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Maj Charles D. Nicol Jr., USMC
Maj Jason R. Burgan, USMC

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14. ABSTRACT

Over the past 20 years, the US Marine Corps has become stagnant in its approach to tactical and operational maneuver. While near-peer competitors have made significant advancements in their armor platforms and anti-tank weapons, the Marine Corps remains 15 years behind many of its peer competitors in the development of active protection systems (APS). These Commercial-Off-The-Shelf APS systems are designed to protect the vehicle in which it is installed, defeating rocket propelled grenades, anti-tank rounds, anti-tank guided missiles, and creating greater situational awareness for individual vehicles and units. An adversary, whether near-peer or hybrid, has the potential to quickly overcome the capabilities of this technology. This paper will review how single-platform APS can be built upon to create a cooperative engagement system (CES) over a fleet of ground vehicles. By employing CES, the Marine Corps can create an asymmetry and exploit tactical and operational maneuver.

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United States Marine Corps
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3070 Moreell Avenue
Marine Corps Combat Development Command
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FUTURE WAR PAPER

Active Protection through Cooperative Engagement: The Rebirth of Tactical and Operational Maneuver

**SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF OPERATIONAL STUDIES**

Major Charles D. Nicol Jr.
and
Major Jason R. Burgan

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Mentor: Dr. Brad Meyer

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Introduction

While the Marine Corps has been focused on counterinsurgency operations for the past fifteen years, peer and near-peer competitors around the world have feverishly pursued military technologies to enable their conventional forces to compete with American military might. Two major advancements are enhanced munitions and Active Protection Systems (APS). "APS are defensive systems designed to protect armored vehicles. The goal of an APS is to detect, intercept, destroy or confuse attacking enemy munitions."[1] In the early 1980s, both the Soviet Union and the US Army began basic analysis of APS. After minimal success in initial research and development, the US Army subsequently decided against pursuing this technology. Meanwhile, the Soviets continued in their development and fielding.[2] Over the past thirty years APS has taken on a variety of forms, ranging from hard to soft-kill capabilities. Commercial-Off-The-Shelf (COTS) single-platform APS is a stand-alone system that can detect, intercept and defeat attacking enemy munitions that are perceived as a threat to the protected vehicle. However, this system only protects a single vehicle and does not provide an external link to a greater network. During the past 10 years, APS has become increasingly reliable, accruing a combat-proven record during Israel's 2014 Operation PROTECTIVE EDGE.[3] In this operation, Israel employed an integrated APS which retained the single-platform system's sensing and countermeasure capability, but also shared real-time information across multiple vehicles through the Israeli Defense Force's (IDF) command and control architecture. Due to the increased lethality of munitions and the absence of APS for US forces, Marine Corps armored forces no longer maintain a tactical advantage of survivability and lethality.

Peer, near-peer, and hybrid adversaries can employ advanced munitions and APS on Main Battle Tanks (MBT), Infantry Fighting Vehicles (IFV), and Armored Personnel Carriers. Employed in conjunction with APS, threat systems such as Anti-Tank Guided Missiles (ATGM), enhanced Rocket-Propelled Grenades (RPG), and Improvised Explosives are considerable threats to US forces. In addition, potential adversary forces possess the capability to employ older RPGs and ATGMs through mass volley tactics on a single vehicle or formation. Therefore, adversary APS provides tactical formations a marked advantage in the employment of their own weapons system, increased survivability against ground and aviation-based fires, and enhanced maneuver capability. Overall, adversary APS bridges the gap between older and newer armored vehicles, allowing for effective employment against the Marine Corps.

Operating against the backdrop of this threat environment, coupled with aging US armor platforms, the Marine Corps' armor formations no longer create a tactical asymmetry on the battlefield. An emerging APS concept known as cooperative engagement can protect both an individual vehicle as well as other vehicles within the formation.[4] Cooperative engagement is defined as a sharing of sensor data and internal system-tasking for protection by defeating enemy munitions, and creating a 'bubble' of protection over the formation. With one APS in a formation providing sensory data for other vehicles, a more lethal kill chain can also be created. *Through use of an APS cooperative engagement system on armor vehicles, the Marine Corps can create an asymmetry on the battlefield by enhancing situational awareness of the combined arms team, increasing survivability and lethality, and exploiting tactical mobility.*

Threat Capabilities

Peer and near-peer forces have spent significant resources on updating and developing advanced armored vehicles. These vehicles incorporate APS, reactive armor, and enhanced metallurgy to improve overall survivability. Examples include the Russian Armata Combat Platforms with both a Third Generation MBT and IFV. The T-14 Armata MBT and the T-15 Armata IFV were developed and fielded with an "extensive array of different APSs that go far beyond anything seen fielded by Russia before."[5] The combination of hard and soft kill APSs is Russia's attempt to mitigate the increasing lethality of modern warheads.

In addition to advancements in survivability, peer and near-peer competitors have made significant advancements in munitions lethality and precision. A significant technological innovation is the long-range ATGM Spike Non-Line of Sight Missile, with a range of 25 kilometers.[6] Although this is a Raytheon-produced missile, it is conceivable that, within fifteen years, adversaries will employ a comparable capability. In 2008, the Russian defense industry unveiled the RPG-30, a counter-APS munition. Referenced in Jane's Defence, munitions like the RPG-30 are designed specifically to defeat individual platform APS.[7] Additionally, significant sensing capabilities have been developed, allowing for the precision targeting of armor platforms. This capability, coupled with APS and increased lethality munitions, continues to negate Marine Corps tactical armor survivability and lethality.

Adversary forces have shown flexibility and ingenuity in developing tactics that pit the strength of the weapon against a known weakness. This was exemplified during the 2006 Hezbollah-Israeli War in which 11 Merkava-4 MBTs were destroyed or damaged in the Wadi Saluki Battle by Hezbollah fighters. Throughout the whole 2006 war, 50 Merkavas were hit by ATGMs, with 20 of them being penetrated.[8] The Hezbollah fighters used swarming tactics

involving volley fire of antiquated RPGs and modern ATGMs to combat the survivability and lethality strengths of the Israeli tank.[9]

A more recent example of a conventional threat was seen during the Russo-Ukrainian War of 2014. During this war, the Ukrainians determined "the greatest advantage of using an ATGM was its ability to engage tanks at extended ranges, allowing the defender to use mobility to repeat the engagement process in a series of fallbacks and ambushes as part of an active defense."[10] In September 2014, the Russians introduced the T-90 with the Arena countermeasures system APS.[11] The T-90's APS created a tactical asymmetry by negating the Ukrainian ATGM advantage. This resulted in several Ukrainian AT gunners claiming the Russians had a "magical shield" over their MBTs.[12]

Overall, peer and near-peer adversaries have successfully incorporated modern technology into a cohesive and successful tactical doctrine. Their ability to sense, target, engage, maneuver, and exploit creates a marked advantage on a battlefield. The next logical step will be an umbrella of aviation and APS over their maneuver forces to exploit opportunities.

Friendly Capabilities

The Marine Corps operates as a combined arms team with a mix of armor vehicles on the battlefield at any given time. These platforms are required to operate across the Range of Military Operations (ROMO) and in all environments. Current Marine Corps armor vehicles, including the M1A1, AAV, and LAV-25, are aging platforms, having been fielded and operated for well over 30 years. Since the fielding of these platforms, updates have focused on improving the fire control systems, general power pack updates, mobility, and survivability against Improvised Explosive Devices. Based on known major Marine Corps ground acquisition

programs, by 2025, the only new ground armor vehicle will be the Amphibious Combat Vehicle (ACV). Due to the current long war on terrorism, there have been no stated requirements for an increase in survivability from the threat of modern "large-caliber tandem shaped-charge warheads."[13] In April 2016, during a Senate Armed Service Committee hearing on US Army Posture, Senator John McCain stated, the US Army is "outranged and outgunned by many potential adversaries."[14] This statement, accompanied by additional congressional oversight, has prompted the Marine Corps to accelerate its analysis and research into the feasibility of the incorporation of APS on armor platforms.

Single-platform APS increases the survivability of an armor vehicle. The system employs radar to track incoming threats and then deploys countermeasures to defeat the threat prior to impact with the vehicle. Currently, there are several COTS variants of APS, with all systems optimized to defeat RPG and ATGM threats and provide point of origin (POO). With POO data, an individual vehicle's situational awareness is measurably increased. Additionally, there are COTS APSs that have been advertised as being able to defeat High Explosive Anti-Tank (HEAT) rounds and kinetic energy penetrators. All systems attempt to minimize collateral damage to surrounding friendly troops and vehicles.[15]

The main COTS systems include:

1. Quick Kill by USA-Raytheon detects incoming RPGs and ATGMs with "an active electronically scanned array radar." This system has "the ability to engage threats fired from any angle or elevation, providing all weather, full 360-degree hemispherical vehicle and crew protection." It also has "the ability to defeat multiple, simultaneous threats."[16]

2. Active Defence System (ADS) by Germany-Rheinmetall provides "hemispheric protection through a sensor-countermeasure module" that determines the type and trajectory of

the approaching target. A "directed-energy countermeasure is ejected, destroying or disrupting the approaching threat to keep it from penetrating the vehicle."[17]

3. Trophy by Rafael provides "360-degree protection and situational awareness by detecting all incoming threats and identifying their launch position." This system intercepts and destroys incoming missiles and rockets with a focused Explosively Formed Penetrator.[18]

4. Iron Fist Light by General Dynamics provides 360-degree coverage for close-range scenarios in all operating environments. The system's "hard-kill concept is based on intercepting the threat by launching a small warhead and initiating it at a safe distance from the protected platform and defeating or destroying the threat through a shock-wave effect."[19]

Though not inclusive, the preceding four systems are representative of current APS technology. Far from being stagnant, this technology continues to develop and improve. However, the only two battle-proven APSs are Russia's Arena system and Israel's Trophy system.

The subsequent fielding of single-platform APS on Marine armor will provide parity with adversary APS-equipped platforms and an advantage over adversaries without APS technology. Against an adversary with APS, the Marine Corps will see diminished munitions effects, placing greater reliance on the full integration of all aspects of the combined arms team. Against an adversary without APS, single-platform APS on Marine armor increases survivability, thus allowing for greater effectiveness of the infantry-armor team, but is susceptible to being overwhelmed by swarming, mass-volley tactics.

Emergent Concept: Cooperative Engagement

The IDF are employing the most sophisticated COTS APS, Rafael's Trophy system. They have integrated their single-platform APS, allowing for shared situational awareness and increased targeting effectiveness. Israel's

> APS is integrated into the Merkava-4 MBT and is built into the armor on their factory line. They operate an integrated Battle Management System (BMS) in conjunction with their Trophy APS. These systems are networked and operate in real time. When a single MBT is attacked, it is auto-populated on friendly unit's BMS. This information is shared across the IDF formation or to a firing agency. This integration represents a significant leap in situational awareness and lethality for the Israelis, allowing crews and commanders to know where they are being attacked from, with their slew-to-threat capability, and decrease engagement times drastically.[20]

Israel's integrated APS is a technological step forward toward cooperative engagement.

As previously noted, an emergent concept is an APS cooperative engagement system (CES). Cooperative engagement is more than an integrated APS's sharing of real-time sensor data. It would create a 'bubble' of protection over a formation through internal system-tasking. The technological leap above other APS concepts would be CES's ability to task specific APSs within a formation to counter sensed threats to all vehicles. This is a significant advancement from current COTS APS. Building upon integrated APS, CES would use shared sensor data to facilitate greater formation survivability and a more effective kill chain.

A CES would be formed with a combination of COTS APS and a universal control system. This protection system would possess a suite of modular countermeasures options, scalable to anticipated threat models or environments, and ranging from high-intensity to low-intensity mission-sets. CES would be optimized to defeat ATGMs, RPGs (to include the RPG-30 or a long-range Non-Line-of-Sight missile), HEAT rounds, and medium recoilless rifles. Furthermore, the protection system would sense tactical Unmanned Aircraft Systems (UAS) and

small arms fire to develop an increased awareness of an adversary. Although industry has claimed the ability to defeat kinetic energy penetrators and large caliber AT munitions, the CES is not intended to replace current base armor requirements or defeat every munition a potential adversary may employ.

The universal control system would be an enhanced version of Network-On-The-Move (NOTM),[21] providing for the cooperation and integration of a formation's APSs and its command and control suite. This control system will automatically prioritize threats and task internal APSs to defeat them. In addition, it will provide POO and the type of munition fired. The sensor data attained through the CES not only aids in defeating a single threat, but it also builds a commander's situational awareness of the adversary disposition.

Currently, COTS APSs possess the ability to defeat two simultaneous threats.[22] With the implementation of CES, the ability to defeat multiple threats will be expanded, allowing for the potential defeat of swarming, mass-volley tactics. There is no expectation that CES will have a one hundred percent success rate; instead, through the defeat of most incoming threats, a tactical formation will be able to execute its mission and counter the adversary through combined arms.

One major concern for the CES will be its potentially large electronic signature. To mitigate this, CES must possess the ability to regulate its radar signature while continuing to meet the requirements of different threat environments. This mitigation could be accomplished through two major advancements over current APS or the IDF integrated APS. First, CES requires the ability to expand or limit the detection range of each system's radar. Next, the protective bubble provided by the universal control system negates the need to have all APSs actively sensing at all times. These advancements would actively minimize the electronic

signature without increasing risk to force or mission. This would be another significant advancement from current single-platform APSs and the IDF integrated APS.

CES employed on Marine armor platforms creates a tactical advantage and asymmetry that does not currently exist. The marked advantage of CES goes across ROMO to peer, near-peer, and hybrid threats. In addition, CES becomes the bridge from the Marine Corps' current armor platforms to a future armor ground vehicle platform. The CES will not provide a 'force-field,' but in conjunction with a platform's base armor, it provides unprecedented advantage over current adversary threat munitions.

Battlefield Asymmetry

Since Operation DESERT STORM, the Marine Corps has maintained a tactical advantage over its peer and near-peer adversaries. This advantage has been due to the holistic employment of the MAGTF and was exhibited during Operation IRAQI FREEDOM I. Since 2003, this advantage has significantly diminished for a variety of reasons. One way to assist in regaining this advantage is the development and employment of CES. Ultimately, CES creates a battlefield asymmetry through enhancing the situational awareness of the combined arms team, increasing survivability and lethality for Marine armor platforms, and allowing for exploitation of tactical mobility across the ground combat element (GCE).

The first significant contribution to achieve asymmetry is enhanced situational awareness. CESs are not solely focused on survivability of individual vehicles; instead, this concept allows for improved unit-level and MAGTF command and control. This coupling of improved survivability and command and control creates a distinct advantage over an adversary.

A real-time common operating picture will be instantaneously available across all echelons of a ground unit. This system enables an individual platform, a company command post, and a battalion operations center to all have the same awareness of identified enemy threats. The information collected through CES will be decisive, increasing a unit's tempo and a leader's decision-making cycle. The CES increases the effectiveness of the ground unit in all environments and across the offense-defense-stability continuum.

This same common operating picture enables the larger command and control architecture of the MAGTF to have instantaneous information on the enemy and subordinate units. Employing the single battle concept, subordinate units throughout the area of operations can have a greater understanding of the operation as it unfolds. This allows for harmonization of all elements of the MAGTF. Logistic and aviation units become more responsive to the needs to a ground force commander through real-time understanding of the battle being supported. All commanders are better able to manage resources, allowing for concentration at a decisive point.

A major capability of a single-platform APS is its ability to provide accurate POO and the type of munition fired. This is taken a step further with CES by assimilating individual platform APS data into the common operating picture. This enables a greater understanding of an adversary's system at the tactical level, allowing a commander to concentrate required resources to attain success.

Another key aspect of CES is increased effectiveness and efficiency of a kill chain. The accurate POO provides the commander the information for proper weapon employment to reduce over penetration and over kill. Ultimately, a commander can effectively employ direct, indirect, and/or aviation-based fires to defeat the individual threat or adversary system.

The second significant contribution to achieve asymmetry is increased survivability and lethality of Marine armor platforms, specifically the M1A1, AAV/ACV and the LAV-25. Survivability is a combination of the platform's base armor, coupled with the effectiveness of a COTS APS. This required increase in survivability by COTS APS is in direct response to the lethality of adversary advanced munitions like the RPG-30, ATGMs, and advanced chemical or kinetic energy penetrators. While a single-platform APS is focused solely on individual vehicle protection, it is a key element of the CES. Taken to the next logical level, it will provide protection of the tactical formation as a whole. The increased survivability through CES allows for unmatched flexibility through task organization of armor vehicles, preventing the need to match like vehicles into sections. The veil of protection provided by CES enables greater survivability in all threat environments, off-setting the limitations of one armor platform with the strengths of another without increasing the risk to force or mission. An example would be a mixed section of tanks and AAVs/ACVs employing CES in support of an infantry formation in an ATGM-saturated urban environment. This mixed armor section decreases the overall risk to force through the protection provided by CES. Risk to mission is also decreased through enhanced survivability, increased situational awareness, and improved targeting of detected enemy positions.

The survivability provided by CES creates increased lethality through the platform's survivability, thus potentially blurring the traditional roles and missions of specific Marine armor units. An M1A1 section could potentially operate in an urban environment with an ATGM threat with limited dismounted security. This is possible due to the veil of protection enabled by the CES, allowing the MBT to provide direct fire support without incurring undue risk to itself or its supported unit. Another example would involve an AAV/ACV providing more flexibility in

dismount points for embarked infantry, increasing the infantry's tempo and ability to gain direct-fire dominance over the adversary. A final example of this improvement would be the ability for the LAV-25 to operate outside of its normal reconnaissance role, instead operating in a semi-IFV role, providing direct fire support to dismounted infantry.

This combination of increased survivability and lethality directly contributes towards achieving a position of advantage. The inherent weaknesses of Marine armor platforms are partially mitigated by the CES, allowing Marine mechanized formations to fully operate in concert with one another. This closes the gap between specific armor platform survivability and ultimately increases the effectiveness of the GCE and MAGTF as a whole.

The third significant contribution to achieve asymmetry is CES's ability to enhance tactical mobility. As CES expands its sensor envelope, maneuverability is also improved through increased survivability and understanding of the enemy system. In a littoral environment CES has the potential to incorporate information from outside sources,[23] creating an expanded sensor envelope to aid in a successful littoral penetration. This same concept can be applied in restricted or unrestricted environments, facilitating the identification and subsequent exploitation of adversary gaps. The common operating picture heightened by CES permits the tactical commander to have a better understanding of the threat environment and potential decisive points. Tactical mobility is significantly enhanced due to the inherent increase in platform and unit survivability and lethality.

This enhanced tactical mobility extends to protection of supporting platforms under the umbrella of CES formations. In the littorals, naval connectors carrying Marine M1A1s and LAV-25s are protected by CES, permitting a quicker build-up of armor combat power in a contested environment. This is decisive in that it allows the MAGTF combat power to repel

adversary counterattacks earlier and breakout from initial lodgments. In restricted and unrestricted environments ashore, tactical convoys, to include logistics and motorized infantry, can be protected under the umbrella of CES. The impact is that platforms normally susceptible to AT fire are now free to maneuver with armor formations in a high-threat AT environment.

The amalgamation of an extended sensor envelope and the protection of support assets increases a unit's operational reach. The CES is a game-changer, providing the ability for all Marine armor platforms and units to consistently operate in a modern high-threat environment. This will prove to be a decisive capability in tomorrow's MAGTF fight. Tomorrow's battlefield will likely be saturated with guided and unguided munitions because of today's proliferation of MBTs, RPGs, and ATGMs. Since the early 1990s, Marine armor has experienced a tactical advantage over ground adversary formations. The CES sustains this tactical advantage and facilitates an asymmetry of Marine forces over all adversaries. This is accomplished through the enhancement of the MAGTF's situational awareness and ability to shoot, move, and communicate.

Conclusion

Although the US' next major adversary is unknown, there is a global proliferation of RPGs, ATGMs, and MBTs. Since 2001, the Marine Corps has operated in a counterinsurgency paradigm. In recent years, there has been a paradigm shift to Phase 0 operations with Special Purpose - Marine Air Ground Task Force (MAGTF) employment and a focus on the Pacific. This new paradigm continues to neglect emerging peer, near-peer, or hybrid threats. The Marine Corps' armor force no longer maintains dominance over its adversary's armor force. Using an APS CES on armor vehicles, the Marine Corps can create an asymmetry on the battlefield by

enhancing situational awareness of the combined arms team, increasing survivability and lethality, and exploiting tactical mobility. This can lead to a shift in our current paradigm for employment of GCE assets.

The current Marine Corps armor-infantry paradigm is conceived around the concept of armor vehicles operating in a direct support role of dismounted infantry. Historically, this tactical employment of armor has proved decisive. The resulting capabilities offered through CES have the potential to shift this paradigm and aid in the reemergence of armor in both an infantry direct support role and as an independent maneuver element. The M1A1 and LAV-25, fielded with CES, will have a marked advantage over every other maneuver element in the MAGTF due to increased situational awareness, survivability, lethality, and mobility. This shift in paradigm is additive to the overall capabilities of the Marine infantry and allows it to better support the Division and ultimately the MAGTF.

The major take-away from this paper is the need for the Marine Corps to continue to invest in technology focused on augmenting its armor platforms as an interim to replacement. The lethality of modern munitions continues to develop at an exponential rate. Therefore, for the Marine Corps to win tomorrow's battles, it must gain an asymmetry on the battlefield through combined arms and the single battle concept of the MAGTF. In the future, as conventional munitions and counter-APS munitions continue to gain increased lethality and proliferation, current APS technology cannot off-set adversary capabilities. At the present time, an APS CES does not exist. This is an emergent technology that, with current industry development trends, has the potential to be fielded within the next fifteen years.

The introduction of battle-proven, single-platform APSs, the IDF's integrated APS, or the emerging concept of CES requires a review of Marine Corps current tactical doctrine and

training. Peer and near-peer adversaries have operated under the umbrella of APS and advanced threat munitions using a cohesive doctrine that the Marine Corps does not presently train against. For the Marine Corps to retain its relevance across ROMO, all environments, and all domains, it must understand and be able to combat current and future emerging concepts and technologies. Today's suite of ground armor platforms, without the introduction of an APS, does not have parity with adversary capabilities. Dominance is not possible without the development and fielding of a CES-like system.

Endnotes

[1] P. Wey, et al., "Analysis of Active Protection Systems: When Athena Meets Arena," *19th International Symposium of Ballistics* (May 7-11, 2001).

[2] R. M. Ogorkiewicz, "Detection and Obscuration Counter Anti-Armor Weapons," *International Defense Review*, December 12, 2002, https://janes-ihs-com.lomc.idm.oclc.org/Janes/Display/1101541.

[3] Elad Popovich, "A Classical Analysis of the 2014 Israeli-Hamas Conflict," *Combating Terrorism Center Sentinel* 7 (No. 11), December 2014; and Michael B. Kim, "The Uncertain Role of the Tank in Modern War: Lessons from the Israeli Experience in Hybrid Warfare," *Land Warfare Paper* (No. 109), June 2016.

[4] Neither APS nor the concept of CES will provide one hundred percent protection from enemy munitions. It will increase overall survivability and enhance a formation's ability to accomplish their mission.

[5] Nicholas de Larrinaga, "Return of the Bear: Russian Ground Forces Modernisation," *Jane's Defence Weekly* (March 8, 2016), 10.

[6] "Spike Series Missiles (Spike-LR/ER/NLOS)," *Jane's Air-Launched Weapons*, October 13, 2016, https://janes-ihs-com.lomc.idm.ocloc.org/Janes/Display/1307316.

[7] Nikolai Novichkov, "Russia Develops RPG-30 To Counter APS-Equipped Vehicles." *Jane's Defence Weekly*, November 20, 2008, https://janes-ihs-com.lomc.idm.oclc.org.

[8] Andrew Feickert, *Army and Marine Corps Active Protection System (APS) Efforts* [CRS Report No. R44598] (Washington, DC: Congressional Research Service, 2016), 4.

[9] Amos Harel and Issacharoff, Avi. *34 Days Israel, Hezbollah, and the War in Lebanon* (New York: Palgrave Macmillan, 2008) and Matt M. Matthews, *We Were Caught Unprepared: The 2006 Hezbollah-Israeli War* (Fort Leavenworth: CSI Press International), 54-55.

[10] Phillip A. Karber, "Lessons Learned from the Russo-Ukrainian War," *Historical Lessons Learned Workshop* (July 8, 2015), 23.

[11] de Larrinaga, "Return of the Bear: Russian Ground Forces Modernisation," 10.

[12] Karber, "Lessons Learned from the Russo-Ukrainian War," 25.

[13] de Larrinaga, "Return of the Bear: Russian Ground Forces Modernisation," 10.

[14] Feickert, *Army and Marine Corps Active Protection System (APS) Efforts*, 4-5.

[15] Interviews from the following: Matthew Diehl (General Dynamics representative), interviewed by Maj Jason Burgan and Charles Nicol, November 3, 2016; Roy McCallum (American Rheinmetall Munitions, Inc., representative), interviewed by Maj Jason Burgan and Charles Nicol, November 4, 2016; Michael O'Leary (DRS Sustainment Systems Inc. representative), interviewed by Maj Charles Nicol, November 4, 2016; Paul Kozick, personal email to Maj Charles Nicol, November 24, 2016.

[16] Paul Kozick, personal email to Maj Charles Nicol, November 24, 2016.

[17] *Ibid.*

[18] *Ibid.*

[19] *Ibid.*

[20] *Ibid.*

[21] "NOTM is a mobile and modular C2 system providing situational awareness and combat operations capability while on the move. The communications system utilizes secure networks, multiple radio suites, and tactical software applications that enable it to provide reliable over-the-horizon, on-the-move data to warfighters in the field." http://www.pelatron.com

[22] Michael O'Leary (DRS Sustainment Systems Inc. representative), interviewed by Maj Charles Nicol, November 4, 2016

[23] Examples of outside sources include information gained from tactical UAS, joint intelligence enablers, special operations forces, and signals intelligence.

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