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Dominik Juling

Truck platooning is a technology that allows trucks to drive in a convoy one behind the other, communicating with one another and adapting themselves to the convoy. There are various configurations with differing degrees of autonomy but, in most cases, there is still a driver on board, which distinguishes the concept from fully autonomous vehicles. In this article, Dominik Juling examines the advantages, hurdles and limits of military truck platooning in Europe, and provides examples of projects and technologies that are already operational. The benefits include fewer drivers, increased safety for the crew and reduced resource consumption.

Truck platooning is an indistinct umbrella term and does not refer to a specific technology or implementation method. Therefore, it is useful to refer to a broad definition. This can be found, for example, in the 2012 research article 'Overview of Platooning Systems': 'The platooning concept can be defined as a collection of vehicles that travel together, actively coordinated in formation. [...] There are many variations of the details of the concept such as: the goals of platooning, how it is implemented, mix of vehicles, the requirements on infrastructure, what is automated (longitudinal and lateral control) and to what level'.[1] In principle, most existing projects are designed to be semi-autonomous, that is, a combination of modern automated technology and human drivers or supervisors. The number of vehicles in a convoy and the selected distance also varies depending on the objective and implementation.

Truck platooning is relevant because in recent years there has been an increasing shortage of truck drivers in the civilian and military sectors. In the civilian sector, the shortage has led to gaps in supply in 2021, and in the military sector it is necessary to deploy soldiers more effectively than for routine overland transport, especially as there is a general shortage of personnel in the European armies.[2] In addition, there are research results on fuel savings when vehicles are close together, which would also help armies in Europe to become more sustainable.[3] The topic is certainly relevant for the future as well, because truck platooning is already collecting valuable data on road traffic, which will benefit civilian and military trucks and mobility solutions of the future.[4] This article helps to identify the opportunities, hurdles and recommendations related to truck platooning for European militaries: what could military truck

1. Carl Bergenheim et al., 'Overview of Platooning Systems', paper presented to the 19th ITS World Congress, Vienna, Austria, 22–26 October 2012.
2. Rachel Gilmore, 'Military Recruiting Issues in West Raise Challenges for Defending Democracy: Defence Chief', *Global News*, 29 January 2023, <https://globalnews.ca/news/9442611/canadian-forces-recruitmet-challenges-democracy/>, accessed 6 February 2023.
3. Sadayuki Tsugawa, Sabina Jeschke and Steve E Shladover, 'A Review of Truck Platooning Projects for Energy Savings', *IEEE Transactions on Intelligent Vehicles* (Vol. 1, No. 1, March 2016).
4. Xiaolei Ma et al., 'Mining Truck Platooning Patterns Through Massive Trajectory Data', *Knowledge-Based Systems* (Vol. 221, June 2021).

British Army on the move, NATO forces deployed to Poland. *Courtesy of Ukraine / Alamy Stock Photo*

platooning look like in Europe and what are the hurdles?

The topic of military truck platooning can be seen in a broader context as an attempt to make military logistics in Europe more efficient. Against the backdrop of the Russian attack on Ukraine, more efficient NATO logistics increase the deterrence potential through shorter intervention times at the borders of NATO member states. The first days and weeks of the Russian invasion have shown that seamless military logistics are crucial to every military campaign. In the initial phase, especially during the Russian advance on Kyiv, Russian troops faced significant logistical problems. This led in some cases to a slowing of the advance or to the abandonment of intact vehicles.

Bonnie Berkowitz and Artur Galocha write in the *Washington Post* that a Russian soldier needs an average of 440 pounds of food and water, fuel, ammunition, medical support, spare parts and more per day.[5] Authors at the Modern War Institute at West Point note that Russian logistics rely heavily on the availability of railways for transport. However, these are often damaged on Ukrainian soil or are not fully Russian-controlled and thus cannot be used reliably. As an alternative, the Russian army does not have enough trucks to maintain logistics operations more than 160 km beyond the last railhead supply dump.[6] Ronald Ti of the International Centre for Defence and Security notes that Russian logistics are too inflexible, using a centrally driven 'push and pull' system. In addition, vehicles are often poorly maintained and the efficiency of military hardware is not up to modern standards.[7] With a modern, partially automated, flexible and interoperable system of trucks, NATO can avoid the problems of Russian logistical operations in the future.

5. Bonnie Berkowitz and Artur Galocha, 'Why the Russian Military is Bogged Down by Logistics in Ukraine', *Washington Post*, 30 March 2022.
6. Michael Hugos et al., 'Logistics Determine Your Destiny: What Russia's Invasion is (Re)teaching us about Contested Logistics', Modern War Institute at West Point, 9 August 2022, <https://mwi.usma.edu/logistics-determine-your-destiny-what-russias-invasion-is-reteaching-us-about-contested-logistics/>, accessed 2 October 2022.
7. Ronald Ti, 'Russian Military Logistics', Russia's War in Ukraine series, No. 3, June 2022, <https://icds.ee//wp-content/uploads/dlm_uploads/2022/06/ICDS_Brief_Russias_War_in_Ukraine_No3_Ronald_Ti_June_2022.pdf>, accessed 2 October 2022.

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Differences Between Civilian and Military Truck Platooning

While the benefits of civilian and military truck platooning overlap greatly, there are notable differences in implementation and military-specific requirements.

Similarities between civilian and military requirements include cost-saving (in terms of both manpower and fuel) and greater efficiency. For instance, Matteo Luccio found that while two people would probably need to be in the first truck in longer convoys, one person would be sufficient in the middle vehicles and in the last truck, which could also deal with other minor tasks and only intervene, make decisions or take over the steering completely in the case of an emergency.[8] Sadayuki Tsugawa considers that the reduction of the drivers' workload and the many technical safeguarding mechanisms also massively increase road safety, which in turn leads to a reduction in traffic jams due to fewer serious accidents.[9] Furthermore, if fewer drivers are deployed overall or if they can also perform other tasks on the route, this reduces costs.[10] In addition to the lining up of numerous trucks, there is also research into the so-called 'leader-follower principle', in which the second of two vehicles is completely unmanned.[11] Even if a driver or supervisor is on board in almost all current projects, the shared medium-term goal of most military or civilian organisations is to save even more drivers through autonomous solutions or to automate driving to such an extent that the supervising driver can also concentrate on more complex tasks while on the road.

Another goal shared by civilian and military outfits using truck platooning includes saving fuel by exploiting the slipstream effect in configurations with little space between the trucks. Saving fuel is not only sustainable and cost-saving, but also strategically advantageous on a large scale. However, the result of how big the savings can actually be varies from study to study. The company Peloton published field trial results showing approximately 7% savings.[12] Another study concludes that, in theory, a saving of up to 15% would be possible for the second truck after the leader, which could be increased through additional aerodynamic coverings. Those could reduce aerodynamic drag up to around 26%.[13] This is also the conclusion of Sebastian Völl, project manager for automated driving at MAN, whose tests in 2019 resulted in only 4% savings, but who is confident that 10% additional savings can be achieved if the distance is reduced to around 10–15 m. The current distance is between 15 and 21 m.[14] The fact that the savings increase as distance is reduced is also shown by the research of Lammert and colleagues.[15] At that time, the maximum savings could be achieved at a distance of about 9 m and a speed of 88 km/h, with up to 6.4% in savings. An American research team calculated that an average fuel saving of 6.4% could save 5.67 billion litres of fuel per year.[16] Fuel savings increase the range of the convoy, but the savings in the lead vehicle are usually lower than in the following vehicles.

In spite of these similarities, however, the differences between specific military objectives

8. Matteo Luccio, 'Developing Systems to Automate Moving Groups of Trucks', GPS World, 30 April 2020, <https://www.gpsworld.com/developing-systems-to-automate-moving-groups-of-trucks/>, accessed 24 October 2021.
9. Sadayuki Tsugawa, 'An Overview on an Automated Truck Platoon within the Energy ITS Project', *IFAC Proceedings Volumes* (Vol. 46, No. 21, 2013), pp. 41–46.
10. Tsugawa, Jeschke and Shladover, 'A Review of Truck Platooning Projects for Energy Savings', pp. 68–77.
11. Scott Wakefield, 'Leader-Follower Vehicles to Offer Army Increased Operational Capability', US Army, 8 April 2021, <https://www.army.mil/article/245091/leader_follower_vehicles_to_offer_army_increased_operational_capability>, accessed 6 February 2023.
12. Richard Bishop, 'Where Does Auto-Follower Platooning Fit Within the Driverless Truck Ecosystem?', *Forbes*, 30 August 2019.
13. Daniel Duan, 'Truck Platooning: The Band of Semi-Trailers', Labroots, 23 November 2017, <https://www.labroots.com/trending/chemistry-and-physics/7405/band-semi-trailers-truck-platooning>, accessed 20 October 2021.
14. Felix Enzian and Ina Brzoska, 'Warum Platooning die Zukunft des Lieferverkehrs ist' ['Why Platooning is the Future of Supply Transport'], MAN Truck and Bus, 15 October 2019, <https://www.mantruckandbus.com/de/innovation/warum-platooning-die-zukunft-des-lieferverkehrs-ist.html>, accessed 22 October 2021.
15. Michael P Lammert et al., 'Effect of Platooning on Fuel Consumption of Class 8 Vehicles Over a Range of Speeds, Following Distances, and Mass', *SAE International Journal of Commercial Vehicles* (Vol. 7, No. 2, 2014), pp. 626–39.
16. Andreas H Glas, 'Platooning – was sind die Vorteile, wenn Lkw dicht auffahren?' ['Platooning - What are the Advantages when Trucks Tailgate?'], Beschaffung aktuell, <https://beschaffung-aktuell.industrie.de/logistik/platooning-was-sind-die-vorteile-wenn-lkw-dicht-auffahren/>, accessed 22 October 2021.

and requirements compared with civilian ones are numerous. This article examines the military requirements of NATO forces in Europe in conflict and peacetime. The strategic objective of truck platoons is the same as that of conventional military logistics convoys on the road. On the one hand, the supply of all branches of the military must be ensured, while on the other hand, in case of crisis, capabilities must be available to transport large quantities of soldiers and supplies from logistics hubs and ports of debarkation to the east of the SACEUR's (Supreme Allied Commander Europe) area of responsibility. The supply lines across Europe are approximately 500 km to 2000 km long, while an unloaded NATO truck has an operating range of up to 800 km.[17]

At the tactical level, military requirements are usually in addition to civilian requirements and not a substitute, because heavy traffic, unpredictable behaviour of other drivers or irregular obstacles on the road are challenges for civilian and military truck platooning systems alike. Also, dirt on the sensors or sensor failure is a challenge for both sectors. Specific military challenges, however, include protection against targeted cyber attacks, the deliberate blinding, jamming or confusion of sensors, a possible loss of GPS signal or the active protection of the convoy in crisis regions. For the force protection of a truck platoon, for example, the Wingman Joint Capability Technology Demonstration programme was developed, in which an unmanned Humvee with a 7.62-mm weapon system successfully follows a manned vehicle and engages targets.[18]

Another difference is that military vehicles must be prepared for attacks that can disable parts of the convoy or, in the worst case, the lead vehicle. To ensure that the halted convoy is not an easy target, the following vehicles should be able to regroup and continue their route autonomously, remotely controlled or steered by a supervising driver on board.

Military truck platooning is best used for day-to-day logistics between sites in Europe, where roads are well surveyed, support infrastructure is good and the likelihood of unforeseen incidents and attacks is low. Nevertheless, a military convoy must always be prepared to travel off-road or in adverse conditions, for example if a bridge in the rear area has been destroyed or there is thick fog or snow storms. In Europe, there are many unpaved roads and forest trails, but also a relatively large amount of dense forest between streets and highways. A transition from paved roads to off-road has to be potentially spontaneous, but it is very challenging for the technology because the environment is unknown, the driving behaviour on mud or snow changes a lot and, on difficult terrain, the following vehicle cannot always easily follow the movements of the leading vehicle.[19] In such situations, it is definitely an advantage to have a human driver in each truck. Another difference to civilian truck platooning is the robustness of the technology and sensors, which must be more resistant to dirt and damage in military vehicles.

In principle, military convoys operating far behind enemy lines on paved roads and with a very low risk of being attacked, function similarly to civilian truck convoys as they can usually travel without armed escorts and can rely on existing refuelling and support infrastructure. The following is a brief description of how conventionally manned NATO logistical convoys are organised when they operate in areas of possible enemy engagement, based on the Tactical Convoy Handbook of the US Army Transportation School, the US Marines Corps Motorized Convoy Operations B4P4878 Student Handout and the Tactical Convoy Ops Handbook.[20] The great majority of NATO forces follow the pattern described below.

Essentially, there are open and closed columns. The first type travels at a distance of 80 m to 200 m, which works best in open terrain and is less likely to be damaged in a heavy attack. On the other hand, this type is more difficult for the commander to control, is exposed for longer periods and can respond to attacks with less concentrated fire. The closed

17. Rheinmetall MAN Military Vehicles GmbH, 'The HX – More Than A Truck', <https://www.rheinmetall.com/media/editor_media/rheinmetallag/events/land_forces_2022/vehicle_systems/B258en07.2019_HX__more_than_a_truck_A4.pdf>, accessed 6 February 2023.
18. Nils Boysen, Dirk Briskorn and Stefan Schwerdfeger, 'The Identical-path Truck Platooning Problem', *Transportation Research Part B: Methodological* (Vol. 109, 2019), pp. 26–39.
19. K M Malone et al., 'Truck platooning voor Defensie' ['Truck Platooning in Defence'], *Militaire Spectator* (Vol. 190, No. 5, 2021), pp. 268–77.
20. Dean J Dominique (ed.), 'Tactical Convoy Handbook', US Army Transportation School, Fort Eustis, VA, 2015, <https://www.jumpjet.info/Emergency-Preparedness/Evacuation-Issues/Tactical_Convoy_Handbook.pdf>, accessed 6 February 2023. See also Marine Corps Training Command, 'Motorized Convoy Operations B4P4878', Student Handout, Camp Barrett, VA, 2019, <https://www.trngcmd.marines.mil/Portals/207/Docs/TBS/B4P4878%20Motorized%20Convoy%20Ops.pdf>, accessed 1 October 2022.

variant, with a range of less than 100 m between vehicles, works best at night, in urban terrain or in areas with heavy traffic, but is more vulnerable to heavy attacks and ambushes.

The typical configuration of a standard march unit is as follows: 1–2 minutes before the convoy, an advance guard vehicle will scout for potential threats and obstacles. The convoy follows, starting with two armed security vehicles with the security team leader, then three to six cargo trucks as the main body of the convoy with the convoy commander, followed by two security vehicles at the end. This line-up can be repeated as often as necessary to extend the convoy. In addition to the armed security vehicles, the cargo trucks can also be individually armed with a mounted machine gun. In addition to the security unit leader and the commander, there should also be an assistant convoy commander in another vehicle, a navigator and, especially for long convoys, a rear security unit leader. In these constellations, for example, the crews of the cargo trucks in the middle of the convoy could be reduced to one person or left out altogether. Or, in the event of an attack on their then autonomous vehicle, an active driver can focus entirely on leadership activities, while the driver's cargo truck, in coordination with the other manned and unmanned vehicles, performs an evasion manoeuvre. In addition, the forward scout vehicle could also be used unmanned in future scenarios and the role of the navigator might not be necessary anymore. The cargo trucks in this example only serve as placeholders and can of course also be medical vehicles, recovery vehicles or maintenance vehicles, which are sometimes accompanying long convoys.[21]

One advantage of the military application is the access to technologies that make the vehicles independent of GNSS information or ensure communication in spite of interference attempts. Examples are advanced inertial technologies and military-only M-code GPS technologies.[22] Sydney Freedberg explains the use of American GPS-independent technologies as follows: 'There's such a thing as an Inertial Navigation System (INS) that uses gyroscopes, accelerometers, and a lot of math to figure out where you're going based purely on heading and velocity, but that kind of dead reckoning loses accuracy the further you go. So military robots need to check their location against landmarks'.[23] This method is not usually used in civilian vehicles.

Sensors that military applications share with civilian ones include radar, optical cameras, light detection and laser-based distance sensors (LIDAR), as well as normal GPS, and digitalised and accurate maps when available. Modern algorithms and machine learning approaches are needed to process the data obtained in a practical way and to increase the effectiveness of autonomous manoeuvres. The associated computer hardware in the vehicle has to be designed in the most appropriate way for military applications.[24] In modern civilian trucks or premium cars, such applications have been standard for years and can be found under the name 'advanced driver-assistance system'. The technologies are well researched and military end users can also benefit from these technologies and from the mass of collected civilian data for their own adapted algorithms.

Current Status of Military Truck Platooning

In the comparison between civilian and military truck platooning, the civilian projects and companies in Europe are clearly in the lead. Only in the US are there larger private and government-funded projects in the military sector. This is due to the fact that the American military has more investment funds available for research, the large land mass means that longer distances have to be covered by truck than in European countries, and the US Army has been researching driverless vehicles for a long time due to the frequent losses caused by IEDs during overseas combat operations.[25]

In the civilian sector in Europe, all the major truck manufacturers are working on developing truck platooning technologies and making it practicable between trucks of different brands. Daimler is still involved in the cooperation, but has given up internal

21. Shawn McKay et al., *Automating Army Convoys: Technical and Tactical Risks and Opportunities* (Santa Monica, CA: RAND Corporation, 2020).
22. Dave Wickenhauser, 'US Military has Unique Needs for Truck Platooning', TruckingTruth News, 4 May 2020, <https://www.truckingtruth.com/news/Article-217/army-truck-platooning>, accessed 24 October 2021.
23. Sydney J Freedberg, Jr., 'Army Wants 70 Self-Driving Supply Trucks By 2020', *Breaking Defense*, 20 August 2018.
24. McKay et al., *Automating Army Convoys*.
25. Aarian Marshall, 'The Army's Self-Driving Trucks Hit the Highway to Prepare for Battle', *Wired*, 8 July 2016, <https://www.wired.com/2016/07/armys-self-driving-trucks-hit-highway-prepare-battle/>, accessed 19 October 2021.

research in 2019 because the company no longer sees a lucrative market for truck platooning.[26] There are major civilian truck platooning projects from Europe, California and Japan such as ENSEMBLE, SARTRE, PATH, GCDC, Energy ITS, KONVOI and the European Truck Platooning Challenge.[27]

There are fewer military projects on truck platooning, and, when there are, they are primarily in the US. One exception is the HX3 truck from Rheinmetall. The product description states: 'In conjunction with a standardised interface, they form the decisive basis for automating the vehicle and the smooth integration of technologies available in the future that will enable platooning of several vehicles or other automated and, in a next step, autonomous deployment scenarios'.[28] This was preceded by a joint project between the German civilian Fraunhofer Institute for Communication, Information Processing and Ergonomics FKIE, the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support BAAINBw, Diehl Defence GmbH & Co. KG, Rheinmetall AG and Bundeswehr University Munich. The initial evaluation of the platooning results was very positive.[29] Apart from that, it is not known whether the Bundeswehr is actively pursuing the implementation of truck platooning, although some of the new trucks are already prepared for it. Experts from the Netherlands Organisation for Applied Scientific Research (TNO) have also looked at the gaps that still need to be closed between civilian and military truck platooning, but without conducting a military hardware project.[30]

At the European level, the European Defence Agency has already been conducting research for several years under the name Hybrid Manned Unmanned Platooning. The following objective has been achieved:

> The EDA aimed to develop a demonstrator of a hybrid fleet of manned and unmanned vehicles, which would be deployed in convoy reconnaissance and/or surveillance (platooning) missions with a manned mobile control and command vehicle (CCV). The project also involved the creation of an automated vehicle, which could be operated from the control station installed in the CCV, or configured to follow a leader vehicle autonomously.[31]

In the US, there is a company called Robotic Research that has developed successful retrofit kits for military leader-follower configurations:

> As part of [the United States Army Combat Capabilities Development Command] Ground Vehicle Systems Center's Autonomous Ground Resupply and Expedient Leader Follower programs, Robotic Research has developed AutoDrive-M – a fault-tolerant, vehicle-agnostic Autonomy Kit that can be installed onto any tactical wheeled vehicle. Supporting such varied modalities such as Leader/Follower, Teleoperation, and Waypoint, AutoDrive-M provides critical functionality to support a variety of mission sets, from logistics to combat operations.[32]

The company Oshkosh also offers trucks with a mature leader-follower kit that drives completely autonomously, in leader-follower or in teleoperation mode. The project received financial support from the US Army Tank Automotive Research, Development, and Engineering Center (TARDEC) to the sum of $49 million, and is part of the US Army's Expedient Leader Follower ExLF programme.[33] Also commissioned by TARDEC was the Wingman Joint

26. Uta Leitner, Peter Smodej and Maximilian Splittgerber, 'Daimler Trucks investiert eine halbe Milliarde Euro in hochautomatisierte Lkw' ['Daimler Trucks is Investing Half a Billion in Highly Automated Trucks'], Daimler Trucks, 2019, <https://media.daimlertruck.com/marsMediaSite/de/instance/ko/Daimler-Trucks-investiert-eine-halbe-Milliarde-Euro-in-hochautomatisierte-Lkw.xhtml?oid=42188247>, accessed 22 October 2021.
27. McKay et al., *Automating Army Convoys*.
28. *Ibid*.
29. Frank Ole Flemisch, 'Cooperative Guidance of Partially and Highly Automated Trucks in Military Platoons', Fraunhofer Institute for Communication, Information Processing and Ergonomics, <https://www.fkie.fraunhofer.de/en/departments/se/StrAsRob.html#1512075532>, accessed 6 February 2023.
30. Malone et al., 'Truck platooning voor Defensie'.
31. Army Technology, 'EDA Completes Hybrid Manned-Unmanned Platooning Project', 8 February 2017, <https://www.army-technology.com/uncategorised/newseda-completes-hybrid-manned-unmanned-platooning-project-5736015/>, accessed 24 October 2021.
32. Robotic Research, 'Leader Follower - Robotic Research', 2 November 2020, <https://www.roboticresearch.com/leader-follower/>, accessed 23 December 2021.
33. Oshkosh Defense, 'US Army Awards Oshkosh Defense $49 Million to Bring Autonomous Technology to the Battlefield', 2018, <https://oshkoshdefense.com/u-s-army-awards-oshkosh-defense-49-million-to-bring-autonomous-technology-to-the-battlefield>, accessed 23 December 2021.

Capability Technology Demonstrator mentioned previously.[34]

The team working alongside Ryan D Lamm from the American Southwest Research Institute (SwRI) was able to successfully test the Small Unit Mobility Enhancement Technology (SUMET) platform in 2016, especially for off-road applications:

> The Small Unit Mobility Enhancement Technology (SUMET) program, funded by the Office of Naval Research, implemented all-terrain navigation using a vehicle outfitted with only camera-based sensors. The SUMET program achieved reliable automated vehicle operation in austere, harsh, off-road environments without depending on global positioning system (GPS) technology. SUMET achieved this by using multi-spectral electro-optical perception and advanced path-planning algorithms. SwRI demonstrated the SUMET platform multiple times in various off-road scenarios. The UGV could detect and avoid pedestrians and natural and man-made obstacles. The sensor suite could distinguish between different terrains, such as dirt, rock, asphalt, grass, wood, and foliage.[35]

This shows that it would also be technically feasible at present to make off-road driving semi-autonomous or even fully autonomous, which is an important military-specific requirement. In the civilian market, there are also possible future points of contact in the civilian off-road sector with a view to timber transport in Sweden or Canada, for example.

Problems and Hurdles for Military Truck Platooning in Europe

Overall, the tests show that drivers can also be reduced in the military sector, that fuel can be saved when vehicles are kept a short distance apart, that there are already various functioning prototypes and that tens of thousands of test kilometres have already been covered on motorways in the civilian sector. The vast majority of trials have been positive. So why isn't a comprehensive military implementation currently being pushed forward in Europe?

Current hurdles and possible further reasons are outlined next. On the one hand, there are positive trial results on motorways, but there is still too little data available for military-specific off-road driving, in narrow and unclear situations, and in potential war zones. This also includes, for example, data for semi-autonomous reversing, driving with a trailer, refuelling a convoy at civilian petrol stations and complex parking manoeuvres. There could also be concerns and opposition from civilian road users to the semi-autonomous military convoys in a large-scale deployment. Another major hurdle is national and EU-wide standards and uniform legislation, without which transnational travel between NATO countries would not be possible. Currently, there is no such uniform regulation of semi- or fully autonomous truck platoons on public roads outside test series. Also, there is currently no known cooperation between European manufacturers of military trucks on platooning-compatible technology, as is the case in the civilian sector. Finally, it is unclear whether the cost of thousands of retrofits can financially justify the savings in drivers. It is also not clear whether it is possible to meet military requirements and safety standards if the middle trucks are operated without drivers at all. If this were the case, the most drivers could be saved and the cost-benefit calculation would be the most advantageous.

In addition to the hurdles mentioned above, there are other reasons why military truck-platooning might not currently be considered in Europe. These include, for example, the fact that apart from a few articles in specialist journals, the concept has not yet been given a place in the debate in the European defence policy scene and defence industry, and is not currently a priority. Furthermore, compared with the US, the research budget of NATO armies is much more limited, and the legislation is usually stricter. The legislation in the Netherlands is an exception to this, as the country welcomes all sorts of automated testing on its streets.[36] Also, compared with the US, the link between civilian companies and research and military applications is not as strong. Another important reason is the perception that investments in semi-autonomous truck platooning are unjustified, as in the foreseeable future autonomous vehicles will be used anyway, which will save even more costs and drivers.

34. Army Technology, 'US Army JCTD Programme Develops Autonomous Combat Vehicle', 5 February 2018, <https://www.army-technology.com/news/us-armys-wingman-jctd-programme-develops-autonomous-combat-vehicle/>, accessed 22 October 2021.
35. Ryan D Lamm, 'Leave the Driving to Us', Southwest Research Institute, 2016, <https://www.swri.org/node/1833451>, accessed 23 December 2021.
36. Government of the Netherlands, 'The Netherlands as a Proving Ground for Mobility', <https://www.government.nl/topics/mobility-public-transport-and-road-safety/truck-platooning/the-netherlands-as-a-proving-ground>, accessed 6 February 2023.

Recommendations

Based on the analysis, it is not possible to conclude whether truck platooning in general is the right way forward for any or all NATO armies, as there are too many factors to investigate and clarify before making such a decision. Nevertheless, overarching recommendations can be made for military truck platooning in Europe.

Due to the diverse requirements and threats related to military operations, systems should be designed for maximum flexibility. The trucks should have supervised, remote-controlled and regular crewed modes, as well as perhaps fully autonomous modes. It should also be possible to vary the distance between the vehicles so that, for example, weak bridges can be driven over one by one rather than in convoy. The same applies to a change from GPS guidance to navigation without GPS and the possibility to drive semi-autonomously off-road. NATO trucks from different manufacturers should be able to connect with one another to form a platoon.

The next recommendation is to use semi-automated truck platoons only in the NATO back area and, at least initially, not near or in crisis zones or in places where attacks are to be expected. It would be better to first collect data with manned trucks in crisis areas and use it to train the semi- or fully autonomous platforms.

Not only in the field of truck platooning, but especially here, the relationship and exchange between the civilian industry, research and legislators should be actively sought and promoted. This could happen, for example, through joint projects or tenders. The focus should be on Europe, but European forces would also benefit massively from transatlantic technology transfers in military truck platooning.

The last recommendation is the creation of a European framework for autonomous and semi-autonomous trucks on the roads, which is also consistently implemented locally by all partner states. Such a legislative body is not expected to take a long time to develop but will probably not explicitly include military requirements. Now is the time for the armed forces to have an impact on the ongoing process, so as not to be left out at a later stage.

Conclusion

It can be observed that truck platooning in the military sector certainly has potential but is not currently a priority in Europe. If, in addition, legal certainty is not rapidly created on European roads, it is possible that semi-autonomous truck platooning will be overtaken by autonomous and unmanned vehicles in a few years. If armed forces decide to use truck platooning, they should proceed quickly with testing and implementation. But truck platooning also has advantages for the long-term introduction of autonomous trucks on public roads, because it allows data and experience to be gathered and the population and drivers to get used to automated vehicle systems. Military semi-autonomous truck platooning in Europe can therefore be viewed as a useful intermediate step towards autonomous trucks and can be linked to civilian development. Military truck platooning can only serve as a transition towards autonomous platforms, but should not be underestimated as a public testing opportunity and data gathering platform. European armed forces should invest more in research and cooperation with civilian industry, as well as push for a Europe-wide legal framework for the use of such systems in road transport. Finally, since the US Army and the US defence industry are the most advanced in this field, European projects follow the example of the US Army. Particularly in times of war on NATO's borders and significant investments in the future hardware of NATO's armed forces, now is the time to usher in a new era of military logistics in Europe. ■

Dominik Juling has experience as a soldier with the German Armed Forces and NATO. He is currently studying Conflict Studies at the London School of Economics and Political Science. He will continue his studies with another Master's degree in Environmental Science at Yale University, where he will further deepen his expertise in the area of Climate and Security.