REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
05/01/2017	Research	07/01/2016 03/31/2017

4. TITLE AND SUBTITLE
Enhancing Future Military Capabilities with Autonomous Driving Vehicles

5a. CONTRACT NUMBER
N/A

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
Argese, Alessio,Lieutenant Colonel, Italian Army

5d. PROJECT NUMBER
N/A

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USMC School of Advanced Warfighting
Marine Corps University
2044 South Street
Quantico, VA 22134-5068

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSOR/MONITOR'S ACRONYM(S)
N/A

11. SPONSORING/MONITORING AGENCY REPORT NUMBER
N/A

12. DISTRIBUTION AVAILABILITY STATEMENT
Unlimited

13. SUPPLEMENTARY NOTES
N/A

14. ABSTRACT
An autonomous driving vehicle can do whatever a manned vehicle does. It can perform the same tasks that military drivers currently perform in a better and more efficient way. With a camera, an autonomous vehicle can easily perform reconnaissance tasks.The Autonomous Reconnaissance Vehicle (ARV) can search areas that neither aerial drones nor humans cannot, such as woods, pipes, caves, and tunnels. The autonomous driving vehicles can perform logistic tasks. Equipped with an assault rifle, an autonomous vehicle can perform limited combat tasks and it can engage and eliminate a target.Within 15 years, technology will allow defense industries to build autonomous driving vehicles. Autonomous driving vehicles will perform an array of tactical tasks releasing the ground forces from dull, dirty, and dangerous tasks. The degree of autonomy of such vehicles will be still limited and under control of human operators. Maybe, in the far future, autonomous systems will be able to make their own decisions without human interference. Yet, it is still a human choice whether to increase the level of independence of autonomous driving vehicles.

15. SUBJECT TERMS
Autonomous driving vehicles, autonomous reconnaissance vehicle, autonomous logistic vehicle, autonomous combat vehicle, artificial intelligence, UGV, UAV.

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU	18	Marine Corps University / School of Advanced Warfighting
Unclassified	Unclassified	Unclassified			19b. TELEPONE NUMBER *(Include area code)* (703) 432-5318 (Admin Office)

School of Advanced Warfighting

United States Marine Corps
School of Advanced Warfighting
Marine Corps University
3070 Moreell Avenue
Marine Corps Combat Development Command
Quantico VA 22134

FUTURE WAR PAPER

Enhancing Future Military Capabilities with Autonomous Driving Vehicles

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

LtCol Alessio Argese (Italian Army)

AY 2016-2017

Mentor: Bradley J. Meyer, PHD

Approved: Bradley J Meyer

Date: 30 May 2017

School of Advanced Warfighting

Disclaimer

DISCLAIMER

THE OPINIONS AND CONCLUSIONS EXPRESSED HEREIN ARE THOSE OF THE INDIVIDUAL STUDENT AUTHOR AND DO NOT NECESSARILY REPRESENT THE VIEWS OF EITHER THE SCHOOL OF ADVANCED WARFIGHTING OR ANY OTHER GOVERNMENTAL AGENCY. REFERENCES TO THIS STUDY SHOULD INCLUDE THE FOREGOING STATEMENT

Table of Contents

Acknowledgments

I would like to thank Dr. B. J. Meyer for his inputs, comments, and critiques that made this paper possible.

I want to address my gratitude to Dr. Linda Di Desidero, Director Leadership Communication Skills Center, for her support and her comments on my paper.

Lastly, I want to thank my wife Nicoletta and my adorable children, Gianluca and Giulia, for their patience and their support. I love you.

Executive Summary

Title: Enhancing Future Military Capabilities with Autonomous Driving Vehicles

Author: Lieutenant Colonel Alessio Argese, Italian Army

Thesis: Other than driving from point A to point B, autonomous driving vehicles fulfill the purpose of carrying a camera, of transporting something, or of carrying a weapon. As such, autonomous driving vehicles can perform an array of tactical tasks, releasing the ground forces from these tasks while reducing the risk of human loss on the battlefield.

Discussion: An autonomous driving vehicle can do whatever a manned vehicle does. It can perform the same tasks that military drivers currently perform in a better and more efficient way. It cannot be distracted, it can drive 24 hours a day, fuel permitting, it does not need to rest or stop, and it can drive cross-country at a faster speed than soldiers can tolerate. As autonomous driving vehicles do not have to serve the purpose of carrying soldiers, they do not need to have the same shape and size of today's military vehicles.
In order to operate in autonomous mode, an autonomous driving vehicle needs a camera, sensors, a GPS, and an artificial brain. With a camera, an autonomous vehicle can easily perform reconnaissance tasks. The vehicle's camera can acquire images and send them back to other systems or soldiers. The Autonomous Reconnaissance Vehicle (ARV) can search areas that neither aerial drones nor humans cannot, such as woods, pipes, caves, and tunnels. Other than reconnaissance tasks, the autonomous driving vehicles can perform logistic tasks. An Autonomous Logistic Vehicle (ALV) can carry supplies to the fighting forces or it can simply carry the load of dismounted forces. A squad or a platoon of ALVs can perform convoy tasks, carrying logistic supplies from point A to point B of the battlespace. If the convoy hits an improvised explosive device, nobody gets injured and there is no need to dispose a medical evacuation within the golden hour. The convoy will continue its journey until it reaches its destination. Equipped with an assault rifle, an autonomous vehicle can perform limited combat tasks. The Autonomous Combat Vehicle (ACV) can engage a target and eliminate it. It can patrol urban areas and rear areas preventing the enemy from reoccupying them and releasing the fighting units from these tasks. Eventually, even if only human creativity might limit the tasks that an autonomous vehicle can perform, autonomous driving vehicles might be outfitted with a loudspeaker. In such a way, they can deliver messages or provide information to the civilian population. With a simple program, such a translator device, they can deliver messages in multiple languages. They can lead civilians to safety areas or refugee camps, according to the situation.

Conclusion: Within 15 years, technology will allow defense industries to build autonomous driving vehicles. Autonomous driving vehicles will perform an array of tactical tasks releasing the ground forces from dull, dirty, and dangerous tasks. The degree of autonomy of such vehicles will be still limited and under control of human operators. Maybe, in the far future, autonomous systems will be able to make their own decisions without human interference. Yet, it is still a human choice whether to increase the level of independence of autonomous driving vehicles.

1. Introduction

In Afghanistan and Iraq, coalition forces have used unmanned ground vehicles (UGVs), in addition to or in combination with unmanned aerial vehicles (UAVs), mainly to overcome the risk of improvised explosive devices (IEDs) or to help soldiers carry heavy loads and equipment.[1] This successful use of UGVs has produced an increasing demand for unmanned systems and the research for a more sophisticated technology in order to introduce fully autonomous UGVs. Because of this, military industries, in support and coordination with military organizations, are widely investing in autonomous-driving technology.

Lockheed Martin, in collaboration with the United States Army Tank Automotive Research, Development and Engineering Center (TARDEC), has developed the Autonomous Mobility Appliqué System (AMAS). AMAS is a kit, which includes a light detection and ranging (LIDAR) system, a global position system (GPS), and cameras, that can be applied to any military vehicle in order to enable unmanned driving.[2] In the version of the Leader-Follower, AMAS allows driverless vehicles to follow the path of a manned-lead vehicle. Yet, in a recent test even the leader vehicle was unmanned.[3] Thus, a fully autonomous driving capability in the near future (2026 – 2030) is in the realm of possibility.[4] It represents an opportunity to exploit not only to save soldiers' lives but also to increase the ground forces' capabilities on the battlefield.

An autonomous driving vehicle can do whatever a manned vehicle does. It can perform the same tasks that military drivers currently perform in a better and more efficient way. For instance, autonomous driving vehicles do not make human mistakes while driving. They cannot be distracted and they always keep the appropriate security distance from other vehicles, if they are programmed to do so. In such a way, autonomous vehicles will reduce

the risk of collisions and car accidents. An autonomous vehicle can drive 24 hours a day, fuel permitting, and it does not need to rest or stop, as humans do. It can drive cross-country at a faster speed than soldiers can tolerate. Autonomous driving vehicles would free all army drivers from the duty of driving. Drivers could have other jobs within the military organization or they might become IT experts that do the maintenance of the autonomous vehicles.

In addition, as autonomous driving vehicles do not have to serve the specific purpose of carrying soldiers, they do not need to have the shape and size of today's military vehicles. They do not necessarily have wheels or tracks. They might be equipped with wheels or tracks but they might also fly at an altitude of 20 inches, following the profile of the ground[5]. They have cameras and sensors to interact with the environment and through which they send information back to the main Head Quarter (HQ).

They might be equipped with an Artificial Intelligence (AI) that enables them to process autonomous decisions, to talk to other autonomous driving vehicles, and to learn from other UGVs' experience. They can carry a pistol, an assault rifle, a heavy weapon, explosives or they can simply carry ammunition for a soldier on the firing line. Other than driving from point A to point B, autonomous driving vehicles fulfill the purpose of carrying a camera, of transporting something, or of carrying a weapon. *As such, autonomous driving vehicles can perform an array of tactical tasks, releasing the ground forces from these tasks while reducing the risk of human loss on the battlefield.*

2. The Most Promising Uses of Autonomous Driving Vehicles

An autonomous driving vehicle needs cameras, sensors, a GPS, and an artificial brain to operate in autonomous mode. It can be equipped with additional software that allows it to

perform the tasks that military organizations want it to perform. For instance, software with the instructions on how to perform reconnaissance duties allows the autonomous vehicle to perform reconnaissance tasks without requiring any specific training. Army reconnaissance units can be employed for other tasks or they can employ autonomous vehicles for the purpose of reconnaissance. If an enemy captures an autonomous vehicle, it might automatically explode, so, it will not reveal the information it carries. Autonomous driving vehicles cannot be tortured or manipulated. Above all, if they are destroyed, they can be replaced.

In addition, the unmanned vehicle can be fitted with a small weapon, such as a pistol or an assault rifle, which it can use for self-defense or to eliminate a target, if asked to do so.[6] Autonomous driving vehicles' primary purpose is to observe or to transport something. According to each of these purposes, autonomous driving vehicles can perform reconnaissance and logistic duties. They can even shoot and eliminate hostile elements, if fitted with a weapon. In such a way, army units would be released "from dull, dirty, and dangerous tasks."[7]

a. Carrying Cameras: Autonomous Reconnaissance Vehicles (ARV)

An autonomous driving vehicle, equipped with a camera and sensors, can easily perform reconnaissance duties instead of human reconnaissance patrols. The vehicle's camera can acquire images and send them back to other systems or soldiers. It can perform the same tasks that unmanned aerial drones perform today. Yet, instead of reconnoitering from the sky the autonomous driving vehicle operates from the ground. It can search areas that neither aerial drones nor humans cannot easily cover, such as woods, pipes, caves, and tunnels.

The autonomous reconnaissance vehicle can search woods more easily and faster than humans can. Multiple autonomous vehicles can be used to perform reconnaissance duty, according to the size of the search area. They can be equipped with wheels to drive cross-country. If they find an obstacle, they can climb it. If the obstacle is too high, they can find another path that allows them to continue the reconnaissance. They can be very silent, as they are powered with a solar engine that produces a noise from 0 to 20 decibels.[8] Thus, if the woods are occupied by hostile elements, the reconnaissance vehicles can drive close to them without being heard.

The autonomous vehicles can carry an infrared (IR) optical system that operates when the visibility is low.[9] Thus, the vehicles can perform reconnaissance at night or when there is fog. It can discover tunnels in the woods and explore them. If it is equipped with an audio-video record system, it can acquire images, record audio and videos, and send them back without making noise as a human patrol might do.

The reconnaissance vehicle might be water resistant in order to operate in terrain with presence of rain, mist, and mud. Due to its low weight, it moves more easily in difficult terrain than humans or current military vehicles can. It can be equipped with detector sensors through which it detects smoke, explosives, radioactivity, chemical or biological materials.[10] In case it detects explosive traps, another autonomous system with the capability of remove explosives can be sent forward. If it explodes when it hits the explosive, there is no need to arrange a medical evacuation, as in the case of a human patrol. Additional reconnaissance system can be sent to continue the activity.

Once the autonomous vehicles have cleared one area of the woods, they can continue the operations without resting, turning their attention to other specific points.

They can operate 24 hours a day without any pause and without the need of logistical sustainment. The autonomous vehicles do not have to be fed and they do not have to carry days of supplies to survive and continue to perform the assigned task. The autonomous vehicles might be organized in squads of three to five vehicles. When one or more squads are operating, the others are in a sort of pause, recharging their batteries in a safe place.

The Artificial Intelligence that they might be equipped with helps the autonomous driving systems communicate to other UGVs. Thus, the autonomous vehicles can continue to perform the reconnaissance from the exact point that the last set of vehicles searched. Simply synchronizing the autonomous driving vehicles will allow the autonomous vehicles to share knowledge and experience. The vehicle can even learn from each other's experience.[11] Not only the newly employed vehicles will know the configuration of the woods, or other specific areas that previous systems have explored, they will also acquire knowledge of explosives and tunnels that other autonomous reconnaissance vehicles have discovered.

As stated earlier, the shape of the UGVs is another interesting advantage that an autonomous driving vehicle might bring to military organizations. The size of the actual military vehicles is large and heavy, as they serve the primary purpose to carry humans, or heavy systems. They are armored or they are equipped with additional elements to protect the soldiers that they carry, for instance, from an explosion. The actual size of the military vehicles limits the performance and duties that these vehicles can accomplish. They cannot enter a thick woods, explore tunnels, or move easily in compartmented terrains.

As an autonomous driving vehicle is unmanned, it does not have humans aboard. Its shape does not have to be similar to the shape of a military vehicle. Actually, the autonomous reconnaissance vehicle should be smaller and lighter in order to move and drive where manned vehicles cannot. For instance, an area of the battlefield that the Intelligence cell has assessed as severely restricted might become only restricted, or even unrestricted, for an autonomous driving vehicle with a small size and weight, such as the Swedish reconnaissance UGV denominated GroundBot.

The GroundBot has the shape of a small ball with two cameras, which are mounted on each side of the ball, that provide 360-degree views. It can be equipped with IR cameras and microphones in order to record audio and video images. Due to its peculiar shape, it can operate in extreme conditions such as deep snow, ice, mud, and sand. It can even float. It weighs only 25 kilograms and its height is 0.60 meters, its width is 0.8 meters, and its length is 0.60 meters.[12]

In the near term, the technological evolution can allow defense industries to produce reconnaissance UGV even smaller, lighter, faster, and with more endurance than the current Swedish version. It might operate far away from its control station in a fully autonomous mode. It can navigate with a GPS system, receiving the coordinate of the searching area and driving there alone, at a consistent distance from human teams. It can perform its task and come back to the main base or it can be used and forgotten, as mass production would make it really cheap.

With such a peculiar shape and small size, the autonomous driving vehicles can drive in dead ground without being discovered by enemy warning systems. They can discover tunnels, access them, and explore them. They can enter and explore caves. If

equipped with a periscope, they can even explore pipes and cross dangerous zones such as a ridgeline.

An autonomous driving vehicle squad might be the first unit that crosses a ridgeline. Thus, if an enemy is heavily defending the ridge line, the autonomous vehicles might be destroyed, but human teams would survive. In any case, they might be able to send the acquired information back to the human teams, as the enemy was not able to destroy the black box that stores the information of the autonomous vehicles. Thus, ground forces might decide to send additional unmanned systems or human teams to seize the ridgeline. Other than carrying cameras and sensors in order to perform reconnaissance tasks, the autonomous driving vehicle can transport something, performing logistic functions.

b. Transporting Something: Autonomous Logistic Vehicles (ALV)

Other tactical tasks that the autonomous driving vehicles can perform reside in the realm of logistics. As an autonomous vehicle can perform the same tasks that manned vehicles perform, they can carry supplies to the fighting forces or they can simply carry the load of dismounted forces. In such a way, autonomous logistic vehicles can follow dismounted patrol units, carrying their heavy load and equipment and increasing their autonomy. Indeed, the autonomous logistic vehicles can carry additional ammunition, food, water, and other heavy loads that human patrols cannot. Thus, the patrol can operate for a longer time without the need of receiving additional supplies.

The autonomous vehicle, equipped with the same sensors, cameras, GPS, and technology of the autonomous reconnaissance vehicles, might have a shape similar to the actual military vehicles but smaller. For instance, they can carry a load up to 750 kg.

They weigh only 215 kg or less and they have relatively small dimensions, such as the Israeli Probot has. The Probot is a large wheeled logistics UGV with a height of 0.43 m, a width of 0.76 m, and a length of 1.07 m.[13] Future technology will allow defense industries to produce vehicles smaller than the Probot with an increasing rate of the maximum payload.

The autonomous logistic vehicles can have wheels or tracks, according to the area where the patrol is operating. It can follow the dismounted soldier or it can follow a waypoint path.[14] As its primary purpose is carrying things, in case of need, it can carry an injured soldier or it can evacuate him in a safe area where the soldier can be rescued and hospitalized.

While carrying a military load for the patrol units, the autonomous vehicle can still acquire images and information. The cameras that it uses to drive will also serve the purpose of searching and mapping the area where the patrol is walking. The acquired information is automatically sent back to the main HQ that will have a constantly updated situational awareness.

A squad or a platoon of autonomous logistic vehicles can perform convoy tasks, carrying logistic supplies from point A to point B of the battlespace. The units that are fighting can simply text a coded message with a cellular phone to the autonomous driving vehicles. The convoy will depart to deliver the required ammunition, food, water, petroleum, oil and lubricant supplies. While carrying the required supplies, the autonomous logistic vehicles might track with its sensors and cameras the amount of traffic encountered on the road. They can send information on the condition of the paths

that they have used to reach the fighting units, while simultaneously performing intelligence and reconnaissance duties.

While a manned logistic convoy requires use of many military drivers, an automated convoy requires none. In addition, the automated convoy can drive 24 hours a day without the need to stop or to rest. The autonomous vehicles can have hybrid engines. They can be solar powered. They can store the solar energy in special batteries that they will use to drive at night. Automated convoys do not make human mistakes, as they cannot be bored or tired of driving as the humans might be. They can drive cross-country at a higher speed than humans can tolerate, if the load they carry allows them to drive fast in cross-country terrain. If the convoy hits an improvised explosive device, nobody gets injured and there is no need to arrange a medical evacuation within the golden hour. The convoy will continue its journey until it reaches its destination. The same considerations apply if the convoy falls in an ambush: the remaining vehicles can continue to perform the assigned task.

Logistic manned convoy might be escorted by infantry patrol units, depending on the area through which they are travelling or the peculiarity of the cargo. An automated convoy might travel unescorted, if it mounts light or medium weapons. Indeed, an autonomous logistic vehicle might be fitted with a lethal package, which might include an assault rifle or a light machine gun. It can open fire in a self-defense mode. In such a way, the convoy can engage potential hostile elements and continue its programmed delivery, if it is able to overcome the assailing enemy. On the other side, other autonomous driving vehicles might escort an automated convoy. These vehicles will carry assault rifles and light machine guns. If the convoy falls into an ambush, the escorting vehicles will open

fire to protect the convoy and to eliminate the threat. Yet, the vehicles outside of the ambush area can continue to drive toward the destination point disregarding the fighting, as no humans are in danger or need to be rescued. Once the autonomous driving vehicles are outfitted with small or medium weapons, they can additionally perform limited offensive tasks.

c. Carrying Weapons or Explosives: Autonomous Fighting Vehicles (AFV)

Other than transporting things, an autonomous driving vehicle can be equipped with a weapon such a pistol or an assault rifle remotely operated.[15] With an assault rifle, the vehicle can engage a target and eliminate it. An autonomous reconnaissance vehicle, while is searching a wooded area, can engage potential enemies that are hidden in the woods. The autonomous fighting vehicle can have boxes filled with 500 ammunition each, far more than a human can carry. To increase its firepower, it can even have a small grenade launcher underneath the assault rifle. Imagine a hundred, a company-size, of autonomous reconnaissance vehicles equipped with roof-mounted weapons: not only they can search woods, or a specific area, they can clear that woods from hostile elements before the arrival of human teams.

Other than carrying a small weapon, the autonomous driving vehicle can simply carry explosive and detonate when they meet hostile elements. They can also detonate if an enemy tries to catch them. If they found a tunnel or a cave, they can explore them and if they find something or somebody suspicious they can explode, destroying the tunnel or the cave. If the enemy has a defense in depth in place, a certain number of autonomous fighting vehicles, equipped with a silent engine and filled with explosive, can assault by surprise the first line of the enemy's defense in depth. They will explode as they make

contact with the enemy units, opening a breach that other infantry units can exploit. They can break through and prepare the terrain for the operational exploitation of the following units, manned or unmanned.

In an urban environment, they can explore buildings and tunnels. If they find hostile elements they can explode or shoot them with the weapons that they carry. They can perform their job alone or with infantry units. Alone, they can move ahead of the infantry units and clear their way. In teaming with infantry units, soldiers can throw small, man-portable autonomous vehicles in buildings and tunnels. Infantry units can then have a clear idea of what there is inside them. The vehicles can still carry explosives or weapons, even a pistol, to clear buildings or tunnels in place of infantry units. The autonomous vehicle can perform such a task in a more rapid way than humans can, saving soldiers' lives. Currently, the American-made Throwbot XT might be used to explore buildings and to send images back to the operator, revealing the layout of rooms and the presence of hostages.[16] The same autonomous system, equipped with a pistol, could eliminate the hostile elements inside the buildings.

In 2014, the Israeli Defense Forces (IDF) employed a Micro Tactical Ground Robot (MTGR) to explore the tunnels that Hamas used in Gaza to hide weapons and command posts.[17] The MTGR is portable, equipped with five cameras, an internal microphone, and IR laser pointers. The vehicle provides 360-degree views and it can collect and relay encrypted information.[18] The same system outfitted with a small gun or rifle, in addition to reconnaissance duties, could open fire against hostile elements or simply explode, destroying the discovered tunnel.

Other than clearing buildings and tunnels, autonomous driving vehicles can patrol urban areas that infantry units or unmanned systems have already cleared, preventing the enemy from reoccupying it. In the current fight against Daesh in Iraq, autonomous vehicles that patrol urban areas would be very advantageous for the Iraqi forces. These vehicles could secure an area, while infantry units are concentrating their main effort elsewhere. Iraqi forces might have used all available infantry units to retake Mosul, if autonomous vehicles were available to secure Falluja. In the same way, an army might use autonomous fighting vehicles to patrol specific areas, releasing the fighting units from such a task. The operational tempo would increase, as the main effort might operate elsewhere, leaving the dull tasks to autonomous driving systems.

As driving vehicles might patrol urban areas, they would be able to patrol the countryside. In the countryside, battalions-size of autonomous vehicles can drive random patterns searching for potential enemies. Once they recognize hostile elements, they can use their small weapons to eliminate them. Thus, they will be able to keep the area clear from the arrival of other hostile elements. On the other side, the autonomous vehicle can patrol an area and send images to the infantry units that are later deployed to deal with the discovered threat. In any case, infantry units would not perform patrol activities and they can be employed elsewhere. To secure an area, patrols need to run 24 hours a day with a shift of 6 – 8 hours of duties. This means that 4 infantry platoons would be required to patrol a company-size area for 24 hours a day. This dull task might be performed from a company-sized unit of autonomous patrolling vehicles and the infantry platoons can be freed from such a task in order to perform other activities.

Currently, the IDF are using unmanned ground vehicles to patrol the border with the Gaza Strip. Recently, the Segev, a new and updated UGV, replaced the Guardium, which was the first remotely driven vehicle used to patrol the Gaza border. The Segev is outfitted with 4 driving cameras and a camera that allows 360-degree views. Its purpose is to gather information for ground forces units. In 2017, the Segev will operate in a full autonomous mode, so the vehicle can drive alone to a specific point marked on a digital map, and it will be fitted with a roof-mounted weapon, which is still remotely controlled by a military operator.[19] In the near future, a fleet of vehicles like the Segev could perform autonomous patrol duties and, if equipped with lethal packages, they could actively engage targets. They could secure the perimeter of a military installation, patrolling the fence 24 hours a day.

If the autonomous vehicles can patrol urban areas and the countryside, they can patrol rear areas. Battalions-size of autonomous vehicles might perform random patrols in the rear. They can patrol the main supply routes. They can search for explosives and when they find a IED they will alert the HQ. At the same time, they can alert all the army units of the discovered IED. The army units can plan accordingly which route take. The HQ might send another autonomous vehicle to dispose of the IED. With the rear area kept safe by autonomous vehicles, automated logistic convoys can drive safely bringing supplies from the rear line to the fighting area.

Eventually, even if only human creativity might limit the tasks that an autonomous driving capability can perform, autonomous driving vehicles might be used as Information Related Capability (IRC) by the Information Operations Cell. Outfitted with a loudspeaker, they can deliver messages or provide information to the civilian

population. With a simple program, such a translator device, they can deliver messages in multiple languages. In case of emergency, they can provide information to people. They can lead civilians to safety areas or refugee camps, according to the situation. They can simply track all the civilians in an area to avoid that they are inadvertently targeted or killed by other autonomous driving systems.

3. Conclusion

Within 15 years, technology will allow defense industries to build autonomous driving vehicles. Autonomous driving vehicles will carry sensors, cameras, and GPS to navigate and interact with the environment. The more sophisticated version of autonomous driving vehicles will be outfitted with AI through which they can learn from other UGVs' experience and through which their level of autonomy from human control will increase.

Autonomous driving vehicles will perform an array of tactical tasks releasing the ground forces from dull, dirty, and dangerous tasks. For instance, in the reconnaissance version, autonomous driving vehicles can perform all reconnaissance tasks that human reconnaissance patrols normally perform. Yet, they do not need to rest, they do not need to be fed, and if destroyed they can be replaced. Their shape will be different from the current military vehicles' shape, as they do not need to carry humans. Thus, they can enter caves, tunnels, pipes, thick woods driving and operating where current vehicles cannot. With their driving cameras and sensors, autonomous driving vehicles will be able to send information to the main HQ that will have a constant, updated situational awareness.

In addition, in the fighting version, an autonomous vehicle with a roof-mounted weapon, they can perform patrol duties. They can patrol the countryside, urban areas, and rear areas.

They can patrol the fence of a military installation. They can engage and eliminate a target, if they find one. They can simply be equipped with explosives and explode when they find a hostile element or when they enter a tunnel or a building occupied by an enemy. Since autonomous vehicles will perform reconnaissance tasks and will patrol a portion of the battlespace, ground forces can perform other tasks and concentrate their effort on the main object of the operation. Speed and tempo will increase with autonomous vehicles performing tasks that normally require a huge number of infantry units.

As Captain Wayne P. Hughes Jr. USN (ret.) stated, "the fundamental error in a debate over robotic development is to think that we have choice. This world is coming, rapidly coming."[20] Autonomous driving capability is part of robotic development and, as such, it is rapidly coming. In the next 15 years, autonomous vehicle will substitute human teams in performing dangerous tasks, as they can be replaced while humans cannot. However, the degree of autonomy of such vehicles will be still limited and under control of human operators. Maybe, in the far future, autonomous systems will be really autonomous: they will be able to make their own decisions in order to perform the assigned task, without human interference in their decision-making loop. Yet, it is still a human choice whether to increase the level of independence of autonomous driving vehicles.

Endnotes

[1]"Shouldering the Load: Militaries Look to Unmanned Beasts of Burden," *Jane's International Defense Review* 49, no. 5 (May 01, 2016) in http://search.proquest.com.lomc.idm.oclc.org/docview/1780069676?accountid=14746 accessed October 25, 2016.

[2]The Autonomous Mobility Applique System (AMAS) provides a low-cost/low-risk, kit-based solution to retrofit active safety, semi-autonomy and autonomy capability onto any vehicle in the military's logistics fleet. AMAS offers Driver Warning/Driver Assist functionality, Leader-Follower convoy operations, Waypoint following capabilities and provides growth to fully autonomous operations. http://www.lockheedmartin.com/us/products/amas1/mfc-amas-overview.html accessed December 12, 2016.

[3]"U.S. Army and Lockheed Martin Complete Second Series of Advanced Autonomous Convoy Demonstrations" in http://www.lockheedmartin.com/us/news/press-releases/2014/june/mfc-061014-us-amy-lockheedmartin-complete-second-series-advanced-autonomous-convoy-demonstrations.html accessed December 8, 2016.

[4]US Department of Defense, *Joint Concept for Robotic and Autonomous System*, Draft version 0.7, February 16, 2016. Autonomy means "the level of independence that humans grant a system to execute a given task. It is the condition or quality of being self-governing to achieve an assigned task based on the system's own situational awareness, planning, and decision-making."

[5]At the 87th Geneva Motor Show, Italdesign and Airbus presented "Pop.Up," a self-driving vehicle that can fly, as it "is propelled by eight counter-rotating rotors." In a similar way, a military autonomous driving vehicle could fly at a low altitude, following the profile of the ground, to avoid enemy's interception. More details are available at the following link http://electriccarsreport.com/2017/03/airbus-reveals-pop-flying-car-concept-geneva-video/

[6]Yaakov Lappin, "Israel's New Segev UGVs to Became Fully Autonomous," *HIS Jane's Defence Weekly*, http://www.janes.com/article/65900/israel-s-new-segev-ugvs-to-become-fully-autonomous accessed December 26, 2016.

[7]László Ványa, "Excerpts from the history of unmanned ground vehicles development in the USA," AARMS Informatics-Robotics Vol. 2, no. 2 (2003): 185–197 www.zmne.hu/aarms/docs/Volume2/Issue2/pdf/02vanya.pdf accessed December 22, 2016.

[8]IHS Defense and Security, "Land Warfare Platforms: Logistics, Support & Unmanned. Throwbot," https://janes-ihs-com.lomc.idm.oclc.org/LogisticsSupportUnmanned/Display/1495486 accessed December 8, 2016. The whispering at a library is calculated at 30 Decibels.

[9]*Ibid.*

[10]IHS Defense and Security, "Land Warfare Platforms: Logistics, Support & Unmanned. Groundbot," https://janes-ihs-com.lomc.idm.oclc.org/Janes/Display/1592362 accessed December 27, 2016.

[11]US Army Training and Doctrine Command, *The US Army Robotic and Autonomous Systems Strategy*, Draft version 0.8, August 5, 2016.

[12]IHS Defense and Security, "Groundbot," https://janes-ihs-com.lomc.idm.oclc.org/Janes/Display/1592362 accessed December 10, 2016.

[13]IHS Defense and Security, "Land Warfare Platforms: Logistics, Support & Unmanned. Probot," https://janes-ihs-com.lomc.idm.oclc.org/Janes/Display/1705025 accessed December 26, 2016.

[14]Lockheed Martin, "SMSS overview," http://www.lockheedmartin.com/us/products/smss/smss-overview.html accessed December 26, 2016.

[15]Yaakov Lappin, "Israel's New Segev UGVs to Became Fully Autonomous."

[16]IHS Defense and Security, "Land Warfare Platforms: Logistics, Support & Unmanned. Throwbot". Throwbot is a small wheeled throwable reconnaissance UGV. The robot can transmit video and audio up to a control range of 30 m through walls, windows, and doors to the Operator Control Unit (OCU). Once deployed, the micro-robot can be directed by the operator to quietly move through a structure and transmit video and audio to the handheld OCU. These stealth capabilities can be used to locate armed subjects, confirm the presence of hostages or innocent civilians, listen in on conversations, and reveal the layout of rooms.

[17]Brendan McGarry, "Israel Deploys Robots to Clear Hamas Tunnels," *Defensetech*, http://www.defensetech.org/2014/07/29/israel-deploys-robots-to-clear-hamas-tunnels/ accessed December 26, 2016.

[18]IHS Defense and Security, "Land Warfare Platforms: Logistics, Support & Unmanned. Micro Tactical Ground Robot (MTGR)," https://janes-ihs-com.lomc.idm.oclc.org/LogisticsSupportUnmanned/Display/1704981 accessed December 26, 2016.

[19]IHS Defense and Security, "Land Warfare Platforms: Logistics, Support & Unmanned. Segev", https://janes-ihs-com.lomc.idm.oclc.org/LogisticsSupportUnmanned/Display/1789802 accessed December 27, 2016.

[20]Wayne P. Hughes Jr., USN (ret), Dean Emeritus, Naval Post-Graduate School in "Joint Concept for Robotics and Autonomous Systems."

Bibliography

Carnegie Mellon University. "Autonomous Driving in Traffic: Boss and the Urban Challenge." *AI MAGAZINE.* Summer 2009.

Grace, V. Jean. "No Driver Required." *National Defense.* November 2009.

Hamlet, Alan J. "The Cognitive Driving Framework: Joint Intent and Belief Inference for Collision Prediction and Avoidance in Autonomous Vehicles." (University of Florida, 2015).

H.R Everett. "Unmanned System of World Wars I and II." The Massachusetts Institute of Technology Press (2015).

Jane's International Defense Review. "New Russian Combat UGV Breaks Cover, Uran-9 Readies for Service." (September 2016).

Kingston Conference on International Security. Robotics and Military Operations. Conference Report. May 2015.

Lappin, Yaakov. "Israel's New Segev UGVs to Became Fully Autonomous." *IHS Jane's Defence Weekly.* http://www.janes.com/article/65900/israel-s-new-segev-ugvs-to-become-fully-autonomous.

Lyons, Doug A. "Autonomous Vehicles: A Policy Roadmap for Law Enforcement." Naval Postgraduate School (Monterey, California: September 2015).

McGarry, Brendan. "Israel Deploys Robots to Clear Hamas Tunnels." *Defensetech.* http://www.defensetech.org/2014/07/29/israel-deploys-robots-to-clear-hamas-tunnels

McElroy, John. "Make way for the Electronic Horse." Ward's Auto World (December 2007).

"Shouldering the Load: Militaries Look to Unmanned Beasts of Burden." *Jane's International Defense Review* 49, no. 5 (May 01, 2016). http://search.proquest.com.lomc.idm.oclc.org/docview/1780069676?accountid=14746.

The Eisenhower School. *Robotics and Autonomous Systems. Final Report.* Spring 2015.

Thomas, David. *Integrated Strategy for Autonomous Drive, Connected Vehicle and Robotics.* PowerPoint presentation. US Army TARDEC, Intelligent Systems, 24 August 2010.

US Department of Defense. *Joint Concept for Robotic and Autonomous System.* Draft version 0.7. February 16, 2016.

US Army Training and Doctrine Command. *The US Army Robotic and Autonomous Systems Strategy.* Draft version 0.8. August 5, 2016.

Ványa, László. "Excerpts from the history of unmanned ground vehicles development in the USA." AARMS Informatics-Robotics Vol. 2, no. 2 (2003): 185–197 www.zmne.hu/aarms/docs/Volume2/Issue2/pdf/02vanya.pdf