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Industry Study

Final Report
Weapons Industry

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WEAPONS INDUSTRY 2011

ABSTRACT: After a decade of war and healthy spending on defense, the United States (U.S.) is now projected to curb spending on the development of new weapons. It is projected that decreased defense spending will have an adverse impact on the weapons industry generally unless action is taken now to mitigate the effects of reduced funding. Specifically, in order to retain the U.S. technological and innovative edge in developing and producing weapons, the U.S. government must (1) establish and communicate industrial policy to counter pressures of a declining defense budget, (2) reform burdensome export processes and policies to enable industry to better compete internationally, and (3) address the need for policy and doctrine for emerging technologies that enable their development and implementation.

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PLACES VISITED

Domestic Travel

Non-Lethal Weapons Directorate; Quantico, VA
USMC Weapons Training Battalion; Quantico, VA
Naval Surface Warfare Center Dahlgren Division; Dahlgren, VA
Radford Army Ammunition Plant; Radford, VA
Senate Armed Services Committee; Washington, DC
Colt Defense; Hartford, CT
Smith & Wesson; Springfield, MA
Naval Surface Warfare Center Indian Head Division; Indian Head, MD
Raytheon: Patriot; Waltham, MA
FLIR; North Billerica, MA
iRobot; Bedford, MA
The Boeing Company; St Louis, MO
Lake City Army Ammunition Plant; Lake City, MO
Arlington Police Department; Arlington, VA
ITT Night Vision; Roanoke, VA
National Rifle Association; Fairfax, VA

International Travel

U.S. Embassy, Ankara, Turkey
U.S. Office of Defense Cooperation, Ankara, Turkey
Undersecretariat for Defence Industries; Ankara, Turkey
Turkish Aerospace Industries; Ankara, Turkey
FNSS Defense Systems; Ankara, Turkey
Aselsan; Ankara Turkey
Rocketsan; Ankara, Turkey
Kale Aero; Istanbul, Turkey
Baykar Machine; Istanbul, Turkey
Tübitak; Istanbul, Turkey
Metallwerk Elisenhütte GmbH; Nassau, Germany
Heckler & Koch; Oberndorf, Germany
AIM INFRAROT-MODULE GmbH; Heilbronn, Germany
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INTRODUCTION

Since World War II, the U.S. weapons industry has been the world leader in the development and production of highly capable, innovative, and technologically advanced weapons. Even as technologies tended to mature, such as those that support development and production of small arms, other areas such as low-cost precision-guided munitions offered opportunities for the U.S. industry to leap ahead of foreign competitors. By continuously improving and innovating, the U.S. maintained an unquestioned lead in the weapons capabilities it provides to its armed forces.

Today that lead faces challenges that require the attention and supporting action from our government if it is to be maintained. Domestic economic issues are forcing a significant reduction in U.S. defense spending, even as developing nations invest in building an internal weapons industry infrastructure that provides a rapid rise in the manufacturing and production capability in low- and mid-technology weapons. In this resource constrained environment, emerging capabilities must compete with traditional capabilities that already have well-established requirements and proponents. Any emerging capability might have to justify its place in the funding priorities. However, the budgets for weapons traditionally favor the tried-and-true technologies and are not easily displaced by unproven newcomers. Moreover, emerging technologies, in some instances, seem to cost more than their predecessors do, and any purported or anticipated financial savings often prove illusory. In the face of these pressures, there are positive steps that can be taken by the U.S. Government to support and enable our weapons industry. *In order to retain the U.S. technological and innovative edge in developing and producing weapons, the U.S. government must (1) establish and communicate industrial policy to deal with pressures of a declining defense budget, (2) reform burdensome export processes and policies to enable industry to better compete internationally, and (3) address the need for policy and doctrine for emerging technologies that enable their development and implementation.*

The weapons sectors studied by this industry study included small arms, ammunition, optronics, Non-Lethal Weapons (NLW), and robotic systems. The analysis includes a broad review of the forces influencing the weapons industry. These forces include the financial health of the domestic industry, DoD policy towards the import and export of weapons technologies, and the global competition in the weapons manufacturing domain. Our research included basic market research as well as site visits to both domestic and international factories including Government Owned, Contractor Operated (GOCO) and Government Owned, Government Operated (GOGO) facilities. Appended to this industry report are three essays that expound on the recommendations made in support of our thesis. These supporting essays are on export controls, weaponized robotics, and NLW.

This report consists of sections detailing the key assumptions and definitions, a succinct definition of the industry studied, a brief discussion of the current conditions, outlook, responses to challenges, government goals and roles, and supporting essays.

KEY ASSUMPTIONS AND DEFINITIONS

In order to fit the constraints of this report, and to concentrate on the central aspects of our study, several assumptions were made. The first and most basic assumption is that the U.S. currently has the lead in technology and innovation in developing and producing weapons. Although this assumption may be arguable in certain elements of the industry where the

technology is mature, we made the assumption across the weapons industry as a whole. The second assumption is that the overall Department of Defense (DoD) budget will decrease in the coming years, perhaps by as much as 10% to 20% over the next decade. A component of this assumption is that the war in Afghanistan will begin to wind down, with troop reductions over the next five years, with corresponding reductions in wartime practices such as supplemental funding. In addition, we assume this condition will translate to the end of highly streamlined acquisition procedures for urgent requirements. Although funding for the components of the weapons industry may not decrease at a uniform rate across the board, this assumption provides sufficient basis for estimating contractions in funding for research and development and procurement of weapons for the U.S. military. The third assumption is that despite current government initiatives to reform U.S. export regulations, it is unlikely that dramatic or revolutionary changes will occur over the next 5-10 years. This assumption is important in our analysis, as reform of export controls is a very important issue to many of the companies we visited.

It is also important to understand basic definitions related to the weapons industry and to the thesis of this study. These definitions, as composed by the Weapons Industry Study Team and used for the purpose of this study, include the following:

- *Technological edge* – The lead in technical knowledge and development of new technologies that can be maintained by a nation, industry, or individual company through continued investment in people, processes, and research and development.
- *Technology levels* –
    - *Low-tech* - The techniques and designs which are no longer cutting edge, utilize small capital investments by individuals or companies, and that the knowledge of the practice can be completely comprehended by a single individual, free from increasing specialization and compartmentalization.
    - *Mid-tech* - Requires research and development to produce cutting edge products. Capital investments by individuals or companies are required and advanced knowledge, skills and abilities are required to manufacture/produce.
    - *High-tech* - Has a great dependence on science and technology innovation that leads to new or improved products and services. They generally have a substantial economic impact, fueled both by large research and development spending, and a higher than industry average sales growth.
- *Innovation edge* – The ability of a nation, industry, or individual company to utilize people, processes, and existing technology to synthesize solutions to challenges in a rapidly changing and competitive environment.
- *Developing* – The act of applying the results of technological research and innovation to the design and readiness for production of a product.
- *Producing* – The act of making a product in sufficient quantities and with sufficient quality and efficiency to support national security. It is important to note that the term "producing" as used in this context most often requires both enhanced technology and innovation to be highly successful, especially in a very competitive environment. Finally, maintaining our critical infrastructure is essential to production of our key weapons systems.

THE INDUSTRY DEFINED

The Weapons Industry is very broad, encompassing low-tech weapons, personal small arms and ammunition, mid-tech weapons and accessories, assault carbines, high performance ammunition, precision guided munitions, and light enhancing technologies. Additionally, the high-tech fields of robotics, directed energy, and NLW can also be folded into this genre. The combination of the overall ICAF curriculum coupled with Weapons Industry Study curriculum provided insight into a good cross-section of the different sectors of the industry. This information has been leveraged to narrow the scope of the weapons industry for the purposes of this study. Based on these experiences we define the weapons industry as including the following sectors:

- *Small Arms*. This sector focuses on the low- and mid-technology personal weaponry that is carried by the soldier into the conflict and associated commercial variants. These weapons include side arms (handguns), rifles, carbines, and light machine guns, up through .50 Browning Machine Gun (BMG).
- *Munitions*. This sector includes the low-tech small arms ammunition, mid-technology precision-guided munitions (PGM), propellants, explosives, and pyrotechnics (energy releasing materials, or energetics). For this study, the scope of this sector includes the production of small arms ammunition, and the development of advanced weapons such as thermobaric munitions.
- *Optronics*. Optronics include mid- and high-tech weapon accessories used for targeting and situational awareness. This sector provides image-intensified optics, infrared (IR)/thermal images, and fused images that combine inputs from these technologies.[1]
- *Non-Lethal Weapons*. This mid- and high-technology sector includes weapons grouped into six general categories: kinetic, chemical and materials technologies, directed-energy, acoustic, electrical, and barriers and entanglements.[2] For this study, analysis of this sector focused on DoD policies and the ethical and legal issues associated with using NLW and is a separate essay attached to this paper.
- *Weaponized Unmanned Systems*. This high-tech sector is defined by the DoD as "a powered vehicle that does not carry a human operator, can be operated remotely by a human operator or can operate autonomously, can be expendable or recoverable, and can carry a lethal payload."[3] For this study, the industry was confined to man-portable, land-based systems typically weighing less than 250 pounds.

CURRENT CONDITION

Three major factors have significantly influenced current condition of the domestic weapons industry. The first factor is a decade of robust defense funding coupled with emphasis on fielding new weapons and weapon accessories quickly to the field. This factor has enabled the investments necessary in people, processes, and technologies to maintain a technological edge and foster continued innovation across all sectors. The second factor is the commercial sales market for several of the weapons sectors, which has supplemented defense sales and further enabled corporate investments to maintain the industry's leadership position. Commercial sales are especially important for the low and mid-tech sectors of small arms, optronics, and NLW, which have substantial domestic and global commercial sales markets that include law enforcement and sport enthusiasts. For example, in the U.S. market alone, the

National Shooting Sports Foundation claims that small arms and ammunition has an economic impact of over $28 billion per year and employs over 180,000 workers in both manufacturing and supplier/ancillary industries.[4] The third factor is the result of the consolidations, mergers, and acquisitions occurring across the U.S. defense industry. This factor has enabled industry to take advantage of integrating the knowledge and innovation of smaller teams with the resources of larger companies, and has provided added benefits related to economies of scale that enhance industry's ability to successfully develop and produce weapons.

These factors that have contributed to the current healthy state of the weapons industry are expected to change substantially over the next decade. Up to this point, robust funding lines coupled with streamlined acquisition procedures related to weapon needs from Afghanistan and Iraq have enabled the industry to respond to DoD needs for innovations in weapons and weapon accessories. Starting almost immediately after 9/11, supplemental funding (table 1 below) was appropriated to support the operations in Afghanistan, and the additional wartime funding provided a basis for the development of new weapons to meet requirements generated from current operations. As such, the weapons industry saw a corresponding increase from the increase in the defense budget. For example, the XM-25 Counter Defilade Target Engagement System and 25mm programmable ammunition[5], thermobaric munitions, the M26 12 Gauge Modular Assembly Shotgun System (MASS)[6], and weaponization of the Predator unmanned aerial vehicle are prime examples of the innovative environment provided by enhanced funding and an emphasis on meeting urgent operational needs. Supplemental funding and streamlined acquisition procedures are normally associated with meeting wartime requirements however, and as the war in Afghanistan winds down, they cannot be counted on by the weapons industry.

Table 1, Budget Authority for National Defense, FY 2001-2011 (in billions of constant FY10 dollars)[7]

	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10 (est)	FY11 (est)
DoD Base	390	415	447	480	439	464	475	524	541	534	540
DoE & Other Defense Related Funding	21	21	22	23	25	25	24	23	31	25	25
Overseas Contingency Operations (OCO)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	130	155
SUBTOTAL National Defense	**411**	**436**	**469**	**503**	**464**	**489**	**499**	**547**	**572**	**689**	**720**
War Supplemental	21	16	84	72	107	118	166	174	140	33	n/a
TOTAL	**432**	**452**	**553**	**575**	**571**	**607**	**665**	**721**	**712**	**722**	**720**

Commercial sales are expected to remain fairly constant; however, competition is more intense than in any period over the last ten years, as companies who have relied heavily on sales to DoD are attempting to diversify. Commercial sales are prevalent across most of the weapons sectors, especially for the low and mid-tech products of small arms and ammunition, optronics, and NLW. For the small arms sector especially, U.S. commercial sales, including sales to law enforcement, constitute an estimated 62% of the world demand for small arms.[8] Businesses that have diversified between commercial and defense market segments, rather than relying solely on defense contracts, have demonstrated stronger financial strength. For example, in the Optronics sector, companies visited ranged from diverse commercial/military markets to defense only markets. One company visited has found widespread application for their products in industrial manufacturing, homeland defense, and health services markets.[9] Another company visited is less diversified, has found few applications for their technology outside their military niche, and therefore expressed concerns over projected federal budget reductions. As defense spending contracts, defense-oriented companies face considerable pressure to diversify to remain financially viable.

The area of commercial sales that offers the greatest promise to offset the decline in

defense spending is in direct international sales. These sales provide direct benefits to the companies supplying the product and a secondary benefit to the DoD, by helping to stabilize the business sector and support competition and innovation. However, U.S. manufacturers of some weapons products are restricted in their ability to sell dual-use products to global consumers. For instance, U.S. firearms manufacturers operate at a competitive disadvantage against foreign firearms manufacturers. Foreign firms wanting to export their product to the U.S. must abide by the International Traffic in Arms Regulation (ITAR). U.S. domestic firearms manufacturers wanting to export their product to the global market must also abide by ITAR, as well as the Arms Export Control Act (AECA). The intention of ACEA and ITAR is to abate the likelihood of a hostile nation acquiring advanced technologies developed in the U.S. and then use that technology against the U.S. and its allies. For the small arms market in particular the 6-to-1 import to export ratio has a significant impact on the health of the sector.[10] The impact of export controls upon direct international sales and the potential for positive reform of export policies and processes emerged as central issues in this analysis of the weapons industry.

The priorities of the industry with respect to mergers and acquisitions are changing from the benefits of strategic integration to the less positive and less orderly necessity of industry consolidation. Over the last decade firms have bolstered their health and position in the weapons industry by merging, consolidating, or acquiring complementary businesses. As an example, two firms in the weapons industry that have significantly increased their market share through mergers and acquisitions are the Freedom Group, formed from private equity firm Cerberus (with foreign ownership) and FLIR. The Freedom Group acquired several of the companies listed in the 2009 "Top 25 U.S. Firearms Manufacturers" list—namely Remington, Marlin, Bushmaster, and DPMS.[11] They rapidly became one of the leading firearms, ammunition and related products companies in the world, with top commercial market positions across all of the major small arms product categories in the U.S. The conglomerate has 11 manufacturing facilities with more than 2,900 employees and delivers products throughout the United States and to more than 80 countries.[12] Similarly, Optronics manufacturer FLIR has acquired 13 companies since 2003.[13] Through these acquisitions, FLIR appears to be the healthiest small optronics firm with a proven 5 year growth rate of 24.5%.[14] More importantly, these acquisitions done for strategic integration posture the company well to develop the next generation of fused IR/image intensified technology. Industry consolidations will not provide such benefits as their objectives relate to reduction in personnel and facilities costs and alignment, rather than to goals of improving technology and innovation.

The weapons industry has provided substantial benefit to the national security of the U.S. with innovation in product capability as well supporting cost efficiency, and it is of critical importance that the government takes appropriate steps to ensure it does not degrade. Two examples of how existing systems were made more effective at a low cost are the Precision Guidance Kit produced by ATK and the arming (weaponizing) of the RQ-1 Predator by General Atomics. The Precision Guidance Kit for artillery and mortar systems is an example of cost conscious innovation where significant operational capability was added to existing unguided munitions at low cost. The innovative idea to arm the RQ-1 Predator unmanned aerial vehicle (UAV) is another prime example of how the current weapons industry supports cost conscious innovation. Demand for an unmanned weapon system that could not only detect but also engage enemy forces in remote areas where manned aircraft operations were either undesirable or too costly to support round-the-clock flight operations, led to the development and fielding of the MQ-1 Predator.[15] This type of innovation was enabled by the existence of and DoD support for

quick reaction acquisition organizations like the Air Force's Big Safari.[16] Industrial Policy should also account for and support such organizations to enable innovation through rapid development and fielding of needed capability in today's dynamic environment.[17] As an example of such innovation for which policy and doctrine support is essential, the arming of a UAV has also provided the basis for further discussion on a logical follow-on capability: arming unmanned land-based robots. This topic is detailed further in an essay contained is this study. In light of the current conditions detailed above, what challenges face the U.S. weapons industry?

CHALLENGES

The domestic weapons industry faces significant challenges in order to retain its technical and innovative competitive edge in the global industry. *The most fundamental challenges faced in the next decade by the weapons industry are the lack of a clearly communicated industrial policy to deal with pressures of a declining defense budget, the burdensome export processes and policies, and lack of policy and doctrine for development and implementation of emerging technologies.*

Projected cuts in the overall federal spending are driving the need for clearly communicated industrial policies for the U.S. weapons industry. A decade of robust funding has had a significant effect on the weapons industry, as defense spending increased by nearly two thirds in the ten years since the September 11, 2001, terrorist attacks and "accounted for 53% of the increase in [federal] discretionary spending in real terms over the past decade."[18] With the substantial increase in funding for programs, many manufacturers increased their program staff and facilities to support the increased workload. In the face of projected reductions, maintaining the right balance of technical staff, facility capacity, and continued emphasis on developing weapons capability to meet operational needs will be key to maintaining an environment conducive for innovation. Industry planners require clear communication of future acquisitions plans and defense spending projections in order to allocate their resources accordingly.

A second major challenge to sustaining an innovative weapons industry relates to the need for judicious government policies that protect U.S. national security interests yet still allows industry partners the ability to leverage export sales. More specifically, the U.S. needs updated policies that address export controls for allies and friendly nations, older generation technologies, and partnering in the development of emerging technologies. With reduced discretionary funding within the defense budget, businesses will look to other means to maintain revenue streams, such as foreign military sales (FMS), direct commercial sales (DCS), or commercial exports—despite the reality that American consumption comprises approximately two-thirds of the world's total market for weapons. Policies that inhibit exporting, or place domestic businesses on an uneven playing field in selling similar technology products abroad will adversely affect the industry's ability to remain competitive and innovative. ITAR and AECA provide the current policy on export and import controls. Through our discussions with several business leaders in the weapons industry it's apparent they understand and support the need to protect U.S. national security interests. However, many of the leaders also aver that the U.S. applies ITAR in an inconsistent manner, restricting sales of technologies that are available through foreign competitors, who may not have comparably restrictive controls. ITAR and AECA limit interaction between industry and the government, contributing to misunderstandings between parties. In addition to being addressed in the body of this paper, a more in-depth discussion of export controls is provided in the essay section of this paper.

The third area that is key to preserving the leadership position of the U.S. weapons

industry is the application of policy and doctrine to enable the implementation of emerging innovations and associated technologies. One example of such an area of innovation is the application of weaponized unmanned ground vehicles (UGV) in battle. While unmanned aerial vehicles (UAV) have been weaponized and policies governing their use have been defined, similar policies for weaponized UGV have not materialized. Ethical concerns regarding autonomy and cultural resistance to reliance on remotely operated systems restrict development in the unmanned systems sector of the weapons industry. In fact the DoD 2009 Unmanned Systems Integrated Roadmap removed the majority of previous references to weaponized UGV.[19] This specific area is separately addressed in an essay contained in this paper. Another example is NLW, which offers warfighters viable options for addressing challenging scenarios in counterinsurgency and stability operations where the objective is to accomplish the mission and protect the force when lethal force is either unnecessary or could even be detrimental to achieving the strategic-level goals of the operations. While the DoD provides approximately $120 million annually to the Joint Non-Lethal Weapons Directorate (JNLWD), its current policies do not encourage their use in theater operations such as in Afghanistan.[20] The JNLWD continues to invest in research and development projects to determine and procure those systems proven to be most effective. More detail on the challenges facing the NLW sector is also provided as an essay in the appendix of this paper. Analysis of the current conditions in concert with the challenges informs our view as to the outlook of the U.S. weapons industry.

OUTLOOK

If the appropriate steps are taken by the DoD to enable and support the weapons industry with regard to the challenges described in the previous section, the U.S. domestic weapons industry will maintain its role as the global leader in providing innovative and highly capable weapons. For example, the IBIS World small arms industry report predicts that from 2011 to 2016, revenue for the industry will grow at a moderate rate of 3.4% per year.[21] This expectation is consistent with the reasoning of many industry analysts who see demand slowing as the economy improves, personal safety fears subside, and overseas contingency operations in Iraq and Afghanistan begin drawing to a close.[22] From a financial aspect, our industry study found nothing to contradict these views in the commercial sector. This growth rate, while small, will provide a solid financial basis for retaining small arms development and production capacity in the domestic sector.

With respect to policy, the government will soon have an opportunity to consider a major policy change in the munitions sector of the weapons industry. The U.S. is currently the largest producer of domestic and military ammunition in the world. For example, the Lake City Army Ammunition Plant (a GOCO) has a production capacity of 1.6 billion rounds annually with current demand near the maximum capacity. As the demand for ammunition drops with the withdrawal of coalition troops from Afghanistan and Iraq, the pressure to totally privatize such facilities may again be considered from a policy perspective. A 2000-2003 Rand study that analyzed the ammunition facilities, recommended movement towards privatization of the arsenals and ammunition plants. The report concluded that the DoD would save between $0.5M and $1.23M in privatizing selective arsenals and ammunition plants.[23] While this discussion will undoubtedly occur, the more important policy consideration must be to maintain our lead in innovation in both product and manufacturing method. There is an opportunity for the DoD to evaluate this cost savings opportunity balanced against the need to maintain sufficient industrial capacity and to use the drop in production requirements as an opportunity to innovate. The

innovation and recapitalization at Lake City that occurred during the Vietnam conflict provided key infrastructure and manufacturing capacity that was key to the successful surge in production for recent conflicts. Failure to maintain a competitive advantage in ammunition production provides an opportunity for foreign manufactures to supplant U.S. global leadership. For example, one foreign ammunition supplier evaluated during this study plans to almost double their production rate largely through modernization of existing production lines. This projected capacity increase through capital investment, could account for a four-fold increase in production rate compared to projected U.S. military production rates. In addition, a 2003 survey by a Swiss organization states that non-Western exporters of ammunition have grown, and the projection is for continued growth.[24] While this would appear to be opposite of U.S. demand signal, the ability of foreign manufacturers of ammunition to eventually compete on both quality and price is a distinct possibility if the U.S. manufacturing base for ammunition is allowed to atrophy.

The optronics industry is in a highly competitive global market and is a prime candidate to benefit from reform of export controls.[25] On August 31, 2010, the Obama administration, announced its plan for reform of two key elements (policy and process) of export control that could directly benefit the U.S. optronics industry, as well as other elements of the defense industry.[26] Although the details of these changes are still to be worked out, the potential for benefit to the optronics industry is clear. These changes in government policy could relieve unnecessary restrictions on technology that is already being made widely available by foreign competition, and the changes could also shorten the timeline for gaining approval to sell these highly competitive technologies.

Yet there will still be obstacles with export controls and optronics will be in the vanguard of this debate. In a speech earlier in the year, Secretary of Defense Robert Gates said that future changes in export controls would be designed to streamline the export-review process and to protect "crown-jewel" technologies. Mr. Gates went on to say the current system puts U.S. firms at a competitive disadvantage with foreign rivals who can export many of the same items we protect "with little scrutiny by their own governments."[27] Based on these comments from Secretary Gates, we believe that optronics technologies should be on the front lines of the export reform debate. The keys to a successful outcome for industry will hinge upon the government's ability to reform existing lengthy bureaucratic processes and to reform policies so that widely available technology is not unnecessary restricted. If the government takes the appropriate steps for export control reform, expanded export opportunities will serve as a hedge to declining budgets and enable maintenance of our technological edge. Additionally, these opportunities will foster industrial base stability, increase revenue, resulting in an opportunity for expanded research and development.

Policy and doctrine support from the DoD can be of enormous benefit to the NLW industry, which has the potential for massive growth across both commercial and military markets. Recent U.S. operations in Afghanistan, or public turmoil in the Middle East (i.e., Egypt, Libya, Syria), or unruly protests of G8 meetings, demonstrate a growing value for military forces or law enforcement agencies to have NLW capabilities as on option for urban operations. More and more governments and policing organizations are looking to non-lethal means by which they can control a potentially violent situation while minimizing or eliminating the potential for using deadly force. The full extent of growth in the NLW sector will hinge on both the expanding need for non-lethal capabilities, fiscal choices, and public (domestic and international) acceptability of these capabilities. Most importantly, policy decisions by the DoD will have a direct impact upon the innovation and implementation of this generation of options

for our military.

The past twenty years have seen Military robots, or UGV systems evolve in quantity and quality as well as capability. The next twenty years will see even more rapid growth and innovation in the technology that supports robots or UGV. However, ethical concerns and cultural resistance have limited development and employment of weaponized UGVs. Service leaders will need to consider appropriate degrees of autonomy in development of weaponized UGVs and overcome cultural resistance so that unmanned systems can reach their full potential to support the fielded forces. Given the direction of the DoD Unmanned Systems Integrated Roadmap, 2009-2034, future UGVs can expect to be limited to the following prioritized capability needs: reconnaissance and surveillance, target identification and designation, counter-mine and explosive ordnance disposal, and chemical, biological, radiological, nuclear (CBRN) reconnaissance.[28] As the technology matures, it is critical that DoD policy directives be updated to reflect operational usage of more capable and more autonomous systems.

The weapons industry, in response to these challenges (i.e., the lack of a clearly communicated industrial policy to deal with pressures of a declining defense budget, the burdensome export processes and policies, and lack of policy and doctrine for development and implementation of emerging technologies), is taking steps to maintain technical and innovative leadership. As discussed in the Current Conditions section, many businesses in the industry are diversifying their weapons related product lines to span commercial markets, or are acquiring complimentary businesses to mitigate any decrease in revenue from DoD contracts. This was evidenced during domestic travel to FLIR and Smith & Wesson. FLIR, for example, has a substantial market demand for mid-tech thermal optics from the health care, marine, and law enforcement markets. Domestic small arms producers like Smith & Wesson and Colt have invested in state-of-the-art machining tools to lower manufacturing costs while ensuring consistent quality in their manufactured products. In addition, some in the weapons industry are lobbying to change government policies and roles that excessively control weapons technology, or establish an unfair playing field for domestic industry in competing for foreign sales.

GOVERNMENT GOALS AND ROLE

Based on the current conditions and outlook established in this study, the primary goal of the U.S. Government should be to maintain and foster the technical and innovative culture resident in the industry today. *In order to retain the U.S. technological and innovative edge in developing and producing weapons, the U.S. government must (1) establish and communicate industrial policy to deal with pressures of a declining defense budget, (2) reform burdensome export processes and policies to enable industry to better compete internationally, and (3) address the need for policy and doctrine for emerging technologies that enable their development and implementation.* To succeed in achieving this goal, the Government should consider:

Ensuring adequate competition. To mitigate the risk of falling into a scenario that mandates necessity as the mother of invention, the Government must adopt the proactive approach that competition is the mother of innovation. The opinion of the Weapons Industry team is that the current number of businesses actively involved in DoD weapons initiatives, within each sector, is at the minimum number needed to ensure both adequate competition, and the production capacity necessary to meet national security needs. For instance, in the domestic small arms sector there are possibly only four businesses, Colt, S&W, Sturm Ruger, and the Freedom Group, that have the product knowledge and production capacity necessary to support

DoD needs for both handguns and assault rifles/carbines. It is critical that the DoD have a strategic industrial policy that recognizes circumstances such as this and allows for steps to prevent further industry consolidation to the detriment of both competition and the minimum need for the U.S. industrial capability.

Fostering involvement from nontraditional businesses. Businesses with tangential technical capabilities, like thermal imaging or high quality optics/lens manufacturing, provide another avenue to gain innovative ideas associated with needed weapons capabilities. Many DoD weapon acquisition programs include integration of commercially available components. Fostering further growth in this area helps ensure the industry remains robust across the technical knowledge base. The DoD acquisition system already has a similar program and policies aimed at growing capable small businesses. Leveraging the Small Business Innovative Research program and contracting goals for small business involvement in weapons programs provides a good basis for establishing this policy.

Supporting export sales and foreign markets. In August 2010, the current administration took action to find ways to overhaul federal trade and export controls.[29] This provides an extraordinary opportunity to address restrictions that are impeding domestic industry's ability to compete with their foreign counterparts. This recommended role is not intended to subvert or put at risk national security concerns to benefit the weapons industry. However, there are several export policy restrictions that appear to be contradictory with Government policies and relationships with allied and friendly nations. Aligning the export control policies to expedite sales to most trusted nations, similar to what is already being done for optronics, could provide a substantial revenue source for industry without risking national security concerns.[30] Reform of both the export control policies and the bureaucratic processes by which they are implemented could be of tremendous benefit to the domestic weapons industry, which is likely to fair well if competing on a level playing field with its international counterparts.

Emphasizing Science, Technology, Engineering and Math (STEM). Based on anecdotal examples from discussions with industry leadership, fostering future experts and leaders across technical functions is important to ensuring the long term future of innovation and technical leadership. Emphasis on educational support for Scientific, Technology, Engineering, and Math programs will help ensure the future workforce maintains the capability for technical innovation.

Developing policies on the application of emerging technologies. There continues to be a need for a national policy at the federal level (Defense, State, and Justice) for the employment and application of weaponized unmanned ground vehicles and NLW technologies. For the NLW sector, a national policy has been under consideration now for over 10 years, but a published policy does not yet exist.[31] Policies for these emerging technologies should be based on safety to the populace surrounding an intended target and to the soldier, and mission success. In all cases, the policies should be based on desired outcomes. For UGVs, special consideration should be given to the acceptable degree of autonomy under which an armed UGVs could operate. This consideration would address ethical concerns while enabling the development of weaponized UGVs. However, less than fully autonomous systems enhance the likelihood achievable technologies will be able to withstand political sensitivities and be employed in the operational environment.

Coupled with the need for policies guiding emergent weapons technologies, the Government also needs to take action to break bureaucratic cultural barriers within the Government agencies. The Air Force experienced similar resistance during initial development and deployment of UAVs. DoD leaders must pay special attention to cultural resistance. Efforts

like the Unmanned Systems Integrated Roadmap as well as strategic transformation programs must consider and monitor the degree of cultural acceptance/resistance that unmanned systems encounter. In the end, leaders should continue to develop systems aimed at "dull, dirty, or dangerous" tasks.[32]

CONCLUSION

The U.S. enjoys technical dominance in the high-tech sector of the weapons industry, including optronics, precision guided munitions, directed energy weapons, and battlefield robotics. The U.S. also remains the innovative leader in the development of low- and mid-tech weapons such as programmable ammunition, targeting accessories for the M4 carbine, and low collateral effects munitions. *In order to retain the U.S. technological and innovative edge in developing and producing weapons, the U.S. government must (1) establish and communicate industrial policy to deal with pressures of a declining defense budget, (2) reform burdensome export processes and policies to enable industry to better compete internationally, and (3) address the need for policy and doctrine for emerging technologies that enable their development and implementation.*

In the absence of such action by the government, the dominance the U.S. has enjoyed over other nations in the weapons industry will decline. Two main factors contributing to that decline are the consolidation of businesses, limiting competition in the weapons sector, and the substantial increase in global manufacturing and production capabilities across the low and mid-tech sectors. Further consolidation in any weapons sector could significantly reduce the advantages of competition, resulting in stagnation of innovative products.

Additionally, export controls play a key role in protecting technical superiority but at the same time limit market opportunities in the increasingly global economy. Changing current policy by reforming export controls would provide another revenue source for domestic weapons producers, keeping product lines open, reinvigorating product enhancement, and lowering the risk of further consolidation.

Finally, emerging technologies such as NLW and weaponized robots show promise in reducing risk to soldiers and limiting civilian casualties. These programs should be leveraged to open additional markets for the U.S. weapons industry and foster technology innovation. Policy and doctrine for the use of these technologies must be addressed and openly debated in order to facilitate their utility and development.

ESSAYS ON MAJOR ISSUES

Essay 1: Export Reforms: Controls & Offsets

In 2010, President Obama met with his Export Council at the White House where he discussed his goal to double exports over the next five years with the hopes of creating millions of new American jobs.[33] The President outlined that export control reforms are to include: (1) what is controlled, (2) how it's controlled, and (3) how those controls are managed and enforced.[34] The President proclaimed that these reforms would help strengthen our national security by focusing our efforts on controlling only the most critical products and technologies and by enhancing the competitiveness of key U.S. manufacturing and technology sectors.[35] That same year, Defense Secretary Gates offered his thoughts regarding the need for fundamental export reform:

> If the application of controls on key items and technologies is to have any meaning, we need a system that dispenses with 95 percent of 'easy' cases and lets us concentrate our resources on the remaining 5 percent. By doing so, we will be better able to monitor and enforce controls on technology transfers with real security implications while helping to speed the provision of equipment to allies and partners who fight alongside us in coalition operations.

Moreover, he added, the current system encourages multinational companies to move research, development, and production offshore, "eroding our defense industrial base" as well as "undermining our control regimes."[36]

These are powerful words which would most likely prompt enthusiastic affirmation by most American industries, particularly the defense industry which is already bracing for significant decreases in future U.S. defense spending. Despite a projected increase in future exports, the U.S. weapons industry still faces challenges because economic offsets are almost always required by foreign buyers. These offsets are also becoming a more determinant factor in the success of U.S. industries hoping to sell their military wares to foreign countries.

Discussion

Offsets have long been an aspect of contract negotiations in Direct Commercial Sales between U.S. companies and foreign governments. However, in Foreign Military Sales, where the sale is handled by the U.S. Government, the U.S. Government has no say in any of the offset transactions between the company and the foreign customer. The capability to meet U.S. and Joint warfighter needs may be severely impacted by the outcome of offset negotiations that the U.S. Government cannot influence in its own favor.

Economic offsets are simply a country's way to apply a multiplier to their investment in an item purchased from a foreign company. This offset could be directly related to the purchase, e.g. an indigenous company supplying parts or doing some other aspect of manufacturing or assembly in their country instead of in the U.S. It could also be an indirect offset, meaning the offset value is not related to the original purchase at all. For instance, a developing country buying some type of armament for their military may also be in need of advanced farm equipment. Typically, these direct and indirect offsets are valued between 20-100% of the contract value.

The true unrealized risk in the completion of a sale is that the offset package may be the point of contention that derails a deal. In fact, it is one of the few reasons that a U.S. company might walk away from a deal entirely. Companies simply cannot ignore the risk of penalties associated with non-delivery of the offset portion of the overall contract. This would satisfy no one and amount to a lot of finger pointing as to the responsible party, with many of the stakeholders pointing to each other because of a lack of a unified policy.

The U.S. has enjoyed a global lead in its ability to research and develop new weapon systems to meet the needs of its warfighters. More and more, joint development with allies has been encouraged across the spectrum of weapon systems as a means to decrease costs. The current outlook for expenditures on military hardware through the next few years is one of declining budgets and potential consolidation of 2nd and 3rd tier domestic suppliers. In this environment, it is the international sale of military equipment that will support the industrial base the U.S. wants to maintain for its own interests. In this environment, economic offsets required

by the majority of other countries deserve further attention and recognition.

Conclusion/Recommendations

Although the President's export control reform initiative shows promise to potentially counter the future decrease in demand from U.S. defense spending, one must keep in mind that reform is still not at hand despite great strides made over the last year. The Obama Administration may ultimately enable American weapons companies to compensate for the anticipated downturn in overall domestic demand by exporting more freely to the rest of the global market, once these controlled low-tech items are removed from export control, as envisioned by the President's Export Council. But this hope and optimism must be measured, as the reality of the global market place is that American consumption comprises approximately two-thirds of the world's total market for small arms. Export control reform alone may not sufficiently make up the difference in decreased demand in the weapons industry, and increased U.S. Government facilitation in Foreign Military Sales and associated economic offsets may be needed as well.

Applying the "Whole of Government" concept of National Security Strategy to the treatment of economic offsets on foreign purchases of U.S. made equipment would seem to make sense.[37] The current Administration should consider rescinding Public Law 102-558, which states: "[n]o agency of the U.S. Government shall encourage, enter directly into, or commit U.S. firms to any offset arrangement in connection with the sale of defense goods or services to foreign government."[38] Further, the law states: "the decision whether to engage in offsets, and the responsibilities for negotiating and implementing offset arrangements, reside with the companies involved."[39]. This would allow the DoD and industry to work with our State department to solicit allies on their compatible needs in order to maximize our DoD budget's potential in providing capability. In addition, the U.S. government could leverage its entire portfolio of FMS and aid programs that provide a myriad of foreign assistance. This is another potential way to sponsor industrial economic offsets. The involvement of agencies outside of the Department of Defense would help maintain the purity of the DoD acquisition while supporting the domestic industrial partner. In addition, the releasability of technology (i.e. export controls), would be more visible across the agencies, thus providing further support for domestic industry. In this regard, the U.S. Government is still using its economic instrument of power to "softly" promote goodwill to our allies and potential allies, while bolstering our own industry and extending our own Department of Defense dollar to its maximum effectiveness. The question that remains from this suggestion is how to implement such a program.

The U.S. government could also choose to enter into the business of selling offset credits on a secondary market. As reported by one defense firm, offsets for particular foreign countries of interest may be bought, or bartered, with another division of their own large conglomerate, or with another firm entirely. This would certainly provide an opportunity for the U.S. government to promote trade of U.S. companies by leveraging the weight of its diplomatic and economic efforts abroad. This, in turn, could provide an additional corporate revenue stream back into the Treasury.

A third option might be the establishment of a merit system for U.S. domestic companies to qualify for the government-assisted offset. Domestic contractors could be held to a specific performance level on DoD contracts that would qualify them to take advantage of any available existing governmental aid to a foreign country that they are doing business with.

Unfortunately, there are as many drawbacks to these suggestions as there are benefits.

Unless the connection between the U.S. government and industry concerning offsets is handled with deft strategic communications, the perception of a strong tie between the sales of military hardware and U.S. humanitarian aid could be catastrophic, and negate any commercial gain that might come of it. This would lend itself to a "strong arm diplomacy" perception, which many administrations, and Congress, would most likely not allow to happen. One other consideration is that U.S. industry may not want this U.S. government help in the first place. All indications from the interviews done for this study tend to back up that assertion. There is a very strong free market enterprise mentality in the U.S., and industry would not want to be beholden to the Government when they are trying to satisfy their shareholders. The business of the government is governing, not business. When the government has tried to enter into business, the results have been poor to mixed.

There is also the scenario that the U.S. Government may not be able to uphold its part of this relationship. This would have the inverse effect of negatively, rather than positively, impacting business transactions. Additionally, if the U.S. Government made its aid applicable to fulfill U.S. industry offset requirements, it may make the U.S. Government more beholden to "quid pro quo" arrangements with other countries for military or defense related sales of equipment. The intertwining of economic diplomacy with the purchase of warfighting material would not be a good policy. This would not be the best situation for the U.S. warfighter, and would cut into the U.S. qualitative and quantitative edge over our adversaries in terms of needed capability and second and third order supply and maintenance effects.

Finally, the political mantra of "don't ship our jobs overseas" might be a fragile argument. When an offset arrangement is made to set up a supplier in a foreign country, one of our prime integrators did not look at that as shipping domestic 2nd tier jobs overseas, but opening up domestic capacity for technological innovation and cutting edge production while shipping older technology and processes abroad.

Export controls and economic offsets are as much a part of the defense business as the technology that is developed. A firm that has a grasp of the existing, and often changing, regulations for export controls may very well have a competitive advantage in the market. This was observed over numerous visits both domestically and abroad. In the nebulous world of economic offsets, where regulation is ambiguous and sometimes contradictory, a major step forward would simply to be for U.S. industry and the U.S. Government to not get in each others way

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Essay 2: Non-Lethal Weapons

Over the last seven years, the U.S military and coalition forces have employed traditional conventional force as part of counterinsurgency (COIN) operations. Some of these operations have resulted in civilian casualties, stoked outrage from the local populace, and provided fuel and support for further insurgent activities. The U.S. has undertaken a focused effort to update COIN strategies to prevent collateral civilian losses and injuries by employing COIN methods to isolate or remove a hostile insurgent in a crowd. One capability available to enhance COIN methods is the use of non-lethal weapons (NLW). NLW could potentially offer warfighters a viable option for addressing challenging scenarios in COIN and stability operations where the

application of lethal force is either unnecessary or even detrimental to accomplishing the mission.

Discussion

The Marine Corps Joint Non-Lethal Weapons Directorate (JNLWD) at Quantico, Virginia, is charged with overseeing the Defense Department's (DoD) NLW program. In 2010, the U.S. in total invested $120 million in NLW.[40] The JNLWD, DoD's current policies and tactics do not encourage their use in Afghanistan operations. However, the JNLWD has developed close-range NLW to support U.S. military forces in situations ranging from peacekeeping to open conflict. The JNLWD continues to invest in research and development projects to determine and procure those systems proven to be most effective. But the institutional support within the DoD and the United States Government as a whole appears to be lacking. For example, according to General Joseph Dunford, Marine Corps Assistant Commandant, "the U.S. Marine Corps has failed to deliver the NLW that coalition forces in Afghanistan need to reduce civilian casualties and protect troops."[41] Moreover, General Dunford added that he has "been somewhat disappointed with our inability to take concepts and turn them into enduring programs."[42] Further, "Marine Corps officials have focused too much effort developing high-end [NLW], such as nets designed to stop sea vessels, rather than at the tactical level, where troops need them most," Dunford said.[43] The low priority afforded to the development of these weapons is reflected in the low-level of funding for the overall program, including research and development of new technologies in particular. While there have been some gains in support of NLW, the DoD as a whole appears uncertain of the operational utility of available NLW. This stance seems to be limiting, rather than encouraging, government and industry support for the development of new NLW.

Issues and Challenges

The development and use of non-lethal technology has ethical issues related to their safety, effectiveness, and legal standing domestically and internationally. For example, the use of tear gas and pepper spray is very contentious because the use of these chemical weapons can cause eye irritation and extreme tearing. Additionally, the use of these capabilities by the military may require the professional application of a pharmaceutical or other antidote for the reversal of effect, which could impose an additional cost. Opponents of these weapons think it is inhumane and unethical to inflict such severe pain. The debate on the employment of NLW has generated questions about implications for U.S. foreign policy. Growing concerns about terrorism have also increased interest in NLW, but international issues exist that need to be addressed. In particular, questions surrounding the issue of whether the use of the NLW would cause suffering that is needless, superfluous, or disproportionate to the military advantage reasonably expected from the use of the weapon remains; could the NLW be controlled so as to strike only a lawful target and thus be discriminate in its effect; and do policies or laws exist that prohibit NLW use.[44]

The status of NLW is ambiguous under broadly ratified international conventions prohibiting the use of certain types of weapons. According to international law, armed forces are not obligated to use NLW or to even consider the use of NLW before applying the use of lethal weapons. Intense legal consideration of the interpretation of the law must always be a priority to ensure military operations are always within the bounds of legality. For instance, some of the

first international treaties accepted by the U.S. on the conduct of war eliminate biological and chemical weapons as an alternative. The treaty defines chemical and toxic agents as "any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans.[45] Some NLW are prohibited as stated in the ratified Chemical Weapons Convention. For example, the U.S. can use tear gas for police action internationally but is prohibited from using it in war. International law forbids the use of certain tear gas on foreign troops that police forces routinely use on their own civilians. In order to overcome these obstacles, the international community will have to make some strategic decisions developing an international policy that standardizes the meaning, intent, and use of NLW globally. This requires consideration of strategic, operational, and tactical impacts.

In addition, U.S. policy may be influenced by the growing interest in the concept of NLW on the part of the American media.[46] Some feel the use of NLW would reflect a lack of political resolve and weakens the effectiveness of the U.S. military by not producing the physical results necessary to punish an aggressor. Others believe the use of NLW would encourage politicians to micromanage U.S. military commanders and places the lives of U.S. military personnel at risk. Politicians envision military commanders with NLW systems applying proportional force to those future threat scenarios where the risk of death or permanent injury to civilians would be counter to the purpose of the intervention and might result in future escalation to lethal weapons systems. Others feel the development of non-lethal technology will trigger unwanted and unintended involvement in parts of the world experiencing turmoil. These critics express concern that this would result in the expanded use of U.S. military forces in non-traditional missions. These considerations ultimately lead one to a number of thorny philosophical and policy considerations and discussions concerning a plethora of ethical questions and dilemmas surrounding the use of NLW. Specifically, the development and use of non-lethal technology has ethical issues related to its effectiveness, safety, and legal standing both domestically and internationally.

Conclusion/Recommendations

Some believe the term non-lethal is inaccurate because almost any weapon can result in a lethal effect, depending on how it is used. The term less-than-lethal incorrectly suggests the weapon cannot be used in a lethal manner. Perhaps a more accurate term would be less lethal, to account for the much reduced possibility of lethal effects. Today's strategic environment stresses the need for the operating forces to have access to leading edge technology and capabilities in order to maintain the competitive advantage to include NLW. The use of NLW can or may help in reducing the risk of escalation of volatile conflicts and provide alternatives for the military that will enhance its operational and tactical capabilities. Further, non-lethal technologies may represent a capable force multiplier, because a non-lethal attack may significantly increase the vulnerabilities of the enemy military force while creating the means for effective coercion or destruction of the enemy's military capability by a smaller conventional force. NLW are important because they could permit military engagement at a lower level of violence.

By heeding the strategic assessment above of the NLW industry, strategic leaders will be able to make better decisions and provide better national policy advice concerning the resource component of national security. The background of the NLW industry, the discussion of the viability of NLW as an alternative, the evaluation of the viability of NLW as an option in a resource constrained environment, and the strategic policy recommendations will serve as data

points to assist strategic leaders as they weigh and prioritize the discernable trends in the development and application of NLW in concert with lethal weapons. It is clear that NLW are viable alternatives and they have a place in our arsenal. However, will they (and the NLW industry) survive the fiscal vortex? NLW appear to serve as an important strategic solution in a complex world, if they can overcome the tangible and intangible factors that continue to hinder their promise. The time to explore the potential and the limits of such a proposition is upon us.

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Essay 3: Weaponized Robots Essay

Military robots represent a small and specialized segment within the U.S. defense industry. While applications and demand have increased significantly in the last several years, ethical concerns and limited strategic guidance will restrict technological development and industry opportunities with respect to weaponized robots. Ultimately, strategic leaders should take action to develop policies that restrict the degree of autonomy for weaponized robotics. Additionally, they should expand research into NLW applications for military robots and continue to remove cultural barriers to large scale implementation of unmanned ground systems.

Discussion

The typical military robot is best described as a remotely or tele-operated system In fact, DOD utilizes the term "unmanned systems" rather than "robots.". However, the Office of the Secretary of Defense Unmanned Systems Integrated Roadmap (2009-2034) which is intended to "focus military departments and defense agencies toward investments in unmanned systems and technologies" establishes a specific goal to "[s]upport research and development activities to increase the level of automation in unmanned systems leading to appropriate levels of autonomy, as determined by the Warfighter for each specific platform."[47] For the purposes of this industry study, research was limited to weaponized unmanned ground vehicles (UGVs) (especially man-portable systems) except where comparisons to other systems was valuable.

Unmanned aircraft systems (UAS) were among the first unmanned systems to be employed in large numbers within the U.S. military. UGVs got their start in the late 1980s through studies that identified explosive ordnance disposal applications. In 1999 the Army adopted the Future Combat System (FCS) which would include "14 manned and unmanned systems tied together by an extensive communications and information network."[48] A few years later, Congress established goals for unmanned systems. Section 220 of the 2001 National Defense Authorization Act states that "by 2015, one-third of the operational ground combat vehicles [will be] unmanned."[49] Although, the Secretary of Defense announced a significant restructure of the FCS program in April of 2009, critical portions of the strategy remained intact. The Army released its BCT Modernization Strategy in October 2009 that will take advantage of development already completed. It plans to field a Small Unmanned Ground Vehicle (SUGV) in one of the earliest capabilities package releases. According to a U.S. Army pamphlet approved for public release, "[t]he Small Unmanned Ground Vehicle (SUGV) is a lightweight, man-portable Unmanned Ground Vehicle capable of conducting military operations in urban terrain, tunnels, sewers and caves. The SUGV performs hazardous missions without directly exposing the Soldier to the dangers found in manpower intensive or high risk missions."[50]

Ten years after the FCS concept, UGVs have been heavily integrated into our operations in Afghanistan and Iraq. However, their use has been limited primarily to support of explosive ordnance disposal (EOD) operations. Today more than 6,000 UGVs have been employed and have "conducted over 30,000 missions, detecting and/or neutralizing over 15,000 improvised explosive devices (IEDs)"[51]

UGVs have also been weaponized. In 2004, the Army unveiled the Special Weapons Observation Reconnaissance Detection System, or SWORDS. SWORDS is a UGV developed by Foster-Miller for the U.S. Army and includes a suite of weapons systems mounted on the same Talon robot chassis currently employed by explosive ordnance disposal personal. Three SWORDS robots were sent to Iraq in 2007 for use with the U.S. Army. Within a few months reports began to surface that the SWORDS units had been returned from deployment without firing a shot. The Army has provided little explanation. In an article published in Popular Mechanics Magazine, Duane Gotvald, the deputy project manager for the system is attributed to saying "[t]he SWORDS robot represents a new technological concept currently in the developmental stage." He acknowledged that "some technical issues still remain and SWORDS is not currently funded."[52]

Despite, or perhaps because of these technical issues, Qinetiq, the parent company of Foster-Miller, subsequently developed an upgraded version of the SWORDS named MAARS. MAARS, for Modular Advanced Armed Robotic System, are marketed as systems that provide options for the escalation of force including non-lethal, less-lethal, and lethal options. Regardless of the improvements, the future of weaponized UGVs seems in peril. Not because of the technology involved but rather because of ethical concerns, cultural biases and the resulting lack of a clear acquisition strategy. The DOD 2009 Unmanned Systems Integrated Roadmap limits future development of UGVs to the following prioritized capability needs: Reconnaissance and Surveillance; Target Identification and Designation; Counter-Mine and Explosive Ordnance Disposal; and Chemical, Biological, Radiological, Nuclear (CBRN) Reconnaissance. While, the Roadmap does include the Armed Robotic Vehicle (ARV) capable of carrying a suite of weapons including small arms, it has been deferred by the Army due to budget constraints.

Critics of weaponized robots typically focus on the autonomous nature of some robots. Still others, like Professor Noel Sharkey from the University of Sheffield, England, debate the applicability of armed robots in light of the laws of armed conflict. In his article titled, "Grounds for Discrimination: Autonomous Robot Weapons", Professor Sharkey notes that "[o]ne of the cornerstones of humanitarian law – the laws of armed conflict and the law of war, as established in the Geneva and Hague conventions and the various treaties and protocols – is the protection of innocents."[53] He goes on to suggest that robots are incapable of making this distinction and raises concerns regarding efforts to arm unmanned systems.

Regardless of the approach, critics of armed robots fail by mistakenly presuming that armed UGVs would be fully autonomous. As noted early, while there is effort being made toward increasing the autonomy of our unmanned systems, currently most systems are tele-operated. Even Professor Starkey's LOAC argument falls into the trap of the fully autonomous false premise.

UASs have been used for the last several years to identify, track, and engage enemy combatants with a high degree of success and no risk to the operators who control them. To be fair, there have been a few cases of mistaken identity and some civilian casualties. However, the nature of war is not perfect and similar mistakes could have been made by manned aircraft performing the same mission. Even P.W. Singer, author of the book *Wired for War*, suggests

some limited utility for armed UGVs. After recounting a scenario where a robot delivers non-lethal substance to solve a hostage situation, Singer notes that "[t]he obvious problem is that what is "unusual" wears off and such tricks only work so many times."[54]

Conclusion/Recommendations

Given the lack of readily available policy, This study offers the following recommendations. First, restrict the degree of autonomy for UGVs armed with lethal weapons. This consideration is aimed at addressing ethical concerns without completely eliminating the development of weaponized UGVs. Additionally, less than fully autonomous systems enhance the likelihood achievable technologies will be able to withstand political sensitivities and be employed in the operational environment.

A second recommendation is to expand UGV research to include non-lethal and less-lethal applications. These emerging technologies may mitigate ethical concerns and allow/encourage greater degrees of autonomy.

Finally, the services must coordinate their development efforts and doctrine with respect to weaponized unmanned systems. The lack of development evident in UGVs may largely be attributed to a cultural resistance within the land components of the Defense Department. The Air Force experienced similar resistance during initial development and deployment of UASs. DOD and the leaders of the Army and Marine Corps in particular must pay special attention to cultural resistance. In the end, leaders should continue to develop systems aimed at "dull, dirty, or dangerous" tasks.[55]

Military robots are here to stay. The past twenty years have seen unmanned systems evolve in both quantity and quality. UGVs have been heavily involved in current operations in Afghanistan and Iraq and ultimately led to weaponized variants of popular systems. However, ethical concerns and cultural resistance have limited continued development and employment of weaponized UGVs. Service leaders should consider appropriate degrees of autonomy in development of weaponized UGVs and coordinate development and doctrine so that unmanned systems can reach their full potential to support the fielded forces.

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