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AUTONOMOUS SYSTEMS IN AFV DESIGN: “ROBOTS IN DISGUISE”

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Major Alex Nitu

Unmanned military vehicles have dominated military thinking in the 21st century. With the modern advances in computation, communication, sensors and endurance, remotely operated vehicles have established themselves as indispensable tools for military employment. Thus far, their dominance has been limited to the aeronautical domain, which is understandable given that it was the Air Forces of the world that gave the first credence to unmanned (air) vehicles some 50 years ago. Aircraft designed and operated in the 1960s such as the Soviet Union's Tupolev Tu-123 and the U.S. Air Force's Lockheed D-21 took on the role of high-altitude strategic reconnaissance platform without the need for a crew, thus eliminating risk to humans.[1] The air domain made the most sense for unmanned vehicles to begin their maturation as a military tool, as the air domain's natural characteristics mimic a straight-forward system itself. An air mission has a known start and end point, the transit medium is unchanging (or at the very least can be selected to have unchanging attributes), and the domain can seamlessly cover the other domains – sea and land – no matter what the latter two's condition.

Why then has there been a much slower development for ground-based unmanned (or autonomous) military vehicles? As alluded to above, the very characteristics of the land domain prohibited the easy development of unmanned vehicles for the land domain. Land based operations don't begin or end at known points as the enemy has a vote in the outcome of friendly operations. The composition of the land domain can differ widely, from sandy dunes to jagged mountains to pastoral plains. Further, land forces must be able to endure and operate in nearly any mode of weather. And finally, land based vehicles need their crews to attend to its repair, replenishments, and in many cases recovery. For air-domain unmanned vehicles, these functions

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[1] David Donald, *Lockheed's Blackbirds: A-12, YF-12 and SR-71*. (Norwalk: AIRtime Publishing, 2003,) 154.

are provided by home-based crew-members, however such an arrangement would be impossible for land-based vehicles.

This paper will examine the form and function of automation in Armour Fighting Vehicles (*AFVs*) may take in the next 20 years.[2] Through an examination of historical and hypothetical examples of automation and autonomous systems in AFVs, we will see how future designs will likely result in optionally-manned near-autonomous AFVs remotely commanded by a nearby crew.

The earliest examples of automation in AFVs occurred within the realms of reactive armour and turret stabilization. Reactive armour is applied to the external surface of existing hull and turret armour, and is generally composed of metal plates with explosives between them. There is a monitoring and triggering system that allows the system to function autonomously once activated. Once a segment of the armour detects an incoming projectile has begun to penetrate its outer strata, it detonates that segment.[3] Then simple physics and high explosives take over, and disrupt the flow of energy from the incoming enemy projectile to the point where it cannot threaten the base armour beneath it. All of this happens within a split second, far too fast for a human's reaction. This is an excellent example of the successful application of automation in AFVs; filling a capability void that is beyond human capacity for the purpose of increased survivability.

Contemporary autonomous defense systems have benefited greatly from the advances in computation and sensors of the past 20 years. This has allowed AFV defensive systems to take

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[2] This paper will examine AFVs in the general sense, as the doctrinal terms of Main Battle Tanks (MBTs) and Infantry Fighting Vehicles (IFVs) can be dogmatic with regards to design and employment. The definition of an AFV is: an armed combat vehicle protected by armour, generally combining tactical mobility with offensive and defensive capabilities. This term (AFV) provides a more neutral framework when considering future concepts.

[3] Tom Clancy, *Armor Cav*. (New York: Berkley, 1994,) 8.

the same tools and concepts of reactive armour and turn them into Active Protection Systems (*APS*). Instead of waiting for an enemy projectile's terminal ballistics phase to activate a defence, active defence systems have the ability to identify, discriminate and counter threats before they make contact with the target vehicle. Examples of contemporary APS are the Israeli TROPHY systems and the Russian ARENA system. Each of these systems employs a robust sensor suite, including modern radar systems normally found on fighter aircraft, to trigger a *hardkill* weapon to intercept enemy warheads traveling at 100s of meters per second.[4]

Autonomous systems in AFVs in the near future will begin *burden sharing* workloads with the crew. Through a fusion of diverse fields of technology, tasks that were once the sole forte of the human will soon become enhanced via automation and specific artificial intelligence. A contemporary example of this trend is the French Leclerc tank, which can drive itself along waypoints, and has a simplified driving mode that can be selected for inexperienced or under qualified drivers.[5] However, the upcoming developments under the U.S. Army *ATLAS* program will see a fulsome maturation of autonomous burden-sharing in AFVs.

The *ATLAS* program (or *Advanced Targeting and Lethality Automated Systems*) is currently a test-bed for trials and fielding of autonomous systems in legacy (i.e. current) AFV designs. It seeks to ease crew burden and tasks across a spectrum of efforts, to include: image processing and tracking, data collection, fire control, and sensors fusion.[6] A clear example how this can happen is the effort involved to locate and identify targets by AFV Gunners. The soldier at the gunner's station must continuously scan the outside environment through the AFV

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[4] Nicholas de Larrinaga, and Nikolai Novichkov, "Analysis: Russia's armour revolution." Jane's Defence Weekly (15 05 2015,) 4.
[5] Christopher F. Foss, Jane's Land Warfare Platforms. (London: Jane's IHS, 2018,) 32.
[6] U.S. Army. Industry Day for the Advanced Targeting and Lethality Automated System (ATLAS) Program. 11 02 2019. 03 05 2019

weapons optics (colloquially called "sights") to detect, discriminate, and identify potential targets for engagement. This targeting process is only effective as the human gunner, who can have varying levels or skill and alertness.

An ATLAS-equipped AFV would be able to perform the same task using machine-learning and artificial intelligence at a much faster rate. Using augmented reality, blended false spectrum visualization, edge detection and tracking, and pattern recognition, the system would then be able to report findings to the human gunner for the ethical decision of whether or not to fire. Current projections indicate that ATLAS will be able to "acquire, identify, and engage targets at least three times faster than the current manual process."[7] An autonomous system can further assist by detecting threats that are difficult for humans to spot, such as targets that are camouflaged or spoofed. In these scenarios, the machine-learning algorithms within ALTAS can detect small and otherwise insignificant "tells" that the vast majority of human gunners would miss. For its advanced nature, ATLAS is not envisaged as a means of autonomous killing, but rather "as a second set of eyes that's just really fast… [like] an extra soldier in the tank."[8] The human is also the one who gives the order to fire, and the one who must live with the consequences. The ATLAS System is *open looped*, with the human informing the key output – application of lethal force.

The ethical considerations regarding fully-autonomous systems within AFV design and utilization should not be dismissed lightly. Fully-autonomous weapons systems are designed to function without human input, and therefore kill enemy humans independently in order to accomplish its mission parameters. There is already considerable debate surrounding the use and

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[7] Ibid.

[8] Sydney J. Freedberg Jr, ATLAS: Killer Robot? No. Virtual Crewman? Yes. (04 03 2019.) <https://breakingdefense.com/2019/03/atlas-killer-robot-no-virtual-crewman-yes/>.

legality of employing *Lethal Autonomous Weapons Systems* (LAWS).[9] Part of the issue is the ethical implications of using a *LAWS* to kill, when the computer system in question has no inherent ethics itself. The system cannot make a value call beyond its original programing. Thus, who will be responsible for the decisions that the LAWS take to end a human life? Proponents use the legal principle of *Qui Facit per Alium Facit per se,* which means "he who acts through another does the act himself."[10] Therefore the military commander that authorized the mission for the LAWS would be responsible. But the degree of abstraction between authorizing a mission and being responsible for deaths at the hands of a robot are unsettling to say the least. A robot, or LAWS, cannot be made to suffer – therefore cannot be punished for any crimes it commits.[11] For these complex philosophical and moral reasons, a fully-autonomous *LAWS*-type AFV will be difficult to rationalize to the public.

If a fully-autonomous system is ethical unviable, perhaps then autonomous systems can reduce work down to a handful or simple executive choices that the crew needs to make. Further, if work can be reduced to the essential decisions, does the crew need to be inside the AFV to make those choices? Already we have seen that some very recent design thinking regarding AFVs has done away with traditional crew layout within the vehicle. A crew gunner no-longer needs to be situated close to the armament and sighting systems, as the crew inputs and outputs for those devices can now be transmitted where needed. As a result, AFVs such as the Russian federation T-14 have placed all three crewmembers side-by-side in the Tank hull, leaving the turret fully-unmanned.[12]

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[9] Lin, Patrick, Keith Abney and George A Bekey. Robot Ethics. (Cambridge: The MIT Press, 2012,) 117.
[10] Ibid. 151.
[11] Ibid. 149.
[12] Nicholas de Larrinaga, and Nikolai Novichkov. 4.

While these practical systems make a logical case for future AFV design, we are still left with an essential question of "Do these technological developments increase combat efficacy?" There have been advanced AFV designs in the past that have proven either half-baked or too troublesome for the meager advantage they provided. The U.S. Army *M60A2* Main Battle Tank (MBT) is one such example. Armed with a 152mm multipurpose cannon that could fire either conventional canon projectiles or a purpose-built anti-tank guided missile called *Shillelagh* – the M60A2 should have been a game-changer for allied tank design.[13] However, the difficulties in harmonizing and integrating the targeting system for two different systems proved troublesome. The high-complexity of the turret system provided the crew and maintenance teams with numerous issues and finicky performance to have to deal with. The M60A2 lasted less than ten years in Army inventory, with the existing tank hulls being revamped into the much more conventional M60A3.

There are also examples of when the cost-benefit analysis simply does not merit a future-thinking design. The American-German joint venture to design a new Main Battle Tank – called the *MBT70*, provided that the technologies could be sufficiently matured to prove reliable, but not provide enough of a combat advantage to warrant the additional cost.

The MBT70 was a ground-up original design, where the M60A2 was an incremental design based on a legacy tank hull. The MBT70 boosted revolutionary technologies that had not been used in AFV design until that point. Hydrodynamic suspension that could adjust ride height and overall stance instantaneously, a driver mounted in a stabilized cupola in the turret for excellent situational awareness, a radically re-designed missile/cannon that corrected the issues

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[13] Duncan Crow, *Main Battle Tanks*. (New York: ARCO Publishing Co, 1978,) 38.

on the M60A2, and cutting-edge armour composition.[14] Although these features increased the vehicles combat efficacy and improved crew survivability, the prohibitive cost would have prevented fielding in adequate numbers for the Cold War era. The project was abandoned, and a much more conventionally designed XM-1 was commissioned in its place.[15]

In order to provide the merits of these technological advances in AFV design, the RAND Corporation conducted a series of computer-modeled simulations using the JANUS combat modeling program - which is widely-respected for in the defence community for its accuracy.[16] The RAND study sought to analysis the effects that these new AFV technologies would have when applied over to a "Baseline" Heavy Brigade Combat Team (HBCT). That "baseline" HBCT would be comprised of early 2000s variant U.S. AFVs, against a similar era Russian-equipped opposition in terrain favorable to the latter. The metric employed was the Loss-Exchange-Ratio (LER), which is expressed as a multiplier that indicates how many enemy vehicles would be destroyed in an engagement for every one friendly loss. For example, a LER of *2.0* would mean that for every one friendly tank destroyed, the enemy would lose two.

In the RAND exercise, the *baseline* HBCT had a LER of *1.25*. When the HBCT was equipped with an *APS*, the LER increased to *1.59*. With the addition of an *ATLAS*-like system (called *QUICKDRAW* during the study's era) the LER increase to *2.45*. Finally, with long range fires (artillery, etc..), as would normally be available to the allied force in conventional warfare, the LER topped out at *4.87*.[17] While this RAND study is a war-game simulation and not an

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[14] Ibid. 39.

[15] The XM-1 MBT would be fielded as the M1 Abrams Main Battle Tank in 1980. The current version of the MBT is the M1 A2 SEP V.3.

[16] John Matsumura, *Future Combat Systems*. (Santa Monica: RAND, 2002,) 33.

[17] Ibid. 41.

after-action field report, it does help to prove the necessity of such types of systems to increase AFV survivability.

Let us look at three theoretical examples that illustrate possible futures for autonomously-enabled AFVs. After an assessment of each options inherent strengths and weaknesses, a conclusion can be reached as to what form and function autonomous AFV systems will take in the future. All of these vignettes will use a fictional AFV that possess' the same core characteristics and capabilities; as it can be taken for granted that any future AFV design will require such abilities. These capabilities and characteristics include: weapons systems that can engage different types of enemy platforms (be it vehicular, aerial, or dismounted), some manner of active defence to counteract enemy weapons effects, a robust communications interlink system, and the vehicle itself is optimized for tactical mobility.

In the first example, the AFV most closely resembles a contemporary Main Battle Tank. It possesses a suite of autonomous capability that has reduced the workload within the vehicle considerably. The vehicle driver directs the vehicle with through *fly-by-wire* controls instead of manipulating steering yokes and pedals directly connected to automotive components; however those mechanical controls are still retained as a redundancy. The onboard computer displays the outside environment through a variety of different means and modes that are selectable and modifiable to the individual driver's preference. Through an array of redundant cameras arranges on the outside hull, the driver could view the outside world via large high-definition displays, or choose to don a visual headset and have an unencumbered 360 degree view of their surroundings with a turn of the head. The drivers system includes augmented reality that overlays map data and tactical orders iconography, while proving its own assessment of terrain to avoid and a path to proceed in accordance with mission parameters.

The turret crew has been reduced to two persons, closely resembling the gunner and commander positions of today. The legacy "loader" crewperson has been replaced by automation. The gunner's duties now consist mainly of supervising the acquisition and targeting system as it carries out its task. That gunnery system operates in the same manner discussed earlier in the essay; selecting targets or "objects of interest" for the discrimination of the human gunner. Redundant legacy controls are still available to the gunnery should the need arise, as is there an ability to load and operate the weapons manually (at a much slower rate of fire and lower accuracy). The commander of this AFV is primarily concerned with operating the C4ISR systems of the vehicle, and ensuring that timely and salient information is transmitted to the higher command echelon.[18] If this AFV's crew assumes a tactical command function (i.e. platoon or company command), then information and direction would be passed lower as well. As most of the raw data analytics is transmitted via C2 and positional software automatically, the human commander would mainly be providing context and assessments. The commander also has the duty and ability to monitor the other crew members, and even assume their duties from his/her station if needs be.

The advantage to this arrangement is that the crew stays with the AFV in order to physically interact with the vehicle, regardless of the mode of operation or adversity of conditions. Enemy electronic warfare (EW) efforts against this AFV would be largely moot, as there is no command link (as there would be with a remotely-operated system.) While enemy EW could jam data transmitting to/from this AFV, that would not preclude the human crew from making a value call and tactical decisions in the absence of communications higher or lower. AFV component malfunctions could be dealt with expeditiously, and redundant legacy systems

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[18] C4ISR = Command, Control, Communications, Computing, Intelligence, Surveillance and Reconnaissance systems.

could allow for degraded mode of operations while waiting to a more opportune time to effect repairs. Vehicle recovery from obstacles known and unknown would be possible via the crew's effort of self-extraction, or with the aid of another vehicle.

The use of autonomous systems in driving, gunning, and commanding has reduced crew fatigue and allowed the crew to make better and more informed decisions. However, this arrangement still puts the crew into harm's way in a very direct and prolonged manner. As AFVs remain a prime target of the battlefield of tomorrow, the presence of the crew within the vehicle places them at the same level of risk as armour crews throughout the 20th century.[19] Even with advances in armour and protection (especially via the autonomous systems described earlier), new anti-armour weapons will also innovate to seek an overmatch.

The next vignette will focus on a bespoke AFV whose autonomous systems integration allow it to be directed remotely, without any provision for a human crew to reside within it. Such an AFV could be smaller than a comparable human-crewed vehicle, as the internal space that would normally house the crew could be removed, reducing overall volume. The separate systems (driving, gunner, and command) would be interlinked and transmitted to a human crew disassociated from the AFV by distance. This distance could vary from the same joint operation area (JOA) as the conflict, or back in the home nation. This distance would be bridged via encrypted satellite communications. Whatever the location of the crew in this example it would be well beyond the reach of whatever munitions system would be possessed by the enemy, and thus they are incapable of being harmed.

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[19] V.K. Kapoor, *Armour in Future Conflicts*. SP's Land Forces (24 Feb 2012,) 3.

Wherever the crew finds itself, the work arrangement could be completely untraditional. The crew stations could be replicated using commercial laptops and user-interface devices connected to the military C4ISR system. The crew's immediate surroundings could be as banal as a secured office space. This manner of approachable work environment can allow for collaborative problem-solving of the tactical issues being faced on the battlefield. Should the AFV be facing a difficult or protracted problem, they can simply get up from their station to discuss the matter with their superior face-to-face. That superior command could even see the problem from the very workspace in question. Issues could be brainstormed as they would in a quick huddle. The AFV itself could be automated to the point where it only needs human direction or authorization in a handful of decision, namely whether or not to employ deadly force. That direction provided by humans could be reduced down to a few images and inputs provide from the AFV through the C4ISR network in the form of a dialogue box or info-graphic with refined analytics.

If this level of remotely commanded autonomous AFV were pursued, the standard calculus of an AFV requiring two to three-crew would be obsolete. The amount of crew made available to provide command direction could shrink or expand based on the tactical problem set. In a straightforward conventional advance across open terrain facing a known and discrete enemy, a team of three crewmembers may be able to command four separate AFVs simultaneously. In an asymmetric environment, conducted in complex terrain with an amorphous enemy, additional crew/experts could augment each AFV to provide greater rigor to its actions. In that case, five or more crewmembers per AFV may be needed. Whatever the crew composition, they could easily work in shifts and thus enable the AFV to conduct continuous operations without worry of crew rest.

As this type of AFV is nearly free of human factor limitations and liabilities, more roles could be placed upon a single vehicle than would have been traditionally prudent. For example, modern Tanks have been optimized for the complimentary anti-tank and anti-fortification role, while eschewing weapons and capability against air vehicles or horizontal obstacles to other platforms. One crew could not be reasonable be expected to be competent on such a wide-range of capabilities. Further, such a potent mixture would make this AFV even more or a high payoff target to the enemy. As the limitations of the crew have been removed, and the liabilities of human life within the AFV have been mooted, those capabilities could be invested in one AFV. This one vehicle could engage fortification with traditional tube-cannons, destroy enemy tanks with beyond visual range (BVR) missiles, use directed energy weapons against swarm UAVs, and use its bulldozer blade to defeat an enemy anti-tank ditch.[20] Working in a squadron network of a dozen vehicles, these types of vehicles would quickly re-enforce their own strengths and cover the weaknesses of the other elements within the combat team.

It is important to note that the future battlefield may not be devoid of human soldiers. If the infantry role is retained for humans, then consideration needs to be given to their protection as well. Many of the systems discussed could be adapted for whatever manner of vehicles carries them to the battlefield, however the natural solution is already provided by the type of AFV taking form in this example. Given the examples wide range of autonomous capabilities across the spectrum on land threats, the combined arms combat team's physical orientation could easily be arranged to place whatever infantry-bearing vehicles well within the defensive capabilities of these AFVs. These AFVs would become a type of "land dreadnaught" to harken back to the days of the First World War. As in the modern Navy, larger naval vessels (such as destroyers

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[20] V.K. Kapoor, *Armour in Future Conflicts*. SP's Land Forces (24 Feb 2012,) 4.

and cruiser) form the nucleus of a fleet, providing a defensive bubble around more vulnerable or less capable ships.[21] The enemy would place an inordinately higher effort to destroy these AFVs, turning them into what is colloquially called "bullet magnets". Given that there is not human toll to the damage or destruction of these AFVs, the impacts of their loss to enemy action is much more muted.

While this example seems to produce a huge force multiplier in terms of tactical effect and potency, there are several drawbacks. As mentioned earlier, the land domain is replete with terrain that can be difficult to cross under the best conditions. If the AFV in question becomes bogged down in mud, or damages itself traversing urban terrain, the crew is completely unable to extract or assist. Even routine tasks would become difficult, such as refueling or daily maintenance. Specialized autonomous vehicles could be developed for complete some of those functions near an active battlefield; however some manner of human intervention will be need for more complex problems. A human response team will need to be a part of this solution, perhaps located at a well-away from enemy direct fire systems, but close enough to respond in a matter of hours. It would shift the human risk off of the crewmembers and onto another set of soldiers, albeit at a much reduced ratio.

The next largest drawback is the dependency of the system on a command-link to the crewmembers via the electromagnetic (EM) spectrum. As with any EM signal, it can be interfered with naturally or intercepted by the enemy. The natural environment can hinder EM

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[21] Maj. Gen. Cedric T Wins, *RDECOM's road map to modernizing the Army: Next Generation Combat Vehicle*. 08 12 2018. 03 05 2019 <https://www.army.mil/article/214694/rdecoms_road_map_to_modernizing_the_army_next_generation_combat_vehicle>.

signal propagation, and in the rare eventually of a solar flare, block them entirely.[22] Satellite communications rely on lower amplitudes and wattages than terrestrial signals, thus making them more susceptible to interference. Not only can enemy seek to target the common-link between AFV and crew for disruption, but the future conflict space could see adversaries using command links to gain access and cause undesired actions. While no publically available example exists, the 2011 example of a Top Secret RQ-170 UAV being brought down almost totally intact within the Islamic Republic of Iran – to much fanfare and publicity, does give pause for concern that some manner of common-link interference almost certainly took place.[23] Total command-link interception and manipulation may not have even been required in this examine. Had Precise Navigations Systems (PNS – such as the U.S. Global Positioning System (GPS)) been "spoofed" (a termed used for the intentional altering of data for a desired outcome,) the RQ-170 could have been indirectly lead to land in an area favorable to capture.

Clearly EM signals based command-linkages between the AFV and crew in this instance provides a rather large vulnerability. In the worst case scenario, enemy electronic warfare targeting a remotely operated AFV could take control and cause them to fire on one another or move to another location for capture. Procedures and contingencies would need to be created for such scenarios. The inherent difficulty in having an autonomous system make a value call as to whether a common-link is genuine or not possess its own host of problems. Ultimately, the only true remedy would be allow the AFV to conduct fully autonomous operations and decision making in scenarios where it could not authenticate the veracity of the command-link, or where the command-link was completely absent. This of course brings back into consideration the

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[22] Christoph Steup, and Kim Hartmann. "The vulnerability of UAVs to cyber attacks - An approach to the risk assessment." *2013 5th International Conference on Cyber Conflict (CYCON 2013)*. (Tallinn: IEEE, 2013.)
[23] Ibid.

ethical dilemmas posed by such a mode of operation. The command-link forms the central weakness of this notional AFV, which the last hypothetically construct attempts to address.

As the first example of a future AFV used autonomous systems to augment the inhabited human crew's workload, and the second example used remotely commanded autonomous systems to remove human limitations and liabilities, the last example will select the strong points of each of these while mitigating the weaknesses. In this final construct, the AFV will be largely autonomous as the second example, but will retain the form and capability to house a human crew with it, similarity to the first example. The crew itself will need to be much closer to this AFV, within a few kilometers at most, instead of the several hundred kilometers as the second example. This configuration removes the crew from the AFV in nominal conditions, but places them at an "arms-length" distance so that they can intervene rapidly.

For this to occur, this crew would have to be transported within yet another armour vehicle. This "crew containing vehicle" need not be anywhere near as complex or robust as the AFV in question, it could be a simple as any contemporary APC in current service. This crew containing vehicle needs to have the same mobility properties and endurance as the AFV it complements, but does not need the same level of armament or sophistication. This vehicle would need a small human crew itself, which could be reduced down to one sole driver. The crew compartment of this APC, which was originally designed to carry dismountable soldiers, can be reworked to house the computer workstations and communication equipment necessary to remotely operate the AFV. How many sets of crews could be held by one APC would be limited by the internal geometry of the APC in question and the amount of risk willing to be entertained. For arguments sake let's assume that one APC can house two sets of AFV crew. Each one of those distinct crews could in turn two separate AFVs via the burden-sharing and optimization alluded to earlier. Therefore one APC, housing two sets of AFV crews, could remotely operate four AFVs simultaneously.

In this scenario, the APC would travel independently behind the frontage created by the AFV squadron at a variable distance largely decided upon by the range of enemy direct fire systems. The crew would direct the actions of the AFV, and should the AFV require human assistance due to malfunction, terrain difficulties, or maintenance, the APC could take the crew to the location of the stricken AFV within minutes. Should one of the AFVs become disconnected from its command-link due to natural causes or enemy EW, the crew could then inhabit the AFV and operate the vehicle directly. If the nature of the conflict is one where there is a known and persistent threat of enemy EW and Cyber capability, the crew to AFV ratio could be maintained at one-to-one vice one-to-two, therefore ensuring that maximum combat power can be maintained. This scalability and variability of crew options provides the greatest flexibility to fighting units.

This final example does not totally remove the risk to human life, as the crew could still be ambushed or destroyed by stand-off weapons. However, unless a serious effort is made to dehumanize the future battlefield of friendly force combatants entirely, there will always be a risk to life and limb in conflict. This example attempts to balance all the different pressures of conflict with the ever-refining field of computerization and automation. There may already be inferences that this concept of operations is desirable.

The previously mentioned T-14 belongs to a family of AFVs, which includes the T-15 Heavy IFV.[24] Given the design principles of the T-14, such as a fully automated turret and

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[24] Nicholas de Larrinaga, and Nikolai Novichkov. 5.

weapons system, along with an aggregated crew controlling the vehicle through a software interface, it is not a massive leap to surmise that the ARMATA fleet is threading toward the type of arrangement illustrated in the final example. While the T-15 is listed as a *Heavy Infantry Fighting Vehicle,* and may well carry out that role currently, it could be configured to act as a *crew carrying vehicle* for the T-14. Even the much simpler ARAMTA family Kuranets-25 APC could fulfill the crew carrying role.[25] This would allow the T-14 to function as outlined in the final example; acting as the land dreadnaught for the ARMATA family and thus providing both protection and firepower to the remainder of the combat team.

The advantages of an optionally-manned near-autonomous AFV remotely commanded by a nearby crew are clear. It optimizes the burden-sharing and task load to the human crew, while reducing the risk to soldiers. That crew is removed from the physical danger space of the vehicles itself, and relocated nearby where they can react if necessary. The dangers of enemy EW interference are mitigated, as are the ethical considerations for surrounding lethal autonomous weapons systems; as humans remain central to decision-making in this Open Loop autonomous design. Given the inherent difficulties of the land domain, such as terrain obstacles, weather, and ground type, a vehicle crew must be present with a AFVs to tend to it should it become immobilized or otherwise incapacitated. But conversely, since automation and artificial specific intelligence can reduce the required human inputs and output to a bare minimum, the crew need not be located within the vehicle to carry out their function. Autonomous systems will only quicken the pace of AFV development, and allied militaries need not be wed to design legacies of the past in order to envision the Armoured Fighting Vehicle of tomorrow.

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[25] Ibid. 9.

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