Applying Schumpeterian Creative Destruction to US Federal Defense Contracting: The Case of Autonomous Systems

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Introduction

Synonymous with America's military interventions in the Middle East and Africa is the drone: A remote controlled, pilotless aircraft often able to sling missiles at ground targets. Yet the drone barely scratches the surface of a revolution in autonomous and unmanned systems that promises to radically change the character of the United States military in the coming years, transforming the defense industry in the process. The Austrian economist Joseph Schumpeter spoke of such disruptive innovations, noting that "the new commodity, the new technology, the new source of supply, the new type of organization … which commands a decisive cost or quality advantage" has the power to "incessantly revolution[ize] the economic structure from within, incessantly destroying the old one, incessantly creating the new one"[1]. This cycle of innovation is aptly termed 'creative destruction', where 'creative' refers to the improved product that rewards firms who are able to shepherd it to market, and the 'destruction' refers to the fate of firms that fail to meet the challenge posed by the innovation.

The invention of military autonomous and unmanned systems (AUS) is the Schumpeterian "new combination", a synthesis of advances in artificial intelligence, robotics, cloud computing, and other related fields. Driven by commercial sector innovation, AUS threatens to displace the eminent position of traditional defense contractors[2] by replacing many of the manned platforms they provide for US military use today. This paper empirically examines publically available federal contracting data for autonomous and unmanned systems between FY2007-FY2017 to find evidence of the creative destruction process in the product space for military autonomous and unmanned systems. To do so, it evaluates both the extent to which established contractors have been successful in receiving prior contracts for AUS and determines the importance of AUS for future military contracting. It concludes that, in the medium term, traditional defense firms are vulnerable to the creative destruction process by the invention of military AUS; ironically due to the same factors that gave them their preeminent Department of Defense (DoD) contracting positions in the first place.

The subsequent sections are organized as follows. Section two is a review of existing literature on creative destruction, defense contracting, and autonomous technology. Section three provides an overview of what autonomous and unmanned systems are, why they are an improvement over existing manned systems, and why legacy defense contractors are not well positioned to compete for them. Section four analyzes Department of Defense contracting data between FY2007-FY2017 to demonstrate that AUS spending is consuming an increasing portion of the defense budget, and that legacy contractors are earning a shrinking share of it. Section five draws a historical parallel with the US aircraft industry in 1956-1961 and concludes that legacy defense firms are more vulnerable to the creative destruction process than their analogous historical counterparts -- large airframe producers.

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[1] Schumpeter, Joseph A. "Capitalism, Socialism, and Democracy".

[2] For the purposes of this paper, the phrases 'traditional contractor', 'legacy contractor', and 'established contractor' are used interchangeably. Note that the definition of these terms is an ongoing subject of debate and will be discussed further in the literature review.

Section Two

Most public discussion regarding military autonomous and unmanned systems concentrates on two things. First is the 'wow factor' – the qualitative improvements AUS offers over previous warfighting technologies. Second, particularly in academic circles, are ethical and definitional concerns about armed autonomous platforms. While this paper discusses the first subject and briefly touches on the second, it breaks new ground by bringing the underappreciated connection between Schumpeterian creative destruction and the defense procurement process into the modern day. In this respect, it is a spiritual successor to G.R. Simon's 1964 "*Missiles and Creative Destruction in the American Aircraft Industry*". The author intends that the paper contribute to three strands of literature. First is a growing body of work dedicated to applying Schumpeter's theory of creative destruction to present day conditions. Second is the literature space regarding small business contracting, acquisitions, and competition in the Department of Defense. Third is the body of work concerning the adoption of emerging military technology, in particular autonomous systems. The pertinent aspects of each of these literature bases will now be reviewed in order and will highlight specifically where this paper aims to contribute.

The first literature area examines present day market conditions to find examples of creative destruction. As noted in the introduction, 'creative destruction' is a term first coined by the Austrian economist Joseph Schumpeter in his 1942 work "*Capitalism, Socialism, and Democracy*" to describe the impact new innovations have on markets and society. While popularized in "*Capitalism, Socialism, and Democracy*", the essential ideas behind creative destruction were first developed in Schumpeter's earlier 1911 work "*Theory of Economic Development*". Three aspects of innovations identified in "*Theory of Economic Development*" are relevant for military AUS. First, Schumpeter's model of innovation is a supply side theory, where the synthesis of the 'new combination' creates its own demand[3]. In this case, the development of autonomous technologies by the private sector has created a demand in the military for AUS. Second, innovation is often embodied by new firms who displace old ones from the product space in question[4]. This paper will argue that small and nontraditional defense contractors will displace legacy firms from the AUS product space. Third is that "development consists primarily in employing existing resources in a different way"[5]. Military AUS is less a technological leap than a new combination of existing commercial sector advances in robotics, cloud computing, and artificial intelligence; a key reason why DoD finds the technology so promising.

With the advent of the internet era, Schumpeter's creative destruction theory as popularized in "*Capitalism, Socialism, and Democracy*" has grown in public and academic prominence. A 2009 paper found that citations in academic works for "*Capitalism, Socialism, and Democracy*" have been gaining momentum since 1956 and, starting in 1994, have even

[3] "Theory of Economic Development." Schumpeter. Pg. 65.
[4] "Theory of Economic Development." Schumpeter. Pg. 66.
[5] "Theory of Economic Development." Schumpeter. Pg. 68.

outgrown Keynes' *General Theory*[6]. Likewise, a simple Google news search for Schumpeterian terms like 'creative destruction' and 'disruption' will return millions of results, with many concentrated in the tech and business world. From studies documenting the destructive effect of Uber on taxi drivers[7] to Netflix's elimination of Blockbuster[8], creative destruction is in vogue – except in the literature for the defense industry. As a 2014 study into defense innovation from the Center for New American Security puts it, "the process of creative destruction has not held for the defense industry"[9], a quote that aptly captures the prevailing academic sentiment on the subject. It is the author's position that this belief has caused most academic literature to concentrate on reforms to the defense procurement process, creating a gap of analysis for some evolutions of the status quo that suggest that certain spaces may be more dynamic than traditionally assumed. This paper aims to fill part of that gap.

Related to the above point is the second literature space: works examining small business contracting, competition, and acquisitions in the Defense Department. A key point of contention when discussing DoD small business contracting is what exactly constitutes a 'small and/or nontraditional defense contractor', or, for that matter, a 'traditional contractor'. The literature on this question is divided, with different authors advancing different methodologies. Two contrasting ones are presented here as an example. The Center for Strategic and International Studies' Defense Industrial Initiatives Group uses a four tiered methodology, splitting defense firms into small (as categorized by the Federal government), large (revenue from all sources exceeds $3 billion), Big Five (the five largest defense contractors), and medium (all else)[10]. Alternatively, a 2013 University of Maryland study first sorts defense firms by their level of compliance with Cost Accounting Standards and their percentage of revenue derived from the Department of Defense, and after assigns the firm a spot on an eight tiered ranking system based on the commercial availability of the product[11]. Both approaches have advantages and disadvantages, yet they illustrate that there is no universally consistent taxonomy in defense procurement. With that said, this paper aims to find a middle ground that captures the spirit of what a 'legacy' or 'traditional' contractor represents while avoiding a system that is so overclassified it obscures important trends that might be occurring in the AUS product space. Since the purpose of this paper is to examine the erosion of legacy defense contractors from the AUS product space, a 'traditional contractor' is broadly defined as any firm that is a top twenty recipient of Department of Defense spending in a given fiscal year of analysis. All other firms are considered to be 'small' or 'nontraditional'. Clarification of this methodology and the advantages it lends is in Section Four.

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[6] Diamond, Arthur. (2009). Schumpeter vs. Keynes: In the long run not all of us are dead. Journal of the History of Economic Thought. 31. 531-541.

[7] Perry, Mark. "Schumpeterian creative destruction – the rise of Uber and the great taxicab collapse". American Enterprise Institute. September 2 2015. Web.

[8] Downes, Larry and Nunes, Paul. "Blockbuster becomes a casualty of big bang disruption". Harvard Business Review. November 7, 2013. Web.

[9] FitzGerald, Ben and Sayler, Kelley. "Creative Disruption Technology, Strategy, and the Future of the Global Defense Industry". Center for New American Security. June 2014.

[10] "Methodology". Center for Strategic and International Studies. N.d. Access online at: https://www.csis.org/programs/international-security-program/defense-industrial-initiatives-group/methodology

[11] Gansler, Jacques and Greenwalt, William et. al. "Non-traditional commercial defense contractors". Center for Public Policy and Private Enterprise. November 2013.

Extensive work has also been done on the importance of competition for Defense Department contracting. As a policy goal, DoD has sought to promote competition for defense contracts, since the presence of competition is considered to be a key sign of a healthy defense industrial base[12]. As the CSIS notes in a 2015 study analyzing the impact of sequestration on the defense industry, DoD has identified seven reasons why defense competition is important:

1. Competition creates an incentive for contractors to provide goods and services at a lower price (economic efficiency)

2. Competition spurs innovation of transformational technologies, which allows the Department to field the best weapon systems for our warfighters quickly

3. Competition yields improvements in the quality of products delivered and services rendered (firms that turn out low quality are driven out of the market and are unable to effectively compete)

4. Competition affords the Department the opportunity to acquire performance improvements (e.g., faster, lighter, more sustainable) by using "best value" source selection criteria

5. Competition provides opportunities for capable small businesses to enter new markets

6. Competition enhances (or maintains) a strong defense industrial base which provides an operational surge capability to handle demand spikes

7. Competition curbs fraud by creating opportunities to reassess sources of goods and services reinforcing the public trust and confidence in the transparency of the Defense Acquisition System."

The degree of competition in the defense industry has been well documented by numerous sources over time[13] [14] [15], not least the Department of Defense itself. Between FY2005-FY2015, DoD published annual competition reports before switching to a quarterly system that is now used[16]. This literature strand often involves a detailed look at the market landscape and the firms in it. In documenting current and predicted shifts in the product space for AUS, this paper aims to contribute to that body of work.

[12] Hunter, Andrew. "Competition and Bidding Data as an Indicator of the Health of the US Defense Industrial Base". Center for Strategic and International Studies Defense Industrial Initiatives Group. May 13, 2015.
[13] A.M. Agapos. "Competition in the Defense Industry: An Economic Paradox". Journal of Economic Issues. June 1971.
[14] Gansler, Jacques and Lucyshyn, William et. al. "Competition in Defense Acquisitions". Center for Public Policy and Private Enterprise. February 2009.
[15] King, David and Driessnack, John. "Analysis of Competition in the Defense Industrial Base: An F/A-22 Case Study". Marquette University. 1 January 2007.
[16] "Guidelines for Creating and Maintaining a Competitive Environment for Supplies and Services in the Department of Defense". Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics. December 2014.

Defense acquisitions are the final pertinent aspect of the second literature space. Research in this area focuses on flaws in the acquisition system and policies that should be adopted to reform it[17] [18] [19] [20] [21]. This paper departs from that focus by anticipating the direction of the status quo acquisitions process, which may prove useful for acquisitions reform experts as they craft future policies.

The final literature strand this paper contributes to is the analysis of emerging technology in the defense industry, in particular autonomous systems. Three types of sources are of concern: journalism, academia, and defense think tanks. This paper complements all three. The first source type, journalism, is the primary source of the 'wow factor' mentioned at the beginning of this literature review. It is largely anecdotal and concentrates on defense announcements regarding emerging autonomous technology [22] [23] [24]. The second source type, academia, focuses on understanding autonomous systems. Past research has focused on definitions of what exactly an autonomous system is, and often wrestles with moral and ethical questions around their implementation [25] [26] [27]. Only more recently has research regarding the integration of autonomous systems into the military force structure come to light[28]. In analyzing US military procurement dynamics for AUS, this paper seeks to contribute to that body of information. The final source type is publically released military documents and defense related think tank studies. Among other things, this literature considers the military utility of next generation technologies like autonomous systems and provides recommendations for how it might be adopted [29] [30] [31]. By charting a shift in status quo contracting, this paper suggests that defense leaders may be listening to these recommendations.

Section Three

Since AUS still resides on the technological and ethical frontiers of human capability, there is no standard, universally accepted definition of what an 'autonomous and unmanned system' is. Two working definitions from existing literature are offered here. First, in the context of the armed forces, autonomy is "the capacity to operate in a real world environment

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[17] Ahern, David et. al. "Report of the Advisory Panel on Streamlining and Codifying Acquisition Regulations: Volume 1 of 3". Section 809 Panel. January 2018.
[18] Ahern, David et. al. "Report of the Advisory Panel on Streamlining and Codifying Acquisition Regulations: Volume 2 of 3". Section 809 Panel. June 2018.
[19] FitzGerald, Ben and Sayler, Kelley. "Creative Disruption Technology, Strategy, and the Future of the Global Defense Industry". Center for New American Security. June 2014.
[20] https://fas.org/sgp/crs/natsec/R45068.pdf (eh)
[21] Schwartz, Moshe. "Defense Acquisitions: How the DOD Acquires Weapons Systems and Recent Efforts to Reform the Process". Congressional Research Service. 23 April 2010.
22 . "Autonomous Weapons are a game changer". Economist. 25 January 2018.
23 Martin, David. "New generation of drones set to revolutionize warfare". CBS News 60 Minutes. 20 August 2017.
[24] Lee, Connie. "Army to pursue 'with urgency' autonomous systems strategy". National Defense Magazine. 1 June 2018.
[25] McFarland, Tim. "Defining Autonomous Weapons Systems". Program on the Regulation of Emerging Military Technologies. April 2018.
[26] Etzioni, Amitai and Etzioni, Oren. "Pros and cons of autonomous weapons systems". Military Review. May-June 2017.
[27] Lin, Patrick et. al. "Autonomous military robotics: risk, ethics, and design". Ethics and Emerging Sciences Group at California Polytechnic State University. 20 December 2008.
[28] Tucker, Patrick. "Report: Weapons AI is increasingly replacing, not augmenting, human decisionmaking". Defense One. 26 September 2016.
[29] Work, Robert O. and Brimley, Shawn. "Preparing for war in the robotic age". Center for a New American Security. January 2014.
[30] "Technical assessment: autonomy". Office of Technical Intelligence. February 2015.
[31] "Strategic roadmap for unmanned systems". Department of the Navy. 29 May 2018.

without any form of external control, once the machine is activated and at least in some areas of operation for extended time" [32]. Second, unmanned is simply "not needing a crew or staff" [33]. Thus, for the purposes of this paper, 'autonomous and unmanned systems' refer to robots, vehicles, aircraft, or other powered machines that are both autonomous and unmanned. These platforms may or may not be armed. While thousands of unmanned systems already exist in the US military's inventory, they are merely adjuncts to manned platforms. Most are consigned to tasks considered too 'dirty, dull, and dangerous' for human operators, like minesweeping or remote logistics delivery [34]. In 2014, former Undersecretary of Defense Bob Work noted that "*despite their large numbers, the use of unmanned combat systems in the air, on land and on and under the sea is still very much in its operational infancy in the U.S. armed forces*"[35]. Even today, the US military relies heavily on manned systems for combat and support operations. However, manned systems have a number of shortcomings that make them ripe for disruption by new AUS platforms. First, manned systems have to account for personnel costs, ie. drivers/pilots, etc. which are eating up a substantial and increasing portion of the military budget. Between FY 2001-2012, compensation costs for military personnel grew 57% (with 4.2% real annual growth), while the DoD's personnel budget grew only 4% across the entire timeframe. By FY2021, the Center for New American Security estimates that total personnel costs could consume 46% of the total military budget: an amount that shrinks the amount of resources available for other, vital military tasks[36]. Second, manned systems become substantially more expensive as the threat environment increases. According to the 2017 US National Security Strategy, the widespread proliferation of guided munitions has made the modern battlespace more dangerous for US forces[37]. Americans place a premium on casualty minimization, so crewed platforms must be stealthy, survivable, and have other defenses to defeat salvos of guided munitions. Unfortunately, these qualities come at a steep cost -- returns in combat effectiveness are not proportionate to the amount of dollars invested[38]. Third, even as the costs for crewed platforms increase, future conflicts will place a premium on the quantity of combat systems available. Extra platforms mean that the total force is more survivable to concentrated guided weapons salvos, and that the force is better able to muster mass against an opponent. Together, these three trends illustrate the fundamental problem faced by military planners working with crewed platforms – the modern battlefield is too lethal to put humans in harm's way without substantial sacrifice of life or incurring unsustainable material costs. As modern guided munitions continue to proliferate to both state and non-state rivals, this problem will only worsen as the status quo becomes increasingly lethal and expensive for the US military.

AUS resolves the aforementioned problems by offering significant cost savings over manned platforms. First, by removing the human operator from the platform, it makes each

[32] Lin, Patrick et. al. "Autonomous military robotics: risk, ethics, and design". Ethics and Emerging Sciences Group at California Polytechnic State University. 20 December 2008.
[33] ibid.
[34] "Work, Robert O. and Brimley, Shawn. "Preparing for war in the robotic age". Center for a New American Security. January 2014.
[35] ibid.
[36] ibid.
[37] "National Security Strategy of the United States of America". White House. December 2017.
[38] Stashwick, Steven. "Signs of diminishing returns for US military investment against A2AD". The Diplomat. 2 September 2016.

individual platform more expendable, since the loss of a robot in combat is not the same as the loss of a veteran pilot with years of experience. This means that AUS platforms do not need many of the expensive survivability upgrades driving up the cost of today's manned systems[39]. Second, it reduces personnel costs. When fully realized, autonomous platforms will reduce manpower requirements for a diverse set of missions ranging from intelligence analysis, data collection, maintenance, and long duration operations, as well as removing human operators from the platforms themselves[40]. Thus, autonomy enables the Defense Department to avoid many of the training, housing, meals, health insurance, or other associated personnel costs that are eating up an increasing percentage of the military budget. Together, these factors mean that the military can afford more autonomous systems per dollar – allowing for the development and deployment of large swarms of expendable systems that can overwhelm enemy defenses[41]. Most significantly, sufficiently advanced AUS can replicate human performance. AUS can take on roles too dangerous for humans, while acting with greater speed, precision, coordination, and lethality than human operators[42]. While autonomous technology has not yet reached such a level of competence, many experts agree it will have sufficiently matured within the medium term – likely the next two decades. Of a group of 1019 national security experts polled by the Center for New American Security, more than 30% believe that autonomous technology will have reached full maturity within the next 11-20 years, about 20% believe it will occur in the next 6-10, and approximately 5% believe it will occur within the next 5[43].

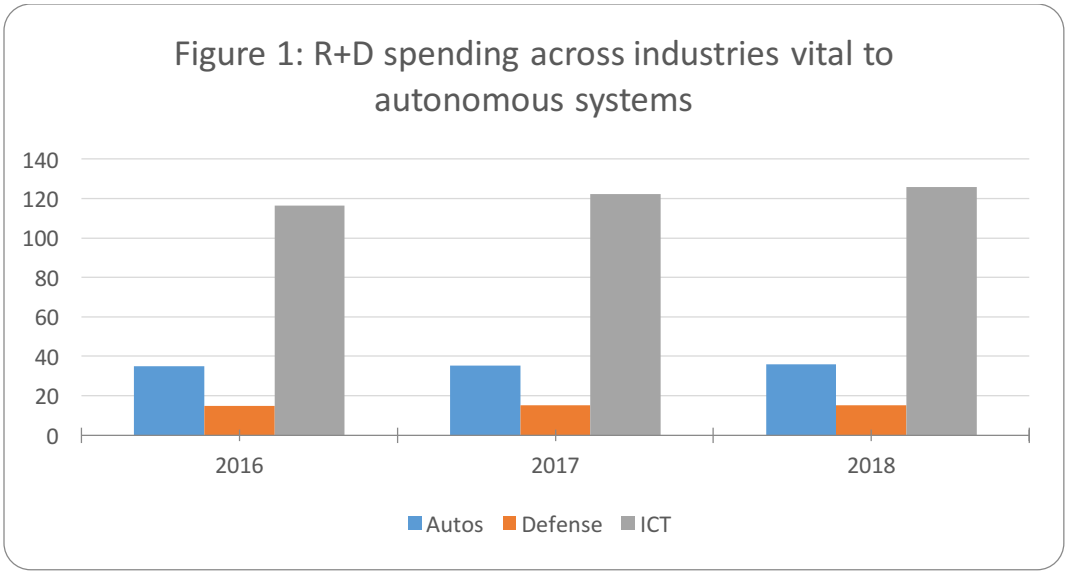
The introduction of mature AUS will supplant many manned platforms today. For example, autonomous submersibles may replace manned ones, or drone swarms may replace today's manned fighter aircraft[44]. Manned systems will still exist, but they will likely represent a shrinking percentage of the future force as the military shifts to AUS to fully realize its cost and quality advantages. Said the Chief of Naval Operations in May 2017, *"There is no question that* ***unmanned systems must*** *also* ***be an integral part of the future fleet****. The advantages such systems offer are even greater when they incorporate autonomy and machine learning…****Shifting more heavily to unmanned*** *surface, undersea, and aircraft* ***will help us*** *to further* ***drive down*** *unit* ***cost****."*[45] The most recent Quadrennial Defense Review projects that "*U.S. forces will* ***increase the use and integration*** *of unmanned systems … [which] … maintain our ability to project power"*[46]. Current plans for human-machine teaming, intended to both reassure ethicists and keep legacy manned platforms relevant, may be set aside. Noted the most recent publicly released Unmanned Systems Integrated Roadmap, "***DoD envisions*** *unmanned systems seamlessly operating with manned systems while* ***gradually reducing*** *the degree of* ***human control*** *and decision making* ***required for the unmanned*** *portion of the* ***force*** *structure*."[47] This

[39] "Work, Robert O. and Brimley, Shawn. "Preparing for war in the robotic age". Center for a New American Security. January 2014.
[40] "Technical assessment: autonomy". Office of Technical Intelligence. February 2015.
"Work, Robert O. and Brimley, Shawn. "Preparing for war in the robotic age". Center for a New American Security. January 2014.
[42] ibid.
[43] Fitzgerald, Ben and Sayler, Kelley. "Technology, strategy, and the future of the global defense industry". Center for a New American Security. June 2014.
[44] Gons, Eric et. al. "How AI and robotics will disrupt the defense industry". Boston Consulting Group. 10 April 2018.
[45] Richardson, John M. "The Future Navy". Department of the Navy. 17 May 2017.
[46] "2014 Quadrennial Defense Review". Office of the Secretary of Defense. 2014.
[47] "FY2013-2038 Unmanned Systems Integrated Roadmap". Department of Defense. 2013.

view is also held outside the military. Unmanned warfare expert Heather Roff conducted a study of over 200 autonomous military systems worldwide and found that "***autonomy is*** *currently not* ***being developed*** *to fight alongside humans on the battlefield, but* ***to displace them***. ***This trend****, especially for UAVs [unmanned aerial vehicles],* ***gets stronger when examining the weapons in development****. Thus despite calls for 'centaur warfighting,' or human-machine teaming, by the US Defense Department,* ***what we see in weapons systems is that if the capability is present, the system is fielded in the stay*** *[meaning instead of]* ***of humans rather than with them***"[48]. Military leaders are already laying the groundwork for this eventuality. In 2015, the Defense Innovation Unit Experimental (DIUx) was founded, one of whose primary goals is to deploy and develop new autonomous and unmanned systems[49]. In 2018, DIUx became DIU, a permanent office[50]

Legacy defense contractors have taken note of the Pentagon's push for autonomous systems and are expecting a share of the action. Said Boeing VP Chris Raymond, "*autonomy… is not a question of if -- it's a question of when, and when that happens we want to be on the leading edge of introducing it*"[51]. However, this confidence may be misplaced. Legacy firms are accustomed to a Cold War dynamic where advanced military technology is first developed by the DoD and its contractors before spreading to the general public, like the invention of the internet and GPS. In contrast, innovation today is driven by the commercial sector and is only later adapted for military use[52]. The commercial sector is more open, attracts more qualified talent, and is far less risk averse than the defense industry. This is reflected in higher research and development spending. Of the three key industries whose research and development concerns AUS – automotive, defense, and information and communications technology -- defense spends by far the least, with information and communications technology (ICT) driving much of the research in artificial intelligence, robotics, and other areas crucial to the development of competent autonomous systems[53] (see Figure 1).

[48] Tucker, Patrick. "Report: Weapons AI is increasingly replacing, not augmenting, human decisionmaking". Defense One. 26 September 2016.
[49] Mehta, Aaron. "Here's the technology in which DoD's innovation hubs will be investing". DefenseNews. 8 September 2017.
[50] Corrigan, Jack. "The Pentagon's startup outreach office is no longer an experiment". Nextgov. 9 August 2018.
[51] "Boeing's Raymond on Acquiring Autonomous Systems Businesses, Echo Voyager, Collaborating with GM." Defense and Aerospace Report. Filmed 11 April 2018. 23 minutes 2 seconds. https://www.youtube.com/watch?v=-CVoqBGxDuk
[52] "FitzGerald, Ben and Sayler, Kelley. "Creative Disruption Technology, Strategy, and the Future of the Global Defense Industry". Center for New American Security. June 2014.
[53] "Global R+D funding forecast". R&D Magazine. 2018.



Instead of leading the introduction of AUS into the military, legacy contractors like Boeing risk succumbing to it. Historically, these firms have been insulated from the creative destruction process by three things: regulatory barriers to new entrants, political preferences for existing capabilities and the firms associated with producing them, and an entrenched interest in the 'traditional way of doing things'[54]. As a result, the defense industry is heavily bureaucratized and risk averse, spending 7 times less on research and development than ICT[55]. It gears its services around the DoD's historical preference for manned systems and lags behind in funding for talent acquisition. This disparity in talent and R&D funding between the commercial and defense sectors means that the military may not trust the competence of AUS built by traditional defense companies and instead will turn to small and nontraditional defense contractors, especially those in commercial industry[56]. This trend is already occurring. Public statements and policy documents indicate that DoD is frustrated with the slow and expensive pace of legacy defense industry innovation, and is turning to tech and commercial firms, small defense companies, and other nontraditional contractors to drive the development of AUS and other advanced technologies[57] [58]. In order to gain access to their expertise, DoD is streamlining the regulatory procedure for these firms, in effect going around the traditional procurements process that has insulated legacy defense companies from the creative destruction process for so long[59]. This plan has the support of top defense leaders. At a 2015 visit to Stanford, then Secretary of Defense Ashton Carter was asked "Why [should Silicon Valley] enter DoD's acquisition system?" In response, Carter joked "Well, I hope [it doesn't] have to enter DoD's acquisition system"[60]. While the current media push emphasizes commercial cooperation on primarily non-platform oriented projects like cyber security and GPS, the data in the next

[54] FitzGerald, Ben and Sayler, Kelley. "Creative Disruption Technology, Strategy, and the Future of the Global Defense Industry". Center for New American Security. June 2014.
[55] see figure one.
[56] Cummings, M.L. "Artificial Intelligence and the Future of Warfare". Chatham House. January 2017.
[57] Markoff, John. "Pentagon Turns to Silicon Valley for Edge in Artificial Intelligence". New York Times. 11 May 2016.
[58] Werner, Debra. "DIUX invites traditional and nontraditional defense contractors to build prototypes". Space News. 24 April 2018.
[59] Munsil, Leigh and Ewing, Philip. "Pentagon's silicon valley push angers defesne contractors". Politico. 17 July 2015.
[60] ibid.

section indicates that it is growing to include autonomous and unmanned systems, posing a significant challenge to established defense firms.

Section Four: Methodology

This section provides the quantitative basis for the qualitative claims made above. First, it shows that defense contracts for AUS and similar capabilities are rapidly rising – both in dollar value and the number awarded -- and will continue to grow well into the future. Second, it shows that traditional, legacy contractors are competing less and less effectively for AUS contracts as time passes. It concludes that as AUS consumes a growing percentage of the defense budget and begins to substitute for manned systems in the medium term, traditional contractors may experience significant competitive pressure that squeezes their businesses.

Two methodological clarifications are necessary. First, the dataset at hand was acquired using a technique adopted from the CSIS Defense Industrial Initiatives Group (CSIS-DIIG), where the author went directly to primary source, contract by contract data. However, CSIS uses the Federal Procurement Data Services (FPDS) website, whereas the author used USASPENDING.gov. USASPENDING.gov was chosen as it is an aggregator of content from FPDS as well as other data sources, and therefore more comprehensive. The analysis of the contracts themselves closely mirrored the CSIS-DIIG methodology: de-obligations were excluded from the data set, contract values were calculated on the basis of total expenditures for the year in question and were not adjusted for inflation. Note that contract values are amended sometimes even several fiscal years after they are originally inputted[61]. Second is the definition of traditional contractor[*]. For the purposes of this paper, a 'traditional contractor' is defined as any firm that is a top twenty recipient of Department of Defense spending in a given fiscal year of analysis. All other firms are considered 'small' and/or 'nontraditional'. To determine which firms were on the top 20 list, the author used the FPDS "Top 100 Contractors Report", which lists the top 100 contractors by total dollars awarded per department, corresponding to the given year of analysis. This taxonomy lends two advantages. First, it is grounded in past industry specific analysis. A 2018 report from the Boston Consulting Group concerning the growing prominence of robotics in defense contracting identified seven firms as 'prime contractors'[+] in the defense market[62]. This paper's methodology functionally includes those firms while also leaving sufficient flexibility to incorporate other established defense players such as BAE Systems and software oriented firms that are particularly relevant to AUS research, such as Science Applications International Corporation. Second, the aforementioned definitions best suit the dataset at hand. Unlike the CSIS-DIIG or its contemporaries, this paper does not aim to analyze total defense spending; it seeks to document the erosion of legacy defense contractors in a single slice of the defense budget that is contested almost exclusively between top defense firms and those that do not even make the top 100 list of defense contractors. Thus, it best fits

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[61] "Methodology". Center for Strategic and International Studies. N.d. Access online at: https://www.csis.org/programs/international-security-program/defense-industrial-initiatives-group/methodology

[*] note: this paper uses the terms 'legacy' and 'traditional' interchangeably

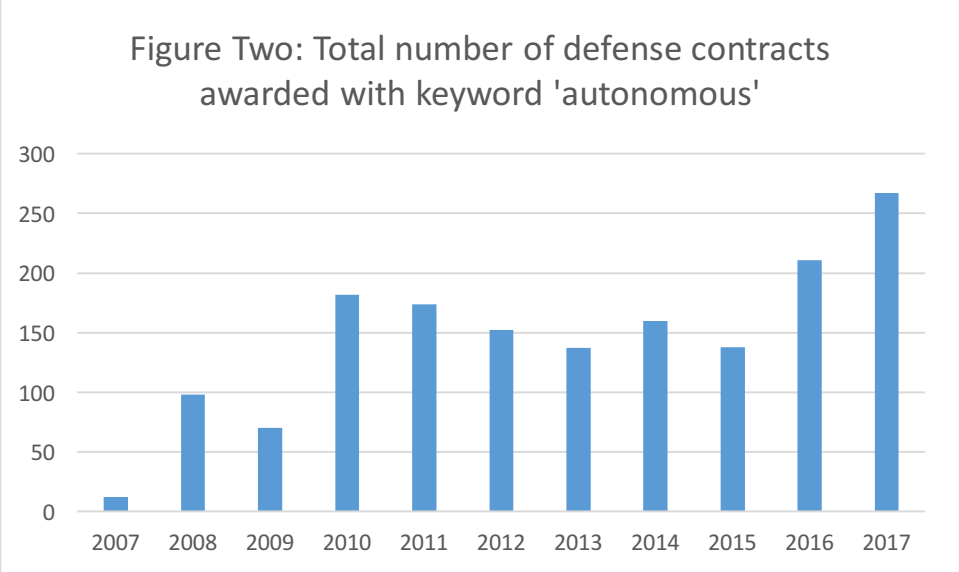
[+] those seven firms are: General Dynamics, Northrup Grumman, Honeywell, Lockheed Martin, Raytheon, Huntington Ingalls, and Boeing

[62] Gons, Eric et. al. "How AI and robotics will disrupt the defense industry". Boston Consulting Group. 10 April 2018.

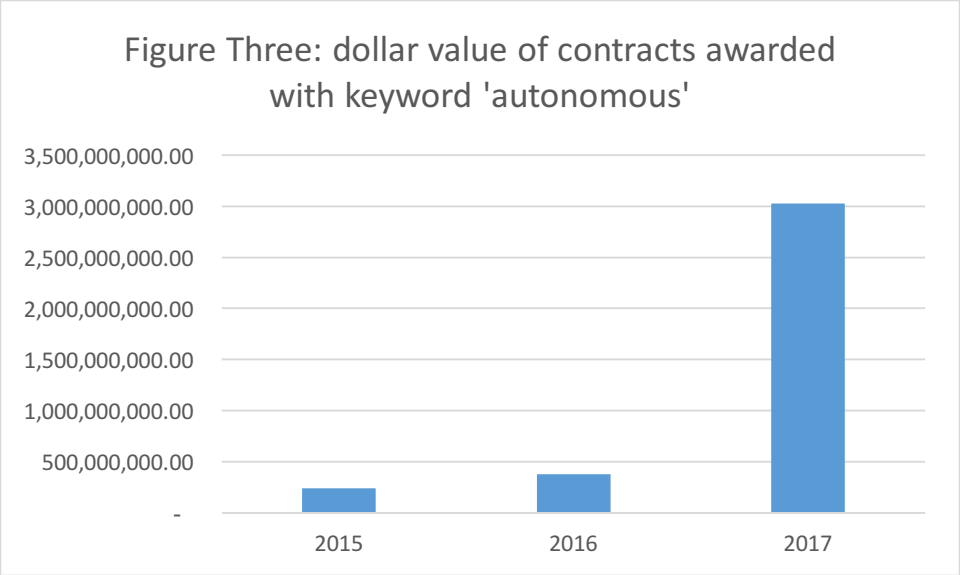
this particular data set to narrowly define 'legacy contractors' and broadly define 'small and/or nontraditional' defense contractors as all firms falling outside the definition of 'legacy contractor'.

Section Four: Analysis

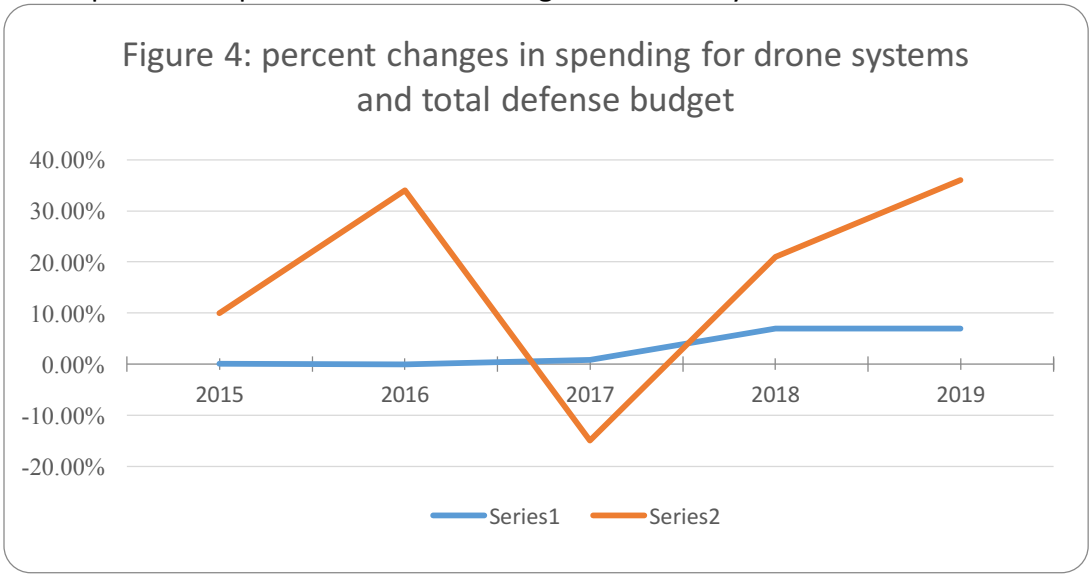
Funding for autonomous and unmanned systems is ramping up and consuming increasing portions of the defense budget. A database search across the entire Department of Defense for military contracts with the keyword 'autonomous' between FY2007-FY2017 shows that the number of contracts awarded has increased 2125% -- from 12 contracts to 267 (see figure two).



The contracts themselves are becoming more valuable. Between FY2015-FY2017 alone, the number of contracts grew 93%, while the dollar value of those contracts grew 1154%, from $241,434,192 to $3,029,577,229 (see figure three).



The trend continues for the drone force – a key transitional platform to full AUS. Between FY2015 and FY2019, spending for drone systems has increased 87%, while total defense spending has grown only 15%. The year by year breakdown is shown in Figure 1 and indicates that growth in spending for drone systems has outpaced the growth of the total defense budget – even in periods of stagnant defense budget changes like in FY2015-FY2016. The only exception to this is FY2017. However, spending reductions here are primarily associated with a wind-down of major acquisition programs and a refocus towards basic research and development – in part aimed at increasing the autonomy of drones[63].

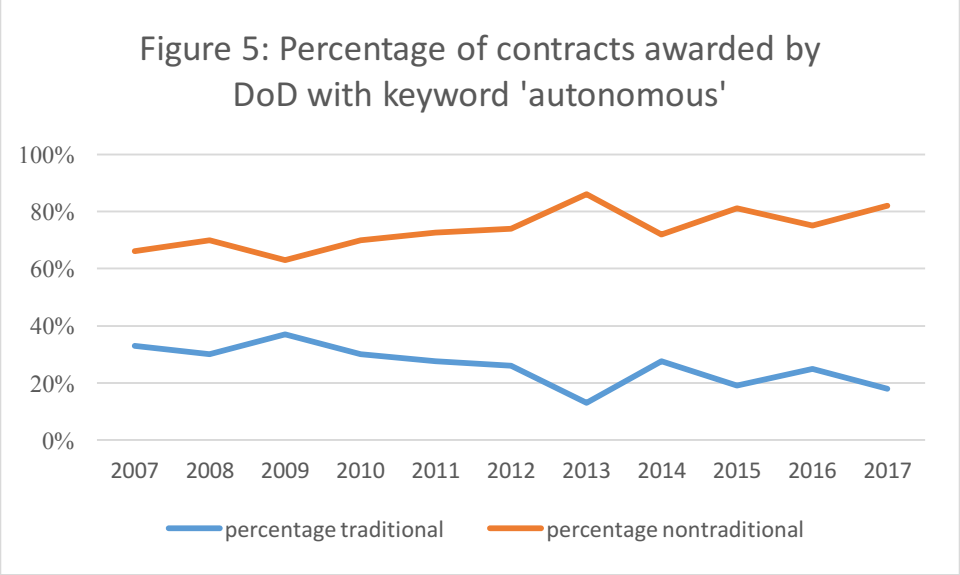


[63] Gettinger, Dan. "Drones in the FY17 Defense Budget". Bard College Center for the Study of the Drone. February 2016.

As Schumpeter noted, the supply of a new innovation creates its own demand. In the coming years, AUS will only grow in financial heft as the underlying technologies mature. Industry analysts forecast that spending for robotics, unmanned systems, and autonomous technologies (all crucial to the development of AUS) will see 10.2% compounded yearly growth through FY2021[64]. With established support in DoD policy documents for a future force containing a significant number of AUS systems -- a vision that has spanned two presidential administrations of opposing parties -- it is safe to predict that the AUS market will become increasingly lucrative.

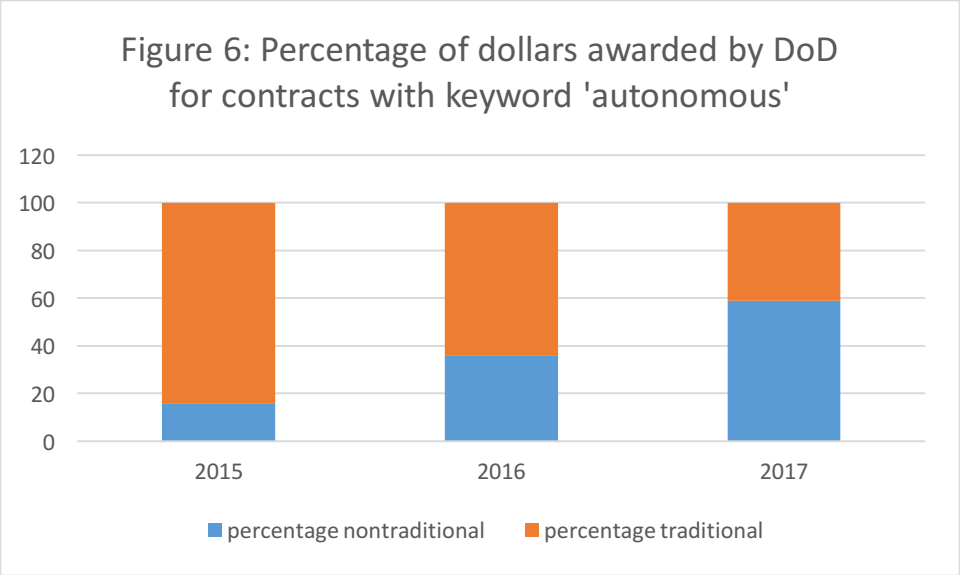
Unlike their larger competitors, small and nontraditional defense contractors are enjoying significant success in competing for existing AUS contracts. This is shown in three pieces of data.

First, even as the number of AUS contracts has increased 2125% from FY2007 to FY2017 (see figure one), the percentage of contracts taken by nontraditional contractors has increased from 66% to 82% in the same timeframe (see Figure 5).



Second, nontraditional contractors are taking ever greater percentages of the dollar value of the aforementioned contracts. Figure 6 indicates both that nontraditional contractors have been both increasing their share of the dollar value of AUS contracts and, most significantly, held a greater share of total AUS contracts than traditional defense firms for the first time in FY2017.

[64] "The National Security Innovation Base: Investments in the Fourth Industrial Revolution". Govini. February 2018.



Third, nontraditional contractors are also increasing their share of robotics contracts, a component interdependent with AUS systems. Notably, FY2017 marked the first time that nontraditional contractors held more than 60% of robotics contracts, beating out established rivals like Boeing and General Dynamics[65].

Finally, it is worth considering whether AUS is simply the next Pentagon fad destined for the dustbin in a few acquisition cycles. This is unlikely for two reasons. First is the sustained political and financial commitment to AUS that has persisted across two presidential administrations of opposing parties. Defense leaders recognize that innovation is crucial to military superiority, and see AUS as a key platform to deliver it[66]. Second is that ethical concerns and calls for human-machine teaming ('centaur warfighting'), both of which might torpedo a full AUS program, are often subordinate to military necessity, i.e. decision-making is primarily left in the hands of the autonomous system[67]. Even if 'centaur warfighting' is advanced as a way to address ethical concerns about armed, autonomous platforms, it will still involve a significant degree of substitution for manned platforms as the force mix shifts to more unmanned systems to generate the necessary mass to fight in a high lethality environment[68].

Section Five

The data above suggests that traditional contractors are being squeezed out of the AUS product space. This section will extrapolate the trend, looking at an analogous historical case and concluding that two factors will restrain legacy defense firms from effectively competing for future AUS contracts.

[65] Gons, Eric et. al. "How AI and robotics will disrupt the defense industry". Boston Consulting Group. 10 April 2018.
[66] "FY2013-2038 Unmanned Systems Integrated Roadmap". Department of Defense. 2013.
[67] Tucker, Patrick. "Report: Weapons AI is increasingly replacing, not augmenting, human decisionmaking". Defense One. 26 September 2016.
[68] Richardson, John M. "The Future Navy". Department of the Navy. 17 May 2017.

Legacy defense contractors face a situation similar to that encountered by the US airframe industry between 1956-1961. At the time, the airframe industry faced an existential threat from the invention of the missile, an innovation which threatened to completely replace traditional military fighters and bombers that constituted over 80% of their revenue. Despite being separated by over 50 years, the circumstances propelling creative destruction in both cases are startlingly similar. First, the invention of the guided missile promised an unmanned fighting platform that was more accurate and effective than traditional airframes. Like with today's AUS advancements, missile technology did not go unnoticed by defense leaders. A US Air Force policy statement from 1957 declared that "*as readily as missiles become operationally suitable, they will be placed into units either to partially or completely substitute for manned aircraft according to military requirements*"[69]. In a significant parallel, the Department of Defense decided that airframe manufacturers lacked the innovative capacity and technical means to be exclusively entrusted with the production of missiles. Nontraditional defense contractors like automobile companies and electronics firms jumped on the opportunity, leveraging their unique expertise to compete for new missile contracts. The competition was zero sum; airframe firms that failed to innovate quickly enough lost out on early research and development contracts that directly led to valuable production orders for the missile type designed. Despite this, the top airframe producers weathered the gale winds of creative destruction. In only a five-year window (from 1956 to 1961), the top six airframe producers became the top six missile suppliers for the Department of Defense. Unfortunately, today's legacy defense firms are unlikely to repeat the same feat and may fall victim to the creative destruction process as they are eliminated from the AUS product space entirely.

To survive, airframe producers innovated in the face of creative destruction. However, today's traditional defense contractors face three disadvantages that imperil their ability to innovate and thus compete for AUS contracts. First is a lack of resources. Despite an improved short term earnings outlook on the back of higher defense spending[70], defense firms do not have enough financial or industrial heft to today's commercial competitors relative to airframe firms in 1961. When competing for missiles contracts, airframe contractors enjoyed a number of advantages; 14 firms alone held 20,000 of the 90,000 research scientists and engineers in the US[71]. The industry was the second largest US industrial employer, and had sufficient spare cash to burn to catch up to commercial electronics firms whose missile innovations threatened the airframe industry's survival. Defense firms today enjoy none of these advantages. The industry suffers from an endemic lack of qualified, young personnel made acutely worse by the fact that it will be hit with a massive wave of retirements in the short run: in 2017, over 25% of the workforce in the aerospace and defense industry was projected to be between the ages of 51-69[72]. Defense also lacks the financial strength to compete with commercial innovators; in 2017,

[69] Simon, G.R. "Missiles and Creative Destruction in the American Aircraft Industry, 1956-1961". The President and Fellows of Harvard College. The Business History Review, Vol. 38, No. 3. pp. 302-314. 1964.
[70] Lineberger, Robin S. and Hussain, Aijaz. "2018 Global Aerospace and Defense Industry Outlook". Deloitte. 2018.
[71] "Simon, G.R. "Missiles and Creative Destruction in the American Aircraft Industry, 1956-1961". The President and Fellows of Harvard College. The Business History Review, Vol. 38, No. 3. pp. 302-314. 1964.
[72] "The Defining Workforce Challenge with US Aerospace and Defense". Aerospace Industries Association. 26 September 2016.

the entire industry held only $38[73] billion in unspent cash despite a gap of $107.1 billion in research and development spending with the ICT sector for that year alone. Second, legacy defense firms are structurally disadvantaged by the acquisitions framework when competing for AUS contracts. Unlike missile contracting where DoD simply widened the space for new entrants to compete, DoD is actively disadvantaging legacy contractors for AUS. The department's outreach to small and nontraditional defense contractors is designed to bypass the multiyear bureaucratic acquisitions process that legacy firms are still subject to. This is especially true for commercial firms, where DoD offices like DIU and Defense Information Systems Agency are shifting to Other Transaction Authority agreements, an expedited procurement process designed to make the DoD a more attractive customer to firms used to the rapid pace of the market. These changes are consequential; as DoD continues to conduct business with these new firms, they will establish trust and a work history that erodes the 'first mover advantage' of legacy defense firms and imperils their ability to compete for future, more lucrative AUS contracts. Compounding these difficulties is the challenge any established firm faces when competing against new entrants with disruptive technology; they have geared their business to provide the existing product and will be naturally slow to respond and exploit the radically new technology at hand – in this case, AUS [74]. This is already playing out in the status quo. Traditional contractors have recognized the threat posed by AUS, yet their responses are incremental solutions to a structural problem: technologies crucial for defense are no longer propelled by defense firms.

Legacy defense contractors are focusing on acquisitions to regain technological competitiveness[75]. For example, in 2017 Boeing acquired drone maker Aurora Flight Sciences[76] and Northrup Grumman acquired Orbital ATK[77], a small aerospace company proficient in AUS technologies. However, acquisitions are not a lasting strategy for regaining innovation leadership. In a 2015 survey of over 200 aerospace and defense leaders around the world, only 28% identified 'Mergers and Acquisitions' as the most effective strategy for driving innovation[78]. The top two strategies were partnership (38.5%) and IP licensing (33.9%), which defense firms are also pursuing. However, these approaches were most directly affected by the two biggest obstacles to defense firms leveraging commercial innovation: 'IP restrictions' (59%) and 'burdensome contracting requirements' (77%)[79]. In short, the future of the defense industry in the AUS space may be grimmer than it appears.

These are long term considerations, and like any prediction, are subject to change should unforeseen circumstances arise. However, it seems likely that, in the short run, AUS will still consume a relatively insignificant portion of the defense budget, and established firms will continue to cede market dominance to nontraditional contractors. As AUS technology matures

[73] " US nonfinancial companies sector in-depth: cash pile grows 9.2% to 1.84 trillion; tech extends lead over other sectors". Moody's Investors Service. 19 July 2017.
[74] The Innovator's Dilemma: The Revolutionary Bestseller that Changed the Way We Do Business (New York: HarperBusiness, 2000), 35
[75] Gons, Eric et. al. "How AI and robotics will disrupt the defense industry". Boston Consulting Group. 10 April 2018.
[76] Weisgerber, Marcus. "The Global Business Brief". DefenseOne. 16 November 2017.
[77] Erwin, Sandra. "Acquisition of Orbital ATK approved, company renamed Northrup Grumman Innovation Systems". Space News. 5 June 2018.
[78] Barney, Jon. "Out of reach? Defense industry may struggle to integrate new technologies". Avascent. 13 October 2015.
[79] ibid.

in the medium term, it may begin to substitute for many manned platforms in accordance with defense planning documents as discussed in section three. By that point, it may be too late for traditional contractors to compete in the AUS space. DoD will have established preferred relationships with those nontraditional firms to supply AUS systems that will constitute a greater percentage of defense spending. Established firms will be trapped by a lack of research and development funding, starved for talent, and stuck in a business model geared towards highly survivable, manned platforms with long service lives; exactly what AUS will disrupt. Ironically, the very things that have kept a handful of defense firms in control of large contracts for so long -- regulatory barriers and entrenched political interests -- may be the cause of their downfall as the DoD looks for nimbler innovators to drive the next military technological revolution.

Conclusion

The creative destruction process is alive and evident over 70 years after Schumpeter coined the term. Ironically, it is being brought to the defense industry by the very factors that isolated legacy contractors from creative destruction in the first place. Especially in the post-Cold War environment, traditional contractors have been protected by regulatory barriers and political preferences for existing capabilities. Thus, they fell behind commercial sector innovation – so much so that advances in technologies considered critical for national security no longer occur through the defense industry. As a result, the creative destruction process will act in the medium term as autonomous and unmanned systems mature sufficiently to destroy much of the market for manned military systems. This trend is bolstered by anemic research and development efforts on the part of traditional defense contractors, a shifting Department of Defense preference for small and nontraditional firms to provide AUS contracts, and changes in the security environment that make the adoption of AUS necessary to maintain military superiority. While the future of the legacy defense firms who provide manned military systems is unclear, particularly in the AUS product space, the industry will certainly face more significant competition than it is used to. Regardless, one thing is certain: autonomous and unmanned systems have already altered the landscape of defense contracting in startling ways. Traditional firms must adapt, or risk being left behind.