fighter?" *The Wall Street Journal*, April 1, 2014.
78. Steve Wadey, "MCM-ITP – a Benchmark in Anglo-French Research Co-operation" (RUSI Defence Systems, Spring 2011).

Appendices

APPENDIX A: SURVEY I	31
APPENDIX B: SURVEY II	34
APPENDIX C: SURVEY III	38

CNAS CREATIVE DISRUPTION SURVEY SUMMARY STATISTICS

As part of the project Creative Disruption: The Task Force on Strategy, Technology and Global Defense Industry, CNAS conducted a series of three short surveys.* These surveys served to highlight perceptions among national security experts on key trends in and issues regarding the future environments for technology, security, government regulations and industry. The following data summarizes the demographics of the survey participants.

AGE	
AGE CATEGORY	PERCENTAGE
18-29	17%
30-39	23%
40-49	21%
50-59	20%
60-69	14%
70-79	5%
80+	0% (2 total)

1019

Total participants (average of 340 per poll)

71%

Experience in the national security realm (public, private, and/or NGO)

29%

No experience in the national security realm (public, private, and/or NGO)

45%

Prior or current military service

55%

No prior or current military service

88%

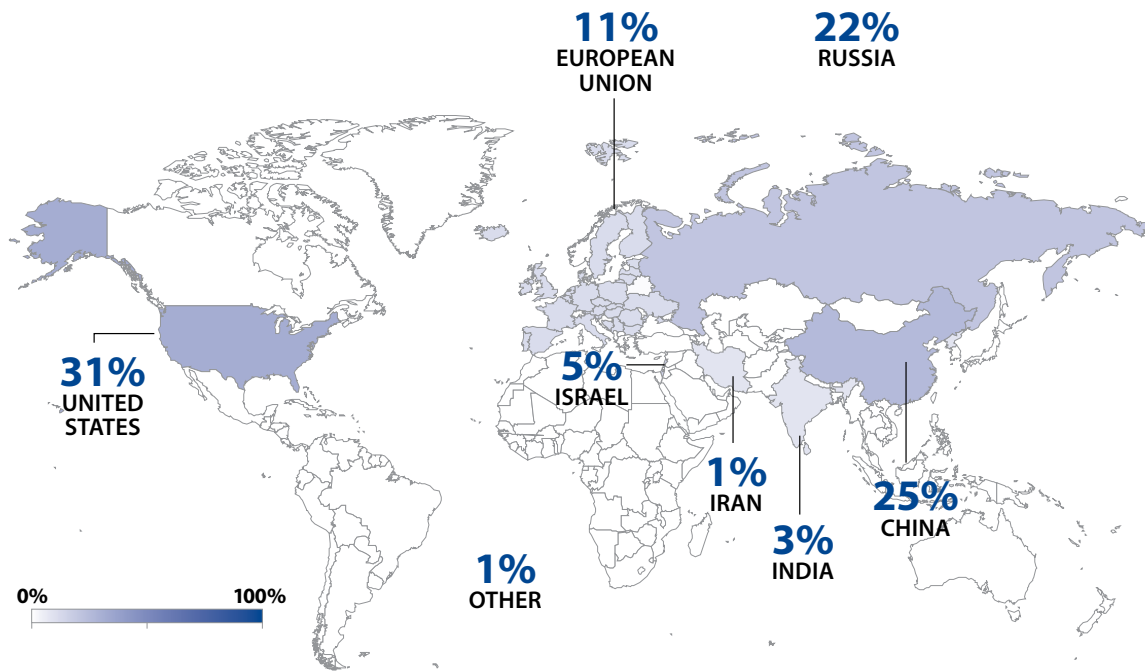
explicitly identified as from the United States

EDUCATION	
LEVEL OF EDUCATION	PERCENTAGE
Bachelor's Degree	35%
Master's Degree	33%
Professional Degree	14%
PhD/EdD	17%

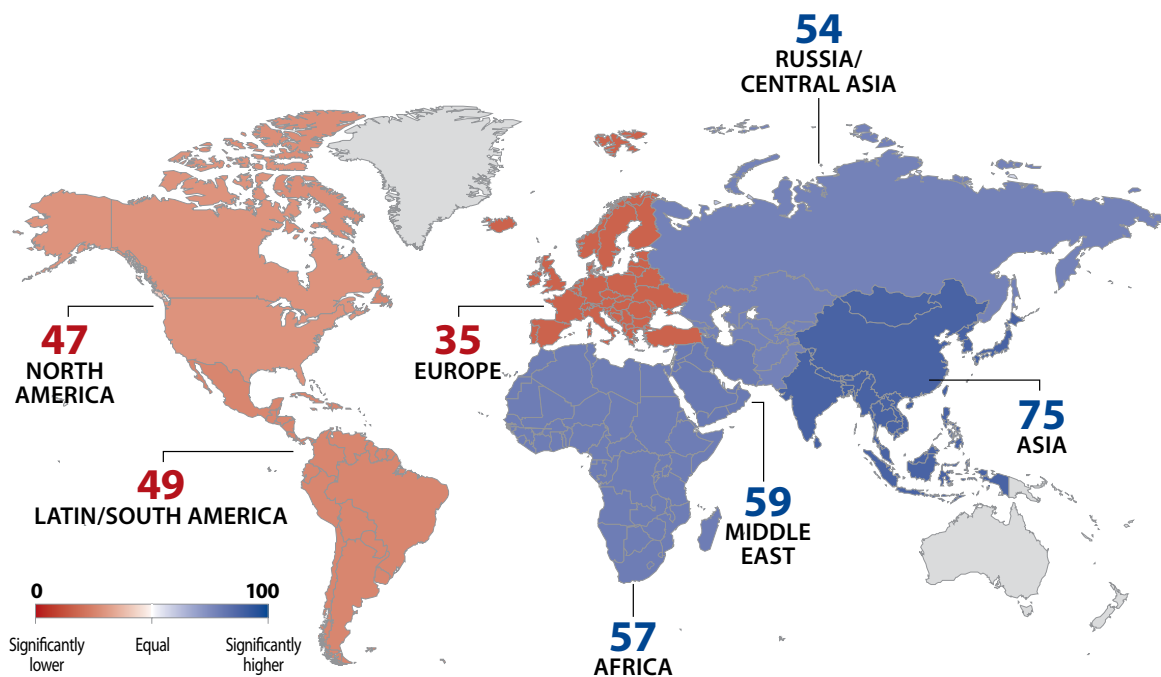
*The authors would like to thank Mike Horowitz for conducting the surveys.

SURVEY 1: JANUARY 2014

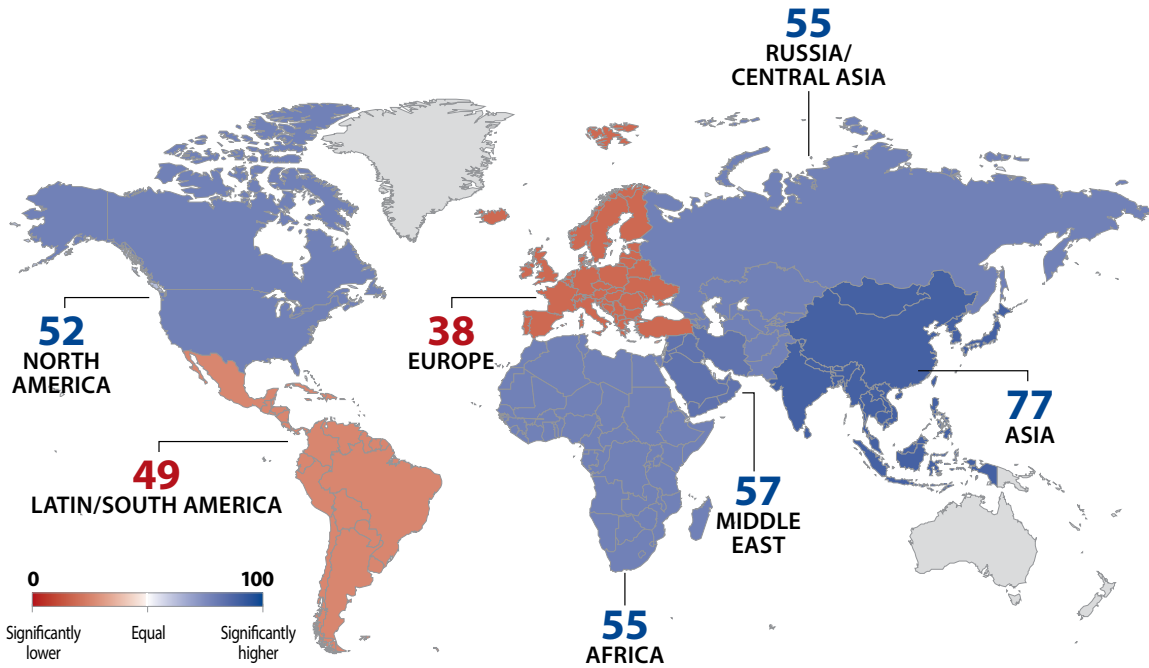
PERCEIVED TOP ARMS EXPORTERS IN 2030



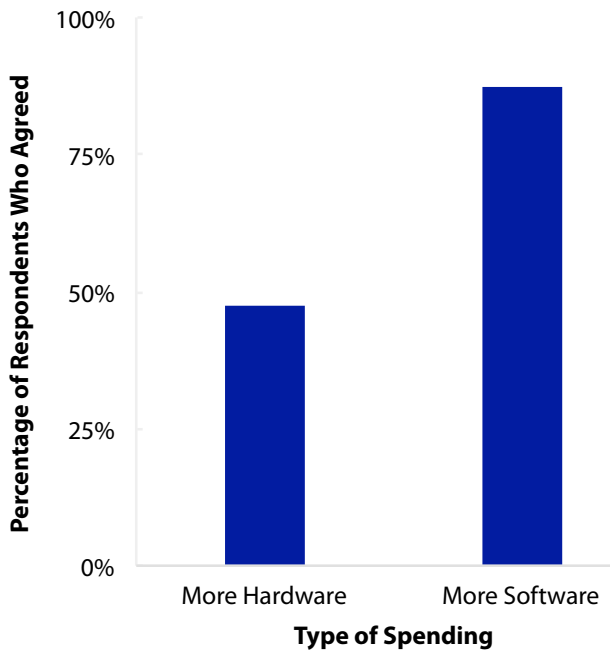
PERCEIVED COMPARATIVE LEVEL OF ACQUISITION SPENDING IN 2030



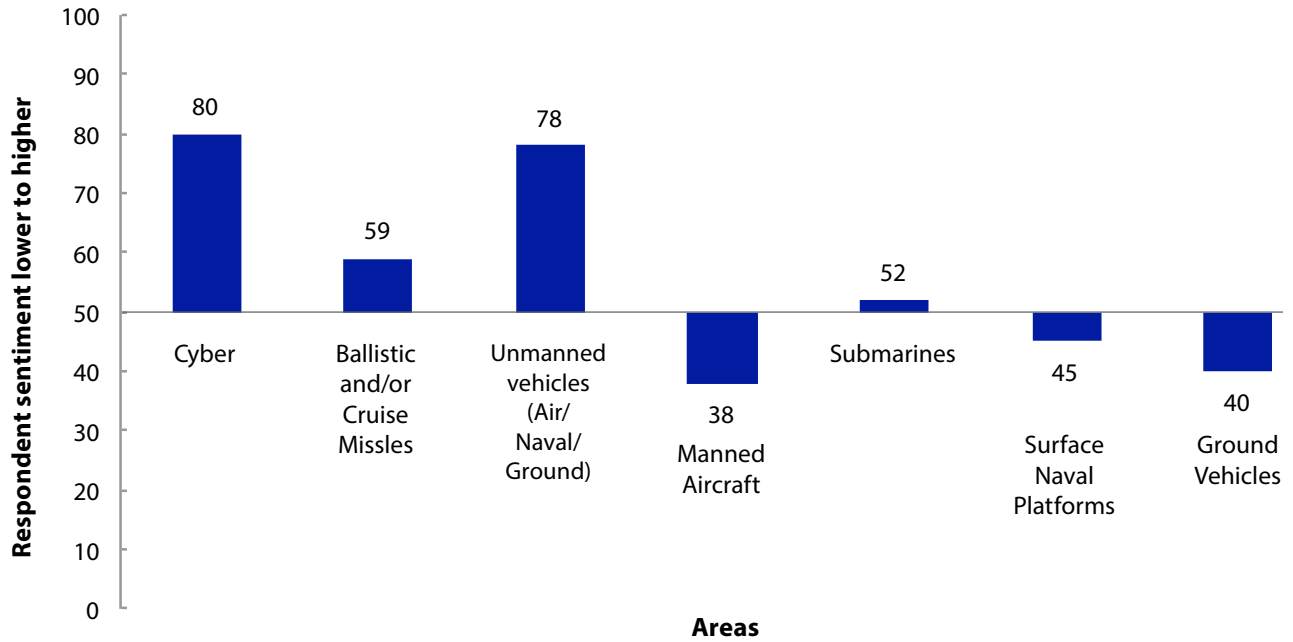
PERCEIVED COMPARATIVE LEVEL OF R&D SPENDING IN 2030



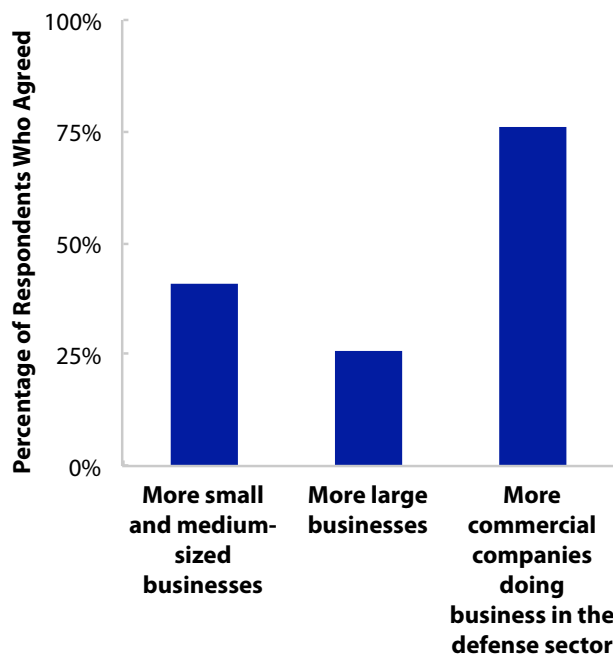
HOW WILL DEFENSE SPENDING ON SOFTWARE AND HARDWARE CHANGE BETWEEN TODAY AND 2030?



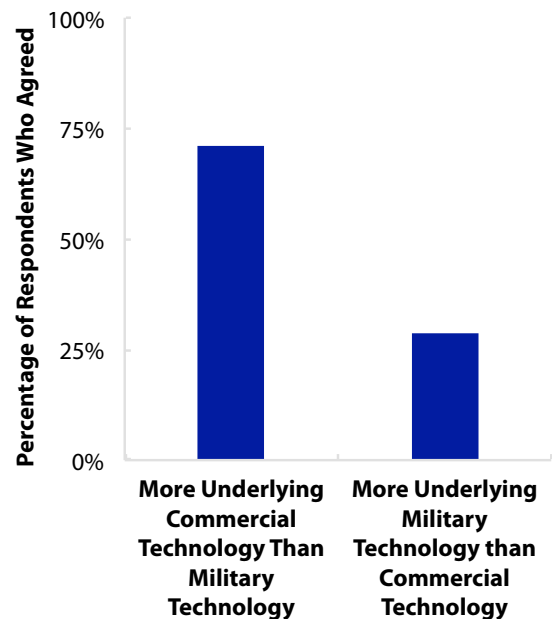
IN 2030, WILL GLOBAL DEFENSE INVESTMENTS IN THE FOLLOWING AREAS BE LOWER OR HIGHER THAN IN 2014, ADJUSTING FOR INFLATION?



HOW WILL THE STRUCTURE OF THE DEFENSE INDUSTRY CHANGE BETWEEN NOW AND 2030?

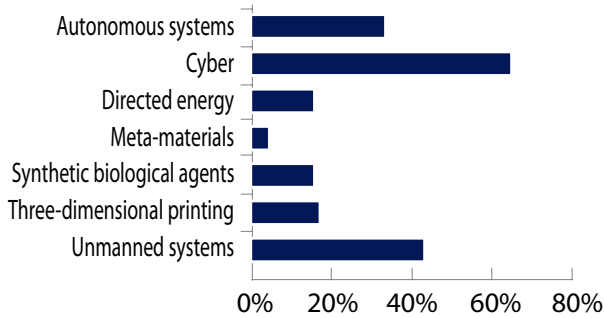


IN 2030, WHAT WILL DRIVE KEY DEVELOPMENTS IN MILITARY TECHNOLOGY?



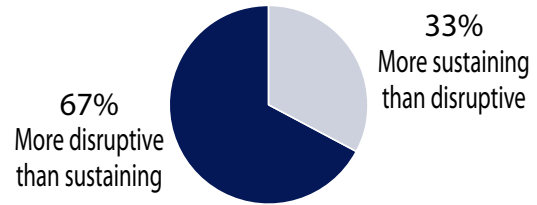
SURVEY 2: FEBRUARY 2014

BY 2030, WHICH OF THE FOLLOWING EMERGING TECHNOLOGIES WILL BE THE MOST IMPORTANT FOR THE GLOBAL SECURITY ENVIRONMENT, INCLUDING FOR BOTH NATIONAL MILITARIES AND VIOLENT NON-STATE ACTORS?

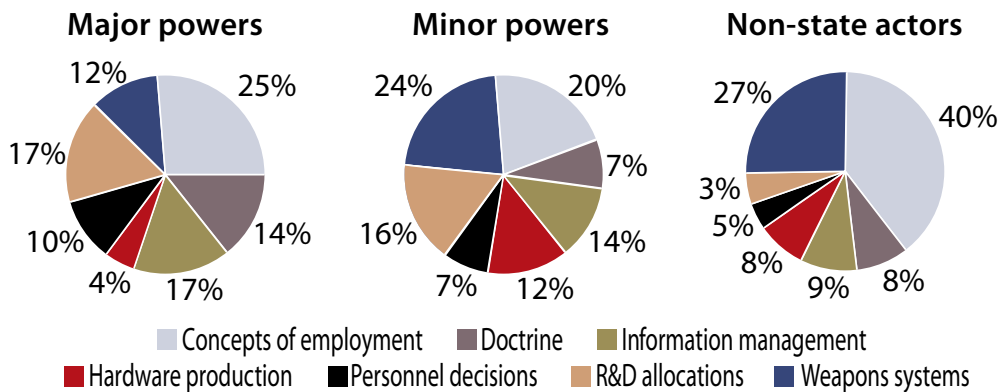


Note: Respondents could pick up to 2 options.

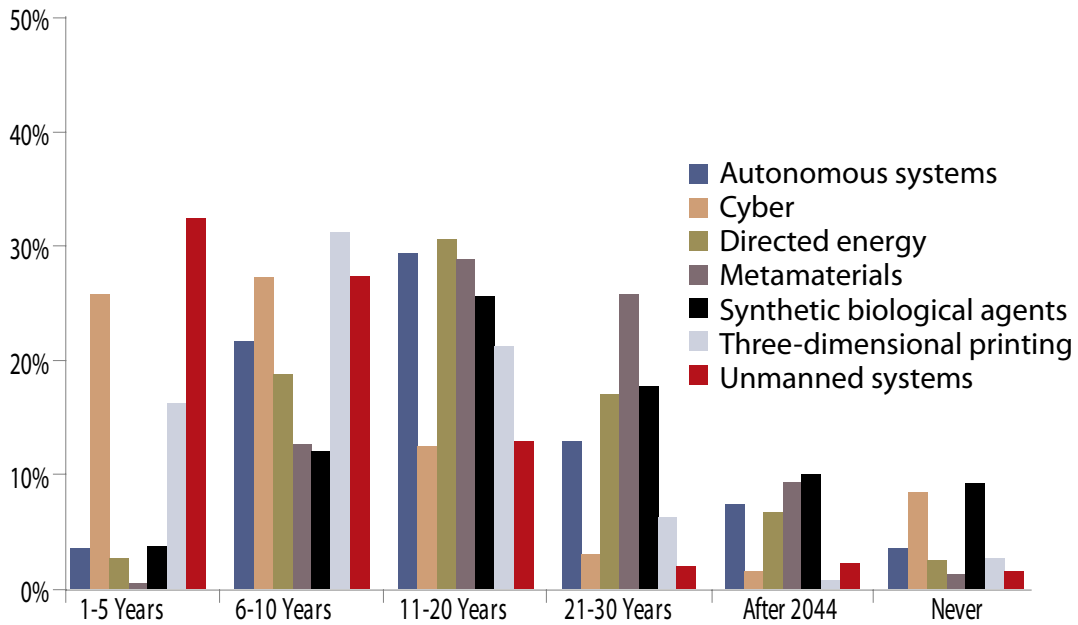
WILL EMERGING TECHNOLOGIES, AS A WHOLE, SERVE TO DISRUPT OR REINFORCE EXISTING GLOBAL POWER DYNAMICS?



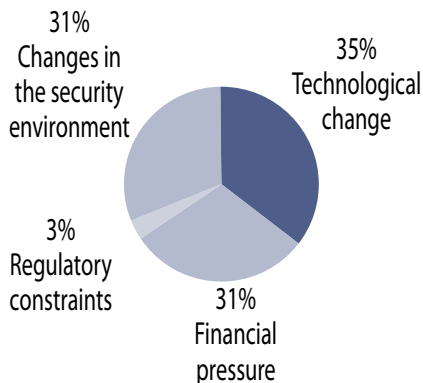
BY 2030, IN WHICH AREA WILL EMERGING TECHNOLOGIES, AS A WHOLE, BE MOST DISRUPTIVE TO NATIONAL MILITARIES AND NON-STATE ACTORS?



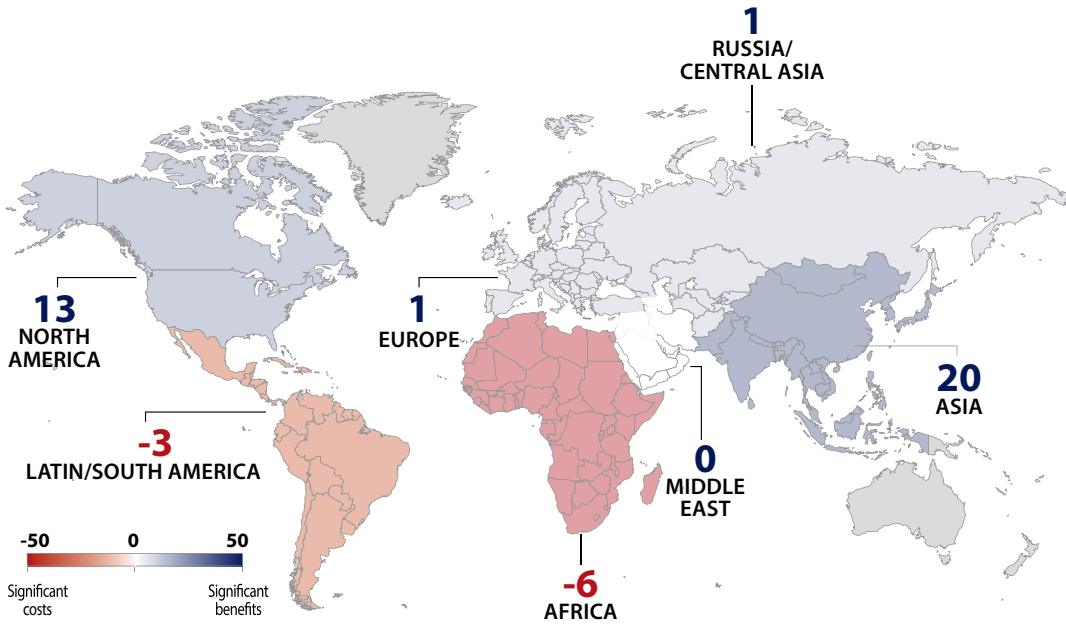
IN WHAT TIMEFRAME WILL THE FOLLOWING TECHNOLOGIES ACHIEVE MATURITY FOR MAJOR MILITARY POWERS, MEANING THEY ARE FULLY INTEGRATED INTO RELEVANT, STABLE SYSTEMS AND ARE NO LONGER EXPERIENCING RAPID CHANGE OR GROWTH?



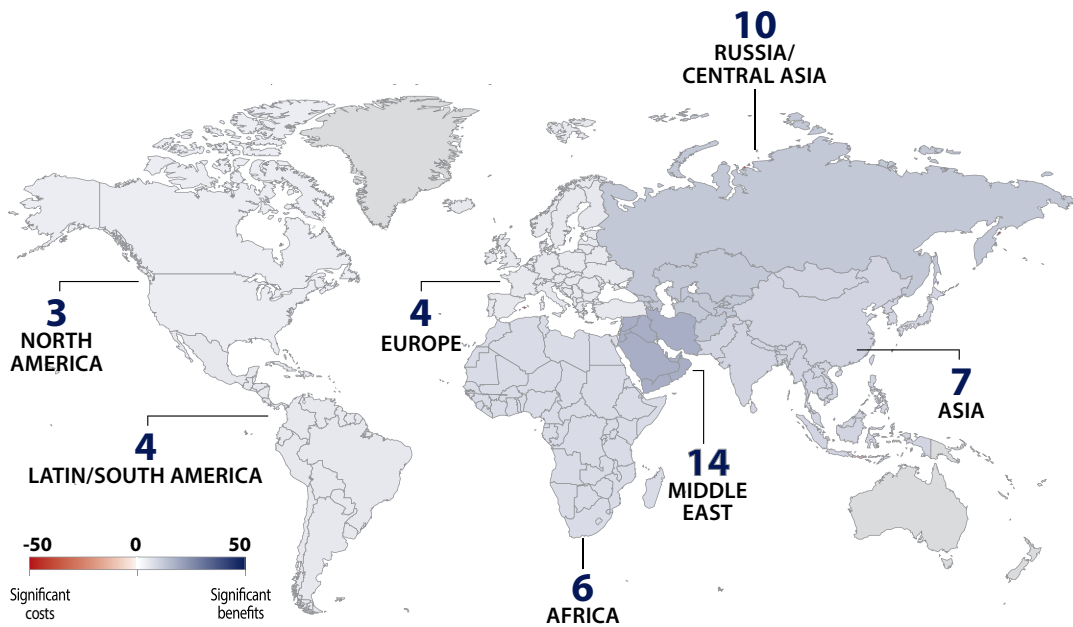
BY 2030, WHICH OF THE FOLLOWING CURRENT TRENDS WILL BE MOST CONSEQUENTIAL TO THE GLOBAL DEFENSE INDUSTRY?



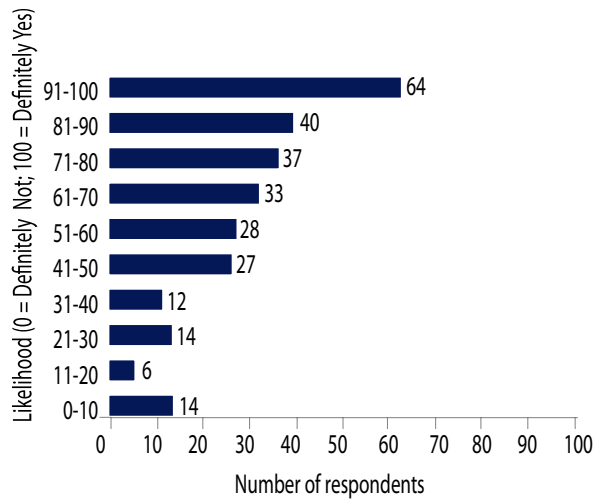
BY 2030, NATIONAL MILITARIES IN WHICH GEOGRAPHIC REGIONS WILL DERIVE THE MOST MILITARY BENEFIT OR FACE THE MOST MILITARY COSTS FROM EMERGING TECHNOLOGIES?



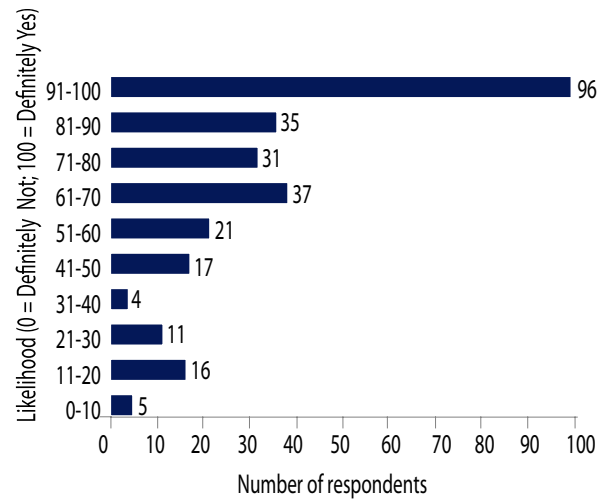
BY 2030, NON-STATE ACTORS IN WHICH GEOGRAPHIC REGIONS WILL DERIVE THE MOST MILITARY BENEFIT OR FACE THE MOST MILITARY COSTS FROM EMERGING TECHNOLOGIES?



BY 2030, WILL A CYBER ATTACK MEASURABLY CHANGE THE PROBABILITY OR COURSE OF A MILITARY CONFLICT?

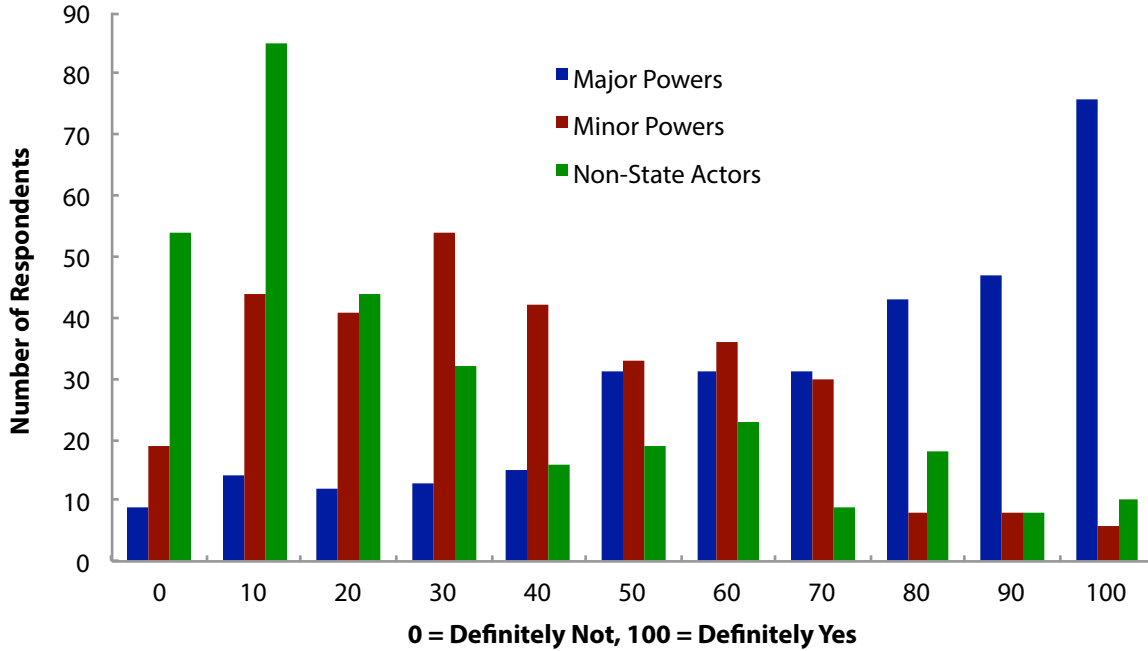


BY 2030, WILL AN UNMANNED AERIAL VEHICLE (UAV) SHOOT DOWN A MANNED FIGHTER OR BOMBER?

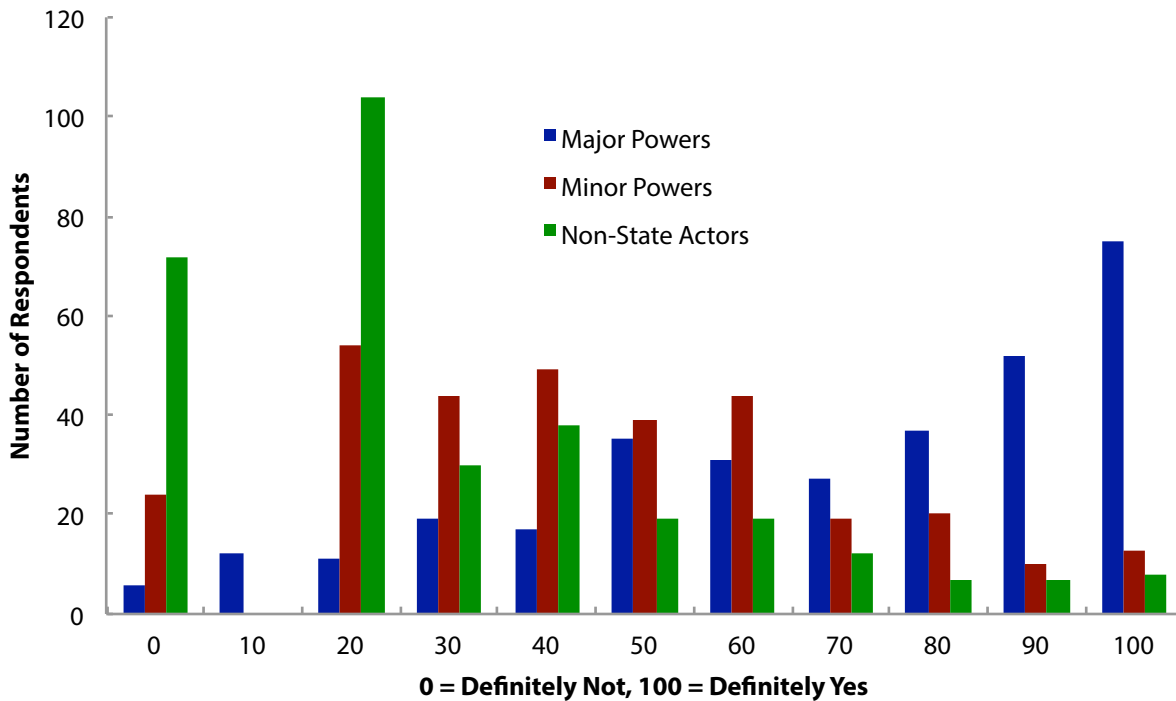


SURVEY 3: APRIL 2014

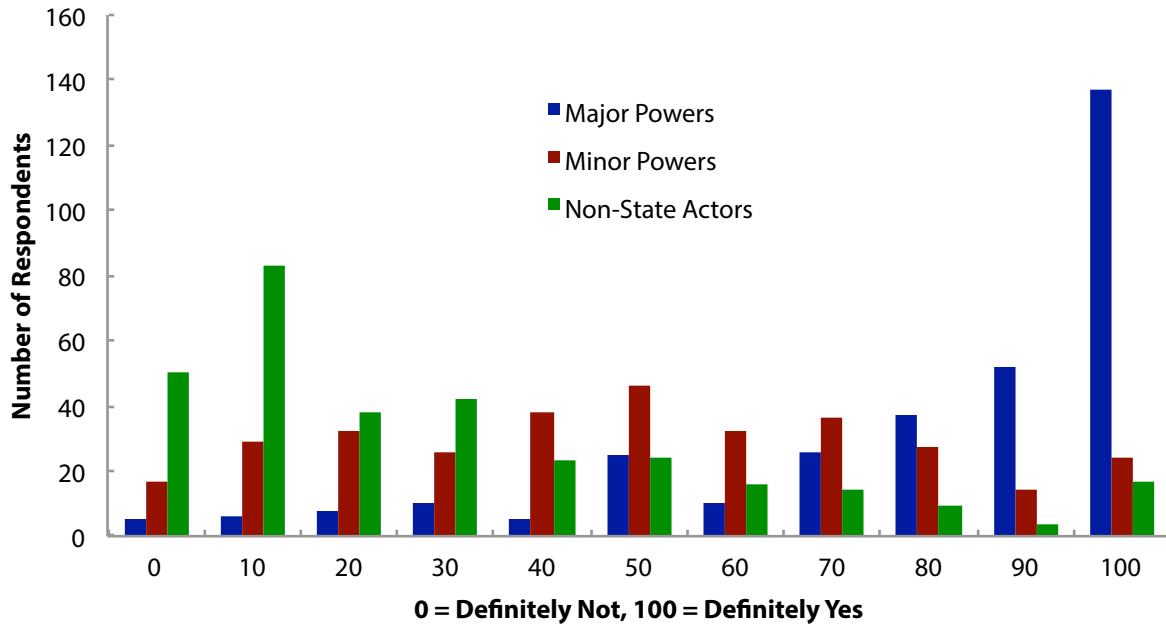
BY 2030, WILL THE FOLLOWING TYPES OF MILITARIES DEVELOP AND DEPLOY A FULLY AUTONOMOUS OFFENSIVE WEAPONS SYSTEM (A SYSTEM THAT, ONCE ACTIVATED, CAN INDEPENDENTLY MAKE TARGETING AND FIRING DECISIONS WITHOUT A HUMAN IN THE LOOP)?



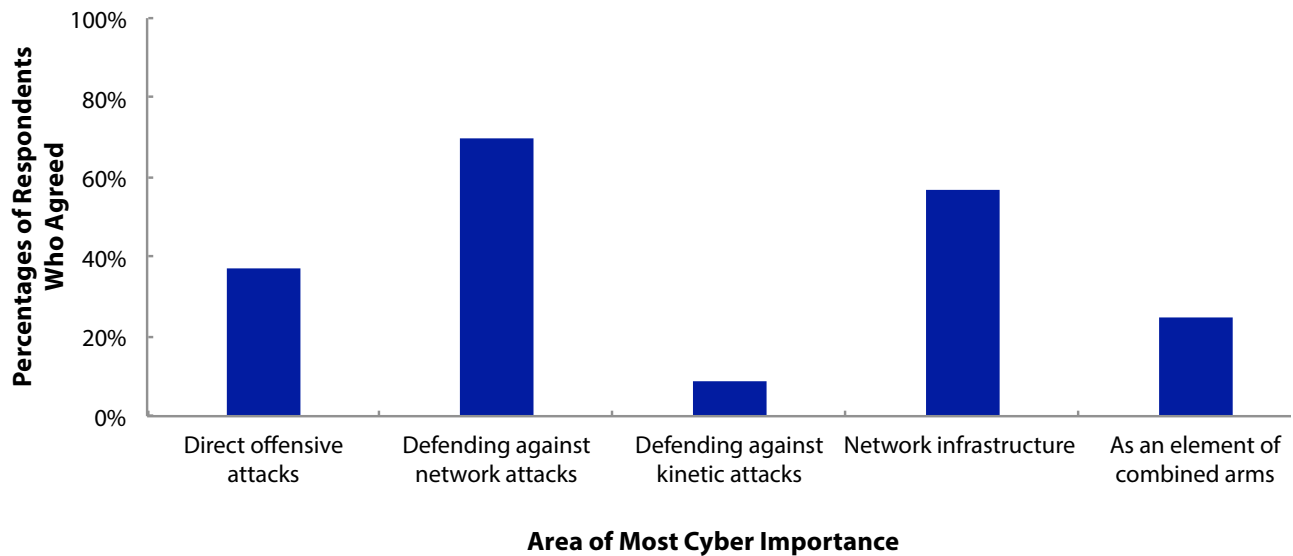
BY 2030, WILL THE FOLLOWING TYPES OF MILITARIES USE A DIRECTED ENERGY WEAPON TO DESTROY, IN COMBAT, A SURFACE NAVAL OR AIR PLATFORM OF ANOTHER COUNTRY?



BY 2030, WILL THE FOLLOWING TYPES OF MILITARIES USE AN UNMANNED AERIAL VEHICLE TO SHOOT DOWN A MANNED FIGHTER OR BOMBER?

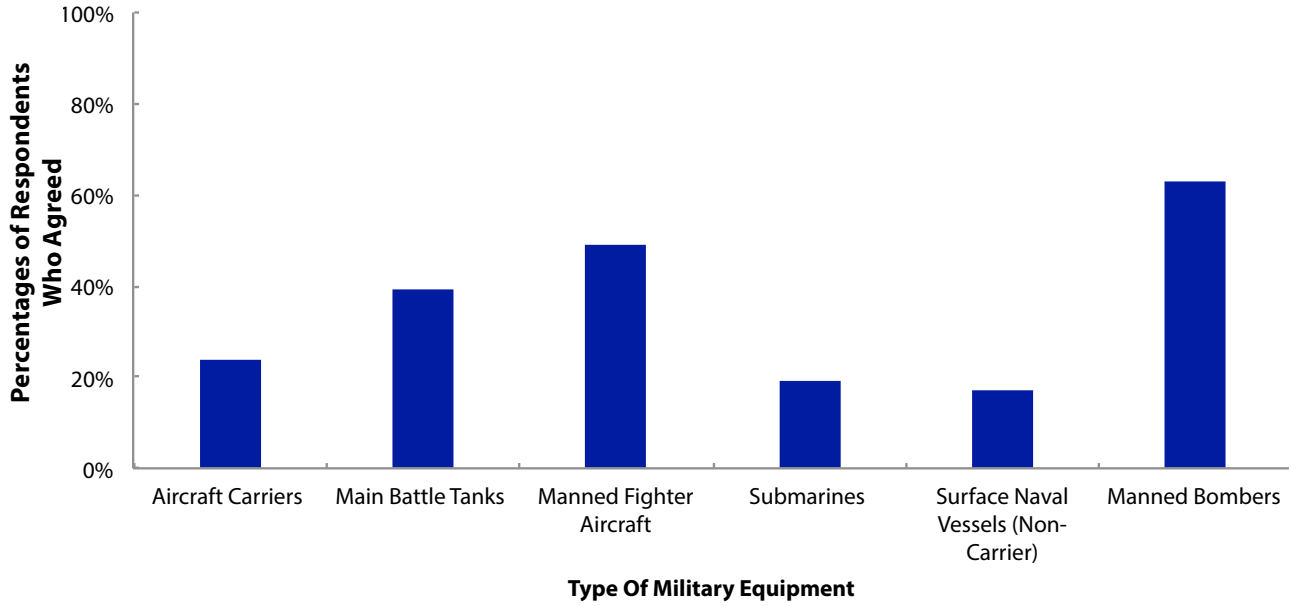


IN WHICH OF THE FOLLOWING AREAS DO YOU THINK CYBER WILL BE MOST IMPORTANT FOR NATIONAL MILITARIES BY 2030?

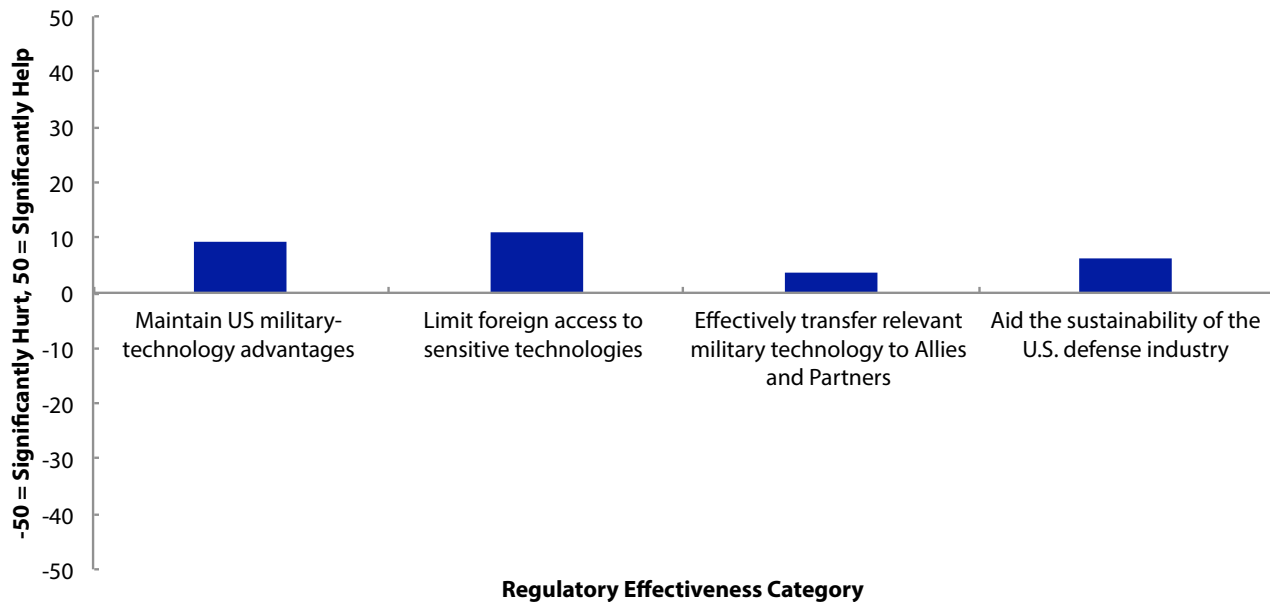


Note: Respondents could pick up to two options.

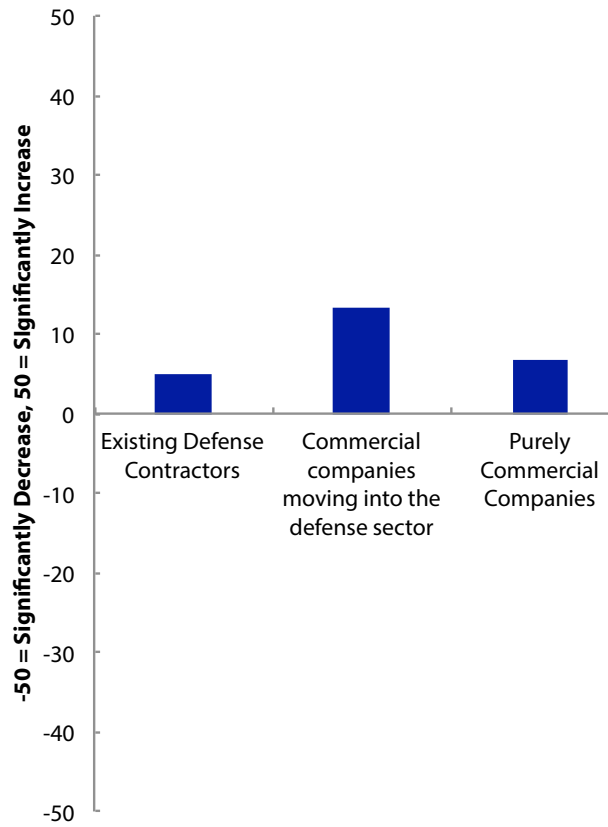
BY 2030, COMPARED TO TODAY, WILL MAJOR NATIONAL MILITARIES BEGIN TO DIVEST THEMSELVES OF ANY OF THE FOLLOWING SYSTEMS DUE TO THE EFFECT OF EMERGING TECHNOLOGIES?



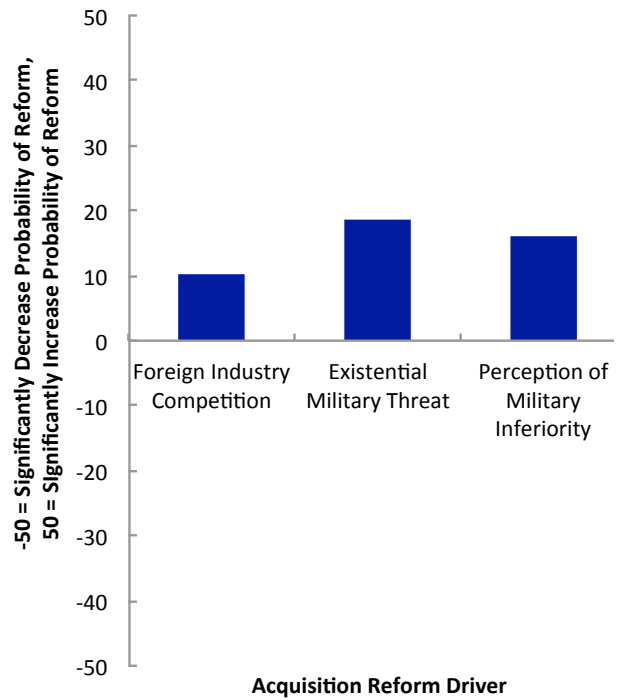
HOW DO REGULATIONS ON THE DEFENSE INDUSTRY SUCH AS ITAR, USML, ETC., HELP OR HURT THE UNITED STATES?



WILL THE PERCENTAGE OF DOD PROCUREMENT SPENDING IN EACH OF THE FOLLOWING CATEGORIES CHANGE BETWEEN NOW AND 2030?



TO WHAT EXTENT WOULD THE FOLLOWING TYPES OF CHALLENGES INCREASE OR DECREASE THE PROBABILITY OF MEANINGFUL REFORM?



About the Center for a New American Security

The mission of the Center for a New American Security (CNAS) is to develop strong, pragmatic and principled national security and defense policies. Building on the expertise and experience of its staff and advisors, CNAS engages policymakers, experts and the public with innovative, fact-based research, ideas and analysis to shape and elevate the national security debate. A key part of our mission is to inform and prepare the national security leaders of today and tomorrow.

CNAS is located in Washington, and was established in February 2007 by co-founders Kurt M. Campbell and Michèle A. Flournoy. CNAS is a 501(c)3 tax-exempt nonprofit organization. Its research is independent and non-partisan. CNAS does not take institutional positions on policy issues. Accordingly, all views, positions, and conclusions expressed in this publication should be understood to be solely those of the authors.

© 2014 Center for a New American Security.

All rights reserved.

Center for a New American Security

1152 15th Street, NW
Suite 950
Washington, DC 20005

TEL 202.457.9400
FAX 202.457.9401
EMAIL info@cnas.org
www.cnas.org

Production Notes

Paper recycling is reprocessing waste paper fibers back into a usable paper product.

Soy ink is a helpful component in paper recycling. It helps in this process because the soy ink can be removed more easily than regular ink and can be taken out of paper during the de-inking process of recycling. This allows the recycled paper to have less damage to its paper fibers and have a brighter appearance. The waste that is left from the soy ink during the de-inking process is not hazardous and it can be treated easily through the development of modern processes.





**Center for a
New American
Security**

**STRONG, PRAGMATIC AND PRINCIPLED
NATIONAL SECURITY AND DEFENSE POLICIES**

1152 15th Street, NW
Suite 950
Washington, DC 20005

TEL 202.457.9400
FAX 202.457.9401
EMAIL info@cnas.org

www.cnas.org

ISBN 978-1-935087-86-1

5 0999 >



9 781935 087861



Printed on Post-Consumer Recycled paper with Soy Inks