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The Next Generation Soldier: A System of Systems Approach?

edited by Alessandro Marrone and Karolina Muti

ABSTRACT

Over the next years, ongoing and future technological innovations, especially related to information communication technology (ICT), artificial intelligence (AI) and cloud will have an increasing impact on Western armies. The soldier will remain the army's primary element, but will need to be more and better connected in a secure way with the various assets at disposal, also learning the lessons from previous and often disappointing efforts towards net-centric or network-enabled capabilities. Moreover, innovations will be significant in terms of lethality, mobility, power generation and protection, as well as in training. Within the broader strategic and technological context, the US, France, Germany, Italy, Israel and the UK are important cases to consider, together with developments within NATO and EU frameworks. The conclusions outline a number of common themes and challenges, with a view to the way ahead particularly for Italy and other European allies.

Army | Drones | Artificial intelligence | Cyber defence | USA | United Kingdom | France | Germany | Italy | Israel | NATO | European Union

keywords

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* Alessandro Marrone is the Head of Defence Programme at the Istituto Affari Internazionali (IAI). Karolina Muti is Researcher in the IAI Defence and Security Programmes and was a Junior Pan-European Fellow at the European Council on Foreign Relations (ECFR). For the useful and constructive exchange of views during the project, the editors thank the Italian Army General Staff, Italian Defence Secretariat General/National Armament Directorate, Leonardo Company – in particular the Electronics Division – and Beretta Company. A final thanks to Danilo Mattera, intern at IAI from September 2021, for his timely contribution to the report's finalisation. This study has been realised with the support of Leonardo, and it has been completed on 15 November 2021.

Executive summary

Over the next years, ongoing and future technological innovations, especially related to information communication technology (ICT), artificial intelligence (AI) and cloud will have an increasing impact on Western armies. The soldier will remain the army's primary element, but will need to be more and better connected in a secure way with the various assets at disposal, also learning the lessons from previous and often disappointing efforts towards net-centric or network-enabled capabilities. Moreover, innovations will be significant in terms of lethality, mobility, power generation and protection, as well as in training. Within the broader strategic and technological context, the US, France, Germany, Italy, Israel and the UK are important cases to consider, together with developments within NATO and EU frameworks. The conclusions outline a number of common themes and challenges, with a view to the way ahead particularly for Italy and other European allies.

The Next Generation Army: Context and trends

In the mid-long term, foreseeable difficulties in the recruitment of adequate military personnel in the West, due to decreasing and ageing population, makes it crucial to employ and rely more on technology and unmanned systems. At the same time, technological innovations are provided mainly and increasingly by civilian companies, thus necessarily follow a market logic which in turn pose issues of adequate security conditions. Moreover, the return of great power competition results in the need by NATO countries to ensure in the land domain a tactical overmatch against near-peer competitors such as Russia and China, while urbanisation trends worldwide increase the likelihood to operate in congested and contested megacities.

In order to operate in such a complex, multilevel and cross-sectoral theatre of conflict, there is a need for a more interdisciplinary and multi-dimensional approach to military innovation. To this end, controlling information streams and avoiding information overload will be essential in contemporary and future land warfare. On the battlefield, it will be necessary to ensure an effective balance between soldiers' protection and mobility, as well as their sustainability in terms of energy reserves and power management. Finally, connectivity and communications remain two crucial aspects of the next generation soldier systems, particularly in relation to cyber defence.

Looking forward, Western armies will have to invest a lot of effort in achieving equipment interoperability, facilitating cooperative procurement, and recruiting and maintaining skilled work-force. Information superiority and situational awareness on the battlefield can eventually translate in better decision-making. This, however, will require next generation strategic thinking, concepts, doctrine and training, as well as the creation of new cross-sectorial civilian-military partnerships and *ad hoc* competences.

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The future of individual soldier equipment and technology evolution

Among the trends in technology innovation that are contributing to the definition of the next generation soldier's equipment, some deserve particular attention. First, Western armies are experiencing an erosion of their long-held competitive advantage over their adversaries in the context of near-peer conflicts, and to regain the upper hand, they need to invest in individual soldier equipment and technology. Secondly, current programmes are focusing on increasing lethality, through the acquisition of lighter and more powerful weapons and ammunition.

In order to increase soldiers' mobility, it will be crucial to reduce the burden of carried loads and improved their ergonomics. Since most of soldiers' equipment requires a lot of electricity, managing energy and power systems will be key priorities. Concerning sensors and navigation, it is expected soldiers will have enhanced multi-spectral sensors able to provide collaborative targeting and engagement capabilities, and an enhanced Fire Control System (FCS) which will ensure increased accuracy and lethality. On the communication side, advances will be facilitated by Software Defined Radio (SDR), 5G technologies and a new body sensor network. In the field of command and control (C2), soldiers will likely be provided with an information architecture covering visual, acoustic, and tactile interfaces ensuring commonality of data.

Robotics will be another fundamental trend in military technology innovation, with future soldiers likely resorting to unmanned systems (UxS) able to quickly reconfigure depending on the mission. To ensure enhanced soldier protection, it will be important to assure an optimal body armour without limiting mobility, possibly by tailoring soldiers' protection according to the mission requirement. Lastly, the clarity and quality of information obtained via Human Machine Interface (HMI) may be improved through a helmet mounted system able to access information without taking eyes off the battlefield.

The United States

The US Army's development of infantry technology for much of the past two decades has taken place along two parallel tracks: advanced technology efforts with integrated approaches like Land Warrior and Future Force Warrior programmes, and rapid fielding efforts that have put new equipment into units being deployed for combat operations, primarily involving irregular adversaries in Iraq and Afghanistan. With the US military shifting towards a focus on deterring near-peer adversaries, there is a perceived need for more advanced capabilities, and a sense of urgency to "catch up" to more advanced threats.

Working towards this direction, the US Army is pushing forward in soldier equipment modernisation in two key areas: the situational awareness of soldiers and weapon lethality. In order to improve the former, the military acquired a series of advanced vision devices to be integrated into a battlefield network. In this context, development is underway of the Integrated Visual Augmentation System (IVAS), a headset that will grant a better integration of soldiers with their unit. With respect to weapons' lethality, the Army is developing a new family of infantry weapons through the Next Generation Squad Weapons (NGSW) programme, and looking to acquire new ammunition and sound suppressors. The Army is also involved in other initiatives encompassing various soldier items. Examples are offered by the Adaptive Squad Architecture, the provision of unmanned systems at the squad, fire team, and individual soldier levels, and new developments in soldier protective gears.

The US Army's approach to modernisation at the infantry soldier level is shaped by a continued commitment to a common squad size and design across its considerable variety of formations, vehicles, and mission profiles. Overall, the trend in US soldier equipment is towards the integration of more and more features that are increasingly connected, thus raising the level at which the squad is required to integrate into the larger formation. At the same time, the US Army is focused on near-peer threats, which request soldiers to be more protected, lethal, and networked. Looking forward, the US Army will likely invest further in the IVAS and the associated networks, as well as robotic platforms. Concerning the latter, it will be important to address possible problems and threats concerning secure communications, loss of communication, sensor degradation and cyber vulnerability.

France

The transformation of the nature of conflicts in which France is called to intervene requires the development of new military capacities. The French Army can still fight in asymmetric conflicts like currently in the Sahel, nevertheless, in accordance with the prospective document "Future land operations" and the "Strategic vision" of the Army Chief of Staff, France must have a battle-hardened army ready in a combined and joint operations context even in the harshest fields of conflicts and facing the toughest clashes, up to a major confrontation, and be capable of winning. To this end, the French Army initiated the Synergy of Contact Reinforced by Polyvalence and Digitalisation (*Synergie du COntact Renforcée par la Polyvalence et l'InfovalorisatiON* – SCORPION), aimed at creating an evolutionary and flexible tactical combat system capable of fulfilling all present and future operational military missions, as well as setting up an Information and Combat System which will ensure informational superiority over the adversary. After the first step that strives to make the most of digital applications, a second step based on the progressive introduction of robotics and artificial intelligence in the SCORPION force will follow around 2035. This unprecedented short and long-term investment would substantially enhance the lethality, mobility, survivability sustainability and situational awareness of combatants.

Against this backdrop, France is working towards the modernisation of soldiers' equipment through the Individual Combatant Equipment (IEC) programme. This programme faces a major challenge: ensuring that individual soldiers will

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continue to benefit from essential links and data once they leave their vehicles. On the other hand, it is facilitated by three main factors. First, the experience gained through the Integrated Infantryman Equipment and Communications (*Fantassin à équipements et liaisons intégrés* – FÉLIN) system, which optimised soldiers' operation and decision-making functions but nevertheless presented difficulties in systems integration. The second factor consists of the Innovation Acceleration Platform for the Combatant (CENTURION), an innovation platform designed to detect, evaluate, develop technologies and integrate those with a demonstrated operational interest in the evolution of the fighter's equipment. Lastly, the third element relates to project VULCAIN which, among other things, is dedicated to the exploration and experimentation of un unmanned ground systems.

Germany

Germany has been working towards the modernisation of its infantry soldiers' equipment for almost three decades. In 2005 it introduced a system called Infantryman of the Future (*Infanterist der Zukunft* – IdZ), which has since become known as the Basic Version (*IdZ-Basissystem* – IdZ-BS). Given the system's excessive weight and bulk, Berlin later inaugurated the improved Future Soldier System-Enhanced System (*Infanterist der Zukunft-Erweitertes System* – IdZ-ES), also known as "Gladius". The IdZ-ES consists of a modular set of 20 different individual components and devices available to the soldier according to the tactical situation and the specific mission. They are divided into three sub-systems. The command, control, computers, communication and information (C4I) sub-system is the core element, linking the overall system to the operations command. The clothing, protection and carrying equipment (*Bekleidung, Schutz- und Trageausstattung* – BST) element is based on a layered approach to combine all the requirements for ballistic and environmental/climatic protection, camouflage, and comfort. Lastly, with respect to the weapons, optics and optronics (*Waffen, Optik und Optronik* – WOO) sub-system, Germany continues to rely on the G36 5.56x45 assault rifle, deemed to be replaced, while a new set of systems is under development concerning optics and optronics.

The German Army is concurrently working on procurement, deployment and further development of the IdZ system. The next step ahead is the IdZ-ES Plus, intended for the units to be assigned to the NATO Very High Readiness Joint Task Force (VJTF). Between 2019 and 2021, Rheinmetall was awarded a contract for IdZ-ES Plus as well as a risk reduction study contract for the definition of a follow-on 3rd IdZ-ES generation (IdZ-ES-3). Although the WOO and, to a certain extent, the BST components of the IdZ programme can be considered the result of the formulation of new operational requirements, this is not the case for the C4I element. Given the new operational possibilities offered by ongoing advances in consumers' electronics, Germany is reluctant to commit to a given technological status in this field, and is therefore currently unable to pinpoint when the IdZ programme will transition into a standard-issue procurement plan.

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Italy

In an attempt to reach a higher degree of preparation for an ever-changing operating environment, in 2019 the Italian Army published a doctrinal document outlining the operational scenarios land forces are likely to face in the future, as well as the capabilities that will need to be acquired to succeed in such contexts. In all scenarios, the Army is committed to adhering to a human-in-the-loop approach, with commanders at the centre of any military operation.

Among the procurement priorities identified by the Army, nano-, mini- and micro-unmanned vehicles and AI applications are deemed most critical. The main procurement channel for current and future innovations of the dismounted soldier equipment is the Individual Combat System (ICS – *Sistema Individuale di Combattimento*), consisting of an integrated weapon apparatus which envisions the soldier as its pivot. The programme encompasses five main components: protection, survivability, C2, nocturnal mobility and lethality. Demonstrating the military's tight collaboration with the whole industrial sector, since 2019 a group of Italian defence companies have formed a consortium aimed at supplying the equipment required by the programme. Moreover, Italy is currently working on technological applications which may have a considerable impact on the characters of the Army's future combat operations, including Enhanced Direct Kinetic Energy Weapons (EDKEW), conformal batteries for the enhancement of soldiers' energy autonomy, and Robotics and Autonomous Systems (RAS).

The Army considers soldiers as the essential elements of military activities, therefore it sees the enhancement of their intellectual and cognitive abilities as a priority for gaining control over the technological and autonomous components. The dismounted soldier represents *per se* a System of Systems (SoS), by combining the tools that are personally held and mastered. Yet, the dismounted soldier is also obviously part of a broader SoS, the squad, with its different and complementary roles played by its members, and the same approach applies to larger formations like platoons. In this context, Rome aims to create units able to operate according to a multi-domain approach in adverse conditions, all the while adopting a criterion of convergence which will ensure their success on the battlefield through the simultaneous use of a variety of performance-enhancing components.

The military shares the view that its networks still need a top-down organisation with a clear-cut, hierarchical command, control and communication (C3) system, not the least to ensure clear and efficient communication during conflict. Though this is already the case at all levels, it poses challenges in leveraging the SoS potentialities at operational and tactical levels. Here, the squad and platoon seem to be the two most appropriate levels to implement a SoS which balance the need for vertical C3 with the benefits of horizontal networks.

The United Kingdom

In the field of soldier modernisation, the UK is moving ahead with a serious exploration of and investment in unmanned systems, electronic warfare and cyber-capabilities, and an overhaul of the British military's command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) equipment and structures. However, cuts in the British Army's traditional capabilities, personnel and armoured vehicles, coupled with a still unaffordable equipment plan, suggest difficulties in reaching such a goal. Nevertheless, the prospective soldier SoS is intended to be transformational. There is an increased focus on persistent engagement through regular deployments to areas of interest abroad, and the future force looks to be more agile in some regards. Notably, much of the British Army will deploy independently in sub-platoon-sized small teams and independent company-scale formations generated by the new Special Operations Brigade and Ranger Regiment, with teams required to inter-operate *ad hoc* with partners.

To advance its soldier SoS, the UK is reflecting over lessons learned through the Future Integrated Soldier Technology (FIST) programme, besides working to complement the roll-out of new equipment and systems to the whole force. In this context, the 2nd Battalion of the Yorkshire Regiment is set to become the Army Experimentation Force, in which units will train and conduct operations with new, untested equipment. As experienced with FIST, the British Army recognises that successful transformation must be underpinned by procurement reforms, for it will be reliant on leveraging commercially-available technology and systems quickly.

A clear example of a British modernisation effort in the field of basic soldier equipment consists of the Virtus Soldier System, designed to emphasise weight minimisation and modularity. The most fundamental part of the new British SoS, however, is the C2 architecture, integrating the other components sitting under the umbrella of the Land Environment Tactical Communication Information Systems (LE TacCIS) programme. By 2024-2025, Project Morpheus intends to provide new tactical communication information systems, while the British Army Digital Transformation Program (THEIA) is exploring AI and machine learning (ML) applications to support the British communication architecture. Among its modernisation initiatives, the UK is also adopting unmanned systems, in particular UGVs, which however are yet to be fully integrated into the C2 architecture.

Israel

In recent years Israel has implemented a series of force structure reforms that boosted spending on technology, as demonstrated by the modernisation programme known as "Digital Ground Army" or Tsayad: a network of networks intended to link all echelons from the individual soldier and infantry squads to the division level. The Israel Defence Forces (IDF) have recognised the importance of new technologies for conducting decentralised operations and maximising the coordination of combined and joint capabilities. In the meantime, they have realises the operating warfare scenario was experiencing a profound transition, acknowledging three main priorities: owing to the rise of subterranean operations, the challenges of fighting among multi-story structures, and the imperative of controlling and saturating the low airspace, with large numbers of small and medium-sized unmanned aerial systems operated directly by the Army; speeding up the ground forces' Observe Orient Decide Act (OODA) loop; and pushing combined and joint capabilities to smaller echelons.

Overtime, the IDF understanding of Tsayad evolved beyond the mere sharing of data, extending its reach to provide C2 for smaller units through Elbit's Torch 750 system. Within this system, Rafael's Fire Weaver provides infantrymen with easy access to fires by facilitating the sharing of targeting information with combined and even joint fires, granting excellent speed and precision. The IDF also eventually inaugurated the Integrated Advanced Soldier (IAS) programme, aimed to fully link infantry systems with Tsayad.

The multi-year "Momentum Plan" or *Tenufa*, launched in 2019, can be considered an Israeli interpretation of the Multi-Domain Operations (MDO) concept, and prescribes the IDS to further accelerate the OODA loop and use technology for enhanced multi-domain operations. With respect to the infantry equipment, Israel is focused on enhancing soldiers' and small units' ability to identify threats and then report that information to the network, all the while feeding information laterally and vertically. To this end, Rafael is developing a system called Automatic Target Recognition (ATR), while Elbit recently produced the Assault Rifle Combat App System (ARCAS). Moving forward, Israel is committed to achieve greater integration of all newly introduced unmanned platforms, which will grant the IDF with a higher degree of automation.

The EU and NATO frameworks

In the last few years, the EU has been investing a certain effort on the next generation soldier architecture. The European Defence Agency (EDA) has been working on the Project Team 21st Century Soldier System (PT 21st CSS), while in the context of the Preparatory Action on Defence Research (PADR), several EU member states have been involved in the development of a Generic Open Soldier Systems Architecture (GOSSRA). The European Defence Fund (EDF) is investing on military innovation for the dismounted soldier, through a series of calls for projects aimed at increasing infantry's capabilities in terms of mobility, availability of tools, energy management and situational awareness.

The digitalisation of European armed forces is gradually changing the way in which EU member states will plan and conduct future conflicts. Despite its growing attention on Emerging and Disruptive Technologies (EDTs) for military uses, the EU is still lacking a data picture for the digitalisation of its armed forces. To mitigate this problem, member states could take advantage of the opportunities offered by the Coordinated Annual Review on Defence (CARD) and the Permanent Structured Cooperation (PESCO). Still, to be able to rely on innovative technologies

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on the battlefield, the EU member states will need to improve interoperability and cooperation among national militaries. Overall, the Union should encourage capability development initiatives among its members in the field of future soldiers' equipment, favouring programmes and activities in research, development, technology and innovation.

In the recent past NATO has not paid a lot of attention to the individual soldier's equipment. However, the Alliance is currently working on a standard for the next generation soldier equipment – the NATO Generic Soldier Architecture (NGSA) – and investigating the impact of EDTs on its military operations. The Alliance is also promoting the development of projects able to translate abstract concepts into concrete military capabilities by favouring cooperation among member states, such as the Military Uses of Artificial Intelligence, Automation, and Robotics (MUAAR) project. In this context, the Alliance should explore the possibility of establishing interoperability standards for the use of military applications of AI, as well as define a common approach for the Verification, Validation and Accreditation (VV&A) of AI applications used in the context of military operations.

Conclusions

This study aims to provide an overview of strategic trends, technological developments and NATO/EU frameworks, as well as an analysis of national realities in major NATO countries and Israel.

The resulting landscape is rather complex and variegated. Yet some key, common themes and challenges can be outlined, with a view to the way ahead particularly for Italy and other European allies:

- The lessons learned from military history and wishful thinking on technological innovation;
- The Army's unique difficulties in dealing with technologies;
- The complicated relation between ICT and the military;
- The requirement: to ensure soldier's superiority against near-peer adversaries;
- The way ahead: a renewed System of Systems approach;
- Near-peer adversaries and Multi Domain Operations;
- The NATO and EU dimensions: opportunities for Italy.

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1. The Next Generation Army: Context and trends

by Karolina Muti[1]

This chapter will present some trends that have an impact on contemporary warfare and the next generation army, through a three-steps approach. Firstly, it will briefly describe some macro-trends influencing the international context and the transformations relevant for the armed forces. Secondly, it will look at trends that more directly influence contemporary conflicts, by zooming on the contemporary battlefield and observing dynamics relevant for the next generation army and the future of the dismounted soldier. Last but not least, it will argument that these simultaneous and multidimensional changes result in open questions that will have to be addressed by Western armed forces, including through their approach to the equipment of next generation soldiers.

1.1 The macro-trends in the international context

Demographic trends are showing how the world population is not only growing, but increasingly organising its life in big cities. This in turn puts under pressure the capacity and the organisational structure of urban areas, with potential consequences for the security and control over the territory. If in 1960 only 0.5 billion of the 3.2 billion of world population lived in towns, nowadays 3.5 billion people out of 7 billion do so[2] – a steady shift from 15.6 per cent to 50 per cent. The force ratio, calculated by dividing the number of population by the number of security forces, increased dramatically in the last 70 years (1950–2020). To give an example, during the Troubles (Northern Ireland) in Belfast (1972) the force ratio was 23:1, over the Iraq war in Baghdad (2000–2020) 100:1, in Aleppo in 2013 214:1.[3] The fertility rate decrease coupled with the progressively ageing population are further demographic tendencies affecting in particular Western societies and influencing directly their Armed Forces. In Europe, in 2019 the average fertility rate was 1.53 births per woman,[4] far below the replacement level of around 2.1. The decreasing population rate does not help in recruiting military personnel, a task that is already difficult considering that the amount of population in working age that sees such a career as appealing is limited e.g. in Europe. Consequently, ageing military personnel is a challenge for most of NATO Armed Forces, even more so for the Army branch due to its specificity and the type of operational tasks that it is expected to accomplish. The related risk of a decline in physical performance of the soldier, together with the reduced number of personnel, makes the role of and reliance on technology and robotics both crucial and a double-edged sword.

[1] Karolina Muti is Researcher in the IAI Defence and Security Programmes.

[2] Anthony King, *Urban Warfare in the Twenty-First Century*, Cambridge, Polity Press, 2021; Anthony King, keynote address at 16th ERGOMAS Conference, Tartu, 19-23 July 2021.

[3] Ibid.

[4] Eurostat, *Fertility Statistics*, March 2021, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Fertility_statistics.

The limited number of deployed personnel goes in pair with the need for higher performance levels, quality of training and highly skilled resources.

In this context, the XXI century globalised city became the perfect theatre for both asymmetric and hybrid warfare. Moreover, the digital era and the resulting connectivity make the conflict "glocal" and the resulting effects "glocalised",[5] that means local and global at the same time, simultaneously localised but connected to other areas and communities around the globe. This produces what has been defined by Anthony King as "transnationalisation of global battlefields" and a "network topography" of the planet.

The second obvious trend-setter is the technology revolution, in particular in military affairs. The pace of innovation in artificial intelligence (AI), robotics, nano- and bio-technologies, unmanned systems (UxS), materials, quantum computing as well as post-quantum, is going to change the contemporary battlefield, in manners that are still hard to grasp and fully understand. Technological innovation is revolutionising the way of conducting war, but in a partial and peculiar way. Indeed, some of its short to mid-term effects have been overrated and encountered, after the high tech enthusiasm phase, a number of important limits in terms of human factor, systems integration, command, control and communication (C3), connectivity, interoperability and logistics.[6] It will likely still be a revolution, but its full potential is not easy to achieve, as proved over the last two decades by the modest improvements in the effectiveness of network centric capabilities across NATO countries. In some cases, land warfare envisages operational complexities that are absent/limited in other domains,[7] with a direct influence on the use of technology. It is the case for instance of having non-combatants' presence in the operational theatre.[8] Additionally, in the land domain for NATO members some technologies like robotics remained underdeveloped, underexploited, and their use by the Allied armies lagged behind compared with its use in other domains.

Another factor linked to technology is that key innovations are increasingly developed by civilian stakeholders, and thanks to globalisation they are more diffuse. The development and production of such technologies, assets and services, in particular information communication technologies (ICT), follow the market logic, which not always pairs with security and safety, posing significant threats when such technologies are adopted by the armed forces, for instance in terms of cyber security and vulnerability to electronic warfare. On the reverse side, the market logic pushes Western defence industries to sell their products to non-Western states, to survive on a competitive and volatile market. Buyers often request technology transfers,[9] thus accelerating the erosion of technological edge

5 Anthony King, *Urban Warfare in the Twenty-First Century*, cit.; Anthony King, keynote address, cit.

6 Interviews, 7 June and 25 August 2021.

7 Interview, 7 June 2021.

8 Ibid.

9 Michele Nones, "Ue/Cina: più integrazione europea a difesa sovranità tecnologica", in

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currently enjoyed by the Western armed forces. Small and mid-size states, not necessary allies, developing the right technical and scientific know-how or niche capabilities (for instance in AI application, biotechnologies) can gain a relevant advantage.[10] In fields such as AI, the misuse of technology for instance as a tool for authoritarian control of societies is an ever present risk. Moreover, civil innovation does not necessarily help Western armies in regaining tactical overmatch over near peer competitors.

Last but not least, while since the 1990s the operational experience of Western armies mostly related to crisis management, counter terrorism, counter-insurgency and stability operations, recent years witnessed a trend towards the return of great power competition. Fortunately, this trend has not brought to major wars yet, but it has already raised the intensity of conflicts that Western troops would encounter by intervening in theatres such as Syria, Iraq and Libya, seriously questioning their superiority in case of a conflict with a peer or near peer competitor, such as Russia or China. Some observers note how near peer competitor threats are at the highest point since the Cold War,[11] fuelling an important adjustment in the US military, including the Army, which is set to affect – albeit to varying degrees – the military doctrine and capabilities of all NATO members. In operational terms, for Western armies the priority in next generation soldier systems is to regain the tactical overmatch over near peer competitors. This objective will continue to drive technology developments in the domain. The very modest outcomes in terms of effectiveness of individual soldier systems in the last two decades led to a reduction, or even a loss of superiority in land warfare by Western armies, in some cases over both state and non-state actors that ended up using equally effective systems.

All these macro-trends co-exist and interact with each other. Therefore, for example, the growing urbanisation will influence both the asymmetric warfare waged by non-state actors and the multi-domain approach to high intensity conflicts by great powers.

1.2 Trends in conflicts

Against this backdrop, the contemporary theatre of conflict appears to be a complex, multilevel and cross-sectorial environment, where the physical, information technology and cognitive dimensions need to be smoothly integrated to be effective. This proves to be a significant challenge even for the most advanced armed forces. The co-existence of both asymmetrical and hybrid warfare is another element that complicates the understanding of contemporary battlefield, with

AffarInternazionali, 4 April 2019, https://www.affarinternazionali.it/?p=73590.

[10] Can Kasapoğlu and Barış Kırdemir, "Artificial Intelligence and the Future of Conflict", in Tomáš Valášek (ed.), *New Perspectives on Shared Security: NATO's Next 70 Years*, Brussels, Carnegie Europe, 2019, p. 35-39, https://carnegieendowment.org/publications/80421.

[11] David Vergun, "Near-Peer Threats at Highest Point Since Cold War, DOD Official Says", in *DOD News*, 10 March 2021, https://www.defense.gov/News/News-Stories/Article/Article/2107397.

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consequences for military doctrine, planning and training. The need for a more interdisciplinary and multidimensional approach that would push ahead systems integration collides with the growing number of its components.[12] In this context, questions arise on how can armed forces better adapt to the dimension and pace of the current changes in the operational environment, to the relation between the human and non-human component, which skills does the next generation soldier need to have, and consequently, what training.

Controlling information streams is considered by many experts as the key for success in contemporary warfare. The dismounted soldier is learning how to operate in coordination with a number of unmanned and potentially autonomous systems, but his/her cognitive abilities to process information or to take a decision are limited by the very human nature.[13] Broader developments in biotechnology or genetics that work to change the latter are to be carefully evaluated including from an ethical standpoint. Against this backdrop, AI and machine learning (ML) come in support to complement human limitations.[14] The soldier in this sense might be supported by a technology solution deemed necessary, but, despite numerous technological advancements, the soldier remains the backbone of the process.[15]

The volume of information available thanks to new technological solutions contrasts with human and biological limits, particularly in Carl von Clausewitz's fog of war, and poses important dilemmas on how to select the necessary information to support an effective decision-making on the field. The risk of information overload poses the question of how to carefully select and filter it, by avoiding algorithm and AI biases and also to avoid the tendency of "micro-management" by higher echelon commanders which have the tendency to go down to the very tactical element. The relation between the commander, for some observers more and more "digital", and the rest of the troops, is also evolving due to the technological leap forward.[16] The commander today can potentially receive biometrical data of his/her soldiers during an operation in order to assess the stress level and health state,[17] but there is no agreement on what impact such information could have on the command's effectiveness and whether it is really necessary. Similarly, a high level official thousands of kilometres away from the operational theatre may have near-real time access to what is happening during an operation,[18] but it is not clear whether this possibility could bring benefits at tactical or operational level. The fact technology allows the military to have something, does not necessarily mean that

12 Interview, 25 August 2021.
13 Interview, 7 June 2021.
14 Interview, 11 June 2021.
15 Alexander Yermakov, "The Army and Air Force of the Future", in *RIAC Analytics and Comments*, 28 January 2021, https://russiancouncil.ru/en/analytics-and-comments/analytics/the-army-and-air-force-of-the-future.
16 Presentation at the 16th ERGOMAS Conference (Digital Commander), July 2021.
17 Interview, 11 June 2021.
18 Ibid.

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it is needed. The same applies to the wearable systems meant to serve the tactics the dismounted soldier is trained to use, without constraining it.

Another important trend affecting conflicts is the long-standing demand in Western societies for force protection. Casualties in conflict, in particular deaths among national combatants, but also non-combatants on the ground, bear a high political price and its acceptance is very limited among the public opinion. This trend has gradually influenced and oriented technical solutions towards an enhancement of both survivability and lethality of the soldier. This directly relates to the need for more accuracy and a longer range of Small Arms and Light Weapons (SALWs) used by the individual soldier. In the artillery field, the trend is to increase the range and use of guided ammunition.[19]

The difficult balance between protection and mobility of the soldier is another key element on the battlefield. In fact, there is still space for considerable improvement when it comes to soldier's tactical gear and its weight, as well as the load bearing capabilities and protection. Developments in the field of new materials are promising in this sense. Power management and sustainability is another factor of uttermost importance for troops to operate effectively, with more enduring batteries.

Connectivity and communications remain two crucial aspects of the next generation soldier systems.[20] Communication acquires a new dimension considering that it entails both communicating with other soldiers and with unmanned systems. The interaction and integration among all components, both wearable (what a soldier wears and physically carries in gear) and peripheral (what helps him to achieve the mission), from the radio to batteries, to the laser range finder or the goggles, is also key.[21] In this context, developments in the field of virtual and augmented reality present new opportunities for training, exercises and simulations, in order to complement, but not substitute, conventional training.[22] These opportunities are particularly relevant to test the effectiveness and sustainability of innovative solutions and equipment affecting the protection-mobility balance, connectivity and communication.

1.3 Open questions for the next generation soldier

The next generation soldier is a fitting example of how a combination of old and new elements will characterise the conflicts of the future, by bringing a number of question marks. Novel technologies improve for example situational awareness,

[19] Alexander Yermakov, "The Army and Air Force of the Future", cit.

[20] Global Defence Technology website: *Connectivity: The Heart of the Future Soldier*, April 2020, https://defence.nridigital.com/global_defence_technology_apr20/connectivity_future_soldier_technology_networks.

[21] Ibid.

[22] Vertigo project (upcoming).

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survivability and lethality of the soldier, together with SALWs precision and range. In parallel, overreliance on technology, especially on those related to communication systems, is a source of vulnerability in case of C3 disruption. Electronic warfare in this sense shows how the dismounted soldier needs to be capable of both using such connected equipment and to operate with damaged communication in case of necessity.[23]

At the same time, the need for better integration of these complex systems, as well as of a multidimensional, interdisciplinary approach is at odds with the fragmentation caused by the number of their subcomponents – body armour, helmet, goggles, SALWs, radio, radar, UxS, and so on.[24] This poses a concrete challenge for equipment interoperability among allies and partners, in context of NATO and EU missions, but also in other bilateral or multilateral *ad hoc* formats. A similar problem arises for cooperative procurement, and defence industrial cooperation is particularly difficult for NATO and EU allies and their partners, not least because of the lack of alignment and coordination in requirements. In addition to that, the pace of technological innovation will create a divide between those countries that have economic and societal means to take advantage of these solutions and those who do not and will have to rely on the assets of allies, or simply fall behind. Last but not least, Western armies will have to face the problem of competition for skilled work-force and retention of it,[25] with a variety of situations in terms of national labour markets within NATO.

Necessary ethical considerations related to the use of AI and autonomous systems may also restrain, or slow down, the use of such assets for some Western countries, with the risk that other states gain advantages in this field without addressing ethical concerns.

The key importance of information superiority and situational awareness on the battlefield can eventually translate in better decision-making, at tactical, operational, or strategic level, but does not do so automatically. The ongoing technology innovation will most probably change the way of conducting war, and facilitate enormously part of the tasks of the future dismounted soldier. The other side of the coin is that effective action in such a changed and ever-connected battlefield, with blurred lines between war and peace, combatants and non-combatants, civilian and military, will require next generation strategic thinking, concepts, doctrine and training. Moreover, it will likely imply the creation of new cross-sectorial civilian-military partnerships, as well as of new competences and figures not only highly specialised but also capable of putting together all the pieces of the puzzle.

[23] Interview, 7 June 2021.
[24] Interview, 25 August 2021.
[25] Can Kasapoğlu and Barış Kırdemir, "Artificial Intelligence and the Future of Conflict", cit.

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2. The future of individual soldier equipment and technology evolution

by Claudio Bigatti and Eugenio Po[26]

This chapter identifies some trends in technology innovation and how they are shaping the development of future individual soldier equipment in Western countries. The United States are the leading actor in this process and, as such, most of the examples are taken from the vast experience of the US Army and its procurement programmes.

2.1 Superiority erosion

A major concern for Western armies' leaders is the erosion of the long-held competitive advantage over expected adversaries, in the context of near-peer conflicts. This competitive advantage has been decreasing in recent years across multiple warfighting domains.

The response to such superiority erosion for the US Army encompasses six modernisation priorities, coordinated by US Army Futures Command: Long-Range Precision Fires, the Next Generation Combat Vehicle, Future Vertical Lift, the Army network, air and missile defence, and soldier lethality.[27]

Soldier lethality is a quite extensive concept, since it includes all the fundamentals: shooting, moving, communicating, protecting and sustaining.

The US Army's aim is to regain the close combat tactical overmatch,[28] i.e. the ability of a squad sized unit (around 10 soldiers) to impose its will on similar sized opponent under all conditions and operational environments.[29]

Building overmatch for close-combat soldiers (i.e. front-line soldiers) – a target for all Western armies – must include investment in individual soldier (known also as Dismounted Close Combat, DCC) equipment and technology, and also improvements on the necessary physical and mental attributes.

[26] Claudio Bigatti is journalist and collaborator of the Italian magazine *Rivista Italiana Difesa* (RID). Eugenio Po is Head of RID.

[27] US Army, *2019 Army Modernization Strategy: Investing in the Future*, October 2019, https://www.army.mil/e2/downloads/rv7/2019_army_modernization_strategy_final.pdf.

[28] Daniel S. Roper, *Regaining Tactical Overmatch: The Close Combat Lethality Task Force*, Arlington, Association of the United States Army, April 2018, https://www.ausa.org/node/6579.

[29] US Secretary of Defense, *Directive-type Memorandum 18-001, "Establishment of the Close Combat Lethality Task Force (CCLTF)"*, 16 March 2016.

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2.2 Lethality

Previous "Future Soldier" programmes almost totally ignored increasing lethality. In the current international security environment, lighter and more powerful weapons and ammunition are the main solutions designed to regain overmatch over adversary (notably Russian and Chinese) small arms.

At squad level, the US Army has acknowledged that it has lost the tactical superiority even against asymmetrical opponents due to the widespread use of Russian/Soviet weapons chambered in 7.62x54R cartridge (PK/PKM machine guns and Dragunov, DMR, Designed Marksman Rifle) whose range is greater than US/western weapons[30] (that means, for example, that adversaries can fire and hit from safe position). To regain the tactical overmatch the US Army in 2018 started the Next Generation Squad Weapons (NGSW), a new programme to develop a new rifle (NGSW-R) and a new light machine gun (NGSW-AR)[31] using a common 6.8 millimetres (mm) cartridge and Fire Control (NGSW-FC). The effort aims to field to the Close Combat Force (CCF) of the Army, basically the front-line troops, with the NGSW-R as the planned replacement for the M-4A1 assault rifle and the NGSW-AR as the planned replacement for the M-249 Squad Automatic Weapon (SAW) both chambered in 5.56x45. The US government developed new 6.8 mm bullet, but the complete cartridge has not yet been selected, since the programme is currently in a competitive prototyping iteration with three suppliers for weapons and ammunition. The latter include SIG Sauer designing weapons and ammunition, Lone Star Future Weapon (which has taken over General Dynamics-OTS/Beretta)[32] for weapons with True Velocity[33] for ammunition and Textron Systems with Heckler & Koch for the weapon and Olin Winchester for ammunition, and two vendors for fire control -Vortex Optics and L3Harris.

Due to the nature of the general-purpose ammunition, the 6.8 mm projectile – with an effective range well over 600 m (estimated around 1,000 m) – will outperform even the last evolution of 5.56 mm and 7.62 mm, being 20 per cent lighter than current 7.62 mm. These systems (weapon and ammunition) will improve soldiers' capabilities in terms of accuracy, range and lethality. The US Army's goal is that over the next five years it would add more than 120,000 new NGSW-AR and NGSW-R to the arsenal to replace the M-4 and M-249 by 2025 in the CCF. However, the M-4

[30] The range of PK/PKM (7.62x54R) and Dragunov DMR (7.62x54R) is far greater than all 5.56x45 chambered weapons of the Rifle Squad. The range of these Russian designed weapons is even slightly greater than the range of M-240 medium machine gun (7.62x51) available (not always) in a couple of examples inside the platoon (in the weapons squad).

[31] NGSW-AR stands for Next Generation Squad Weapon-Automatic Rifle but this weapon is actually a machine gun since is belt fed.

[32] On 30 June 2021 a new company, LoneStar Future Weapons, has taken the lead on the post-development phase of the weapon originally designed by General Dynamics-OTS/Beretta becoming prime contractor and taking over the entire project form General Dynamics-OTS/Beretta.

[33] True Velocity, "True Velocity to Bring Manufacturing Expertise and Innovation to Force Modernization", in *PR Newswire*, 12 April 2021, https://prn.to/3p0OMwW.

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and M-249 will not be retired from service and the timing of their future phase-out remains unclear.[34] Two of the three 6.8 ammunition (SIG Sauer and General Dynamics-OTS/Beretta with True Velocity) can be adapted to current 7.62x51 NATO weapons,[35] so a possible alternative could be the adoption of the 6.8 mm on previous 7.62 mm platforms.

Since in the past decades several infantry weapons programmes were expected to be revolutionary and then have been terminated before adoption, it is unclear if NGSW (and its 6.8 mm) will get into production or not. Anyway, the US Army retains the need for a powerful and lighter family of weapons, and as happened in many cases, if the US Army adopts a new calibre, that calibre – sooner or later – will become a NATO standard.

Regarding NATO's assault rifles, although the replacement of the NATO 5.56 mm cartridge is not a subject under discussion, it would be however a desirable improvement (especially if the US Army adopts new 6.8 mm). For Western forces, replacing the NATO 5.56[36] is anything but simple: the previous experience of the shift from 7.62 to 5.56 mm on assault rifles has shown how complex it can be.

The introduction of a new cartridge, more powerful in terms of range and terminal energy, dimensionally "interchangeable" with 5.56 so that current assault rifles can be simply converted to the new calibre, can be a feasible approach. An approach similar to the NGSW programme. Currently candidates appear to be the 6 mm ARC (Advanced Rifle Cartridge) and the 6.5 Grendel.

New trends in military small arms (rifles, light machine guns and even pistols) include introduction of innovative suppressors that minimise flash and reduce sound levels: quieter fire means no need of ear protections, better situational awareness and easier voice communication. Sound moderators design is one of the new frontiers where the use of 3D printing and innovative materials will be employed to optimise characteristics and to reduce infrared (IR) signature.

Regarding 40 mm low velocity grenade launchers, weapons (M-203/M-320 like) often included in the equipment of the ongoing Future Soldier programmes, new ammunition were developed: they have increased performances (muzzle velocity and/or superior effects)[37] but are also guided. Mini-missiles have a maximum

[34] At the moment only the CCF weapons will be replaced with the new NGSW-AR and NGSW-R. The rest of the US Army units (300,000-400,000 soldiers) will keep M-4 and M-249.

[35] 7.62x51 mm NATO is standard rifle cartridge for assault rifles widely used by NATO, today is the standard NATO calibre for NATO's General-Purpose Machine Gun, GPMG, and ammunition arms Marksman Rifle, DMR (as US Army's M-110A1 SDMR).

[36] 5.56x45 mm is a NATO a standard cartridge widely used by NATO members as small arms ammunition cartridge.

[37] Muzzle velocity is the speed of a projectile with respect to the muzzle at the moment it leaves the end of a gun's barrel (i.e. the muzzle). Superior effects is referred to the terminal ballistic on the target (i.e. effects of the projectile when it hits and transfers its energy on the target).

range of 1,000-2,000 m and a Semi-Active Laser (SAL) or IR (uncooled) seeker and can replace anti-material rifle. Other solutions, launched by the 40 mm grenade launcher, as the DefendTex Drone40, used by British Army in Mali for surveillance and reconnaissance, can be employed as loitering munitions[38] and are capable of operating in swarm.

Various families of loitering munitions/killer UAVs are under development. Most of them are still big and heavy (as AeroVironment Switchblade), making them suitable for Platoon level (40 soldiers or more), but further reduction in weight and dimensions can adapt these systems to a single dismounted soldier (DCC).

Other promising technologies, such as High-Power Microwave, High-Power Laser, will probably have a longer time horizon, well beyond 2030, which is difficult to detect at the moment.

2.3 Mobility

Reducing the burden of carried loads carried is crucial to increase mobility. Heavier loads decrease stamina, strength, acceleration and agility. Strictly connected to weight and loads is ergonomics: most equipment is carried by Modular Lightweight Load-carrying Equipment (MOLLE) -like systems. The increase of ergonomics of load carrying equipment, and of equipment itself, and a newer and greater emphasis on female soldiers – who are cleared to conduct similar combat roles to their male counterparts – are fundamental aspects to improve DCC capabilities.

The way to do so is lighten loads and increase the comfort of the DCC with solutions encompassing clothing, Human Machine Interfaces (HMIs), thermal physiology and the way in which soldiers are loaded. To reduce the burden on frontline soldiers several exoskeletons are under development, ranging from powered exoskeletons such as ONYX from Lockheed Martin, with all the limits of a system that needs energy, to passive-exoskeleton not requiring any power source as Exobuddy procured by Dutch Army or V-Shield from Italian company Mech Lab.

Unmanned ground vehicles (UGVs) can be used to lighten the load, for logistics, as well as enhance the command and control capability of the dismounted infantry. Systems as Lockheed Martin Squad Mission Support System (SMSS), or the US Army's Squad Mission Equipment Transporter (SMET), IAI REX, or HDT Robotics' Micro Utility vehicle (MUV) can be very useful to play this role.

2.4 Power system and managing energy

Managing energy and power systems are key points of the soldier system because most of the equipment requires a lot of electricity. Two solutions are generally

[38] A loitering munition is a weapon system category in which the munition loiters over the target area for some time, searching for targets, and attacks once a target is located.

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employed to manage power: a centralised or decentralised architecture. Within a centralised power system, there is a single central component that provides the power. In a decentralised system, this task is distributed over a number of devices. Both have advantages and disadvantages.

Providing enough energy for the soldier systems is a key issue. Wearable power systems (with great attention to ergonomics) with lithium-ion rechargeable batteries is the most advanced solution. On the mid-term, batteries will likely become lighter and more energy-dense, while in the long-term the target will probably be portable wearable fuel cells (hydrogen or methanol feed) able to storage more energy than the batteries.

2.5 Sensors and navigation

As for energy, in the field of sensors – and broadly speaking electronics – the future is about open architecture systems, with various modular elements combining together.

Soldiers will have enhanced multi-spectral sensors enabled by modular integration, to provide mission-tailored systems at significantly reduced weight. Sensors will be capable of fusing their feeds and being shared among soldiers, providing collaborative targeting and engagement capabilities. This move can be considered as part of a system of systems approach.

Currently, US Army Enhanced Night Vision Goggle III and Family of Weapon Sight-Individual (ENVG III/[39] FWS-I) programmes provide dismounted soldiers with a solution that allows them to navigate and rapidly acquire and engage targets in all light levels and conditions.

In the field of weapons' sensors, soldiers will have an enhanced Fire Control System (FCS), a ruggedised system that increases accuracy and lethality. Future generation FCS will combine variable magnification, a ballistic calculator, an atmospheric sensor suite, and a laser rangefinder in a small and light system. Examples of future FCS are the two finalists of the NGSW-FC of the US Army. The two systems, respectively from L3Harris/Leupold and Vortex Optics, have aforementioned features and also an in-scope digital display that produces an adjusted aim-point for the soldier within the field of view. NGSW-FC was designed to provide soldiers with an "integrated approach" to increase accuracy and decrease the time required to engage a threat.

Notably, future systems will have digitally enhanced aiming, automated target recognition/tracking algorithms, direct view primary optics, and an integrated design leveraging emerging technologies such as artificial intelligence and

[39] BAE Systems website: *ENVG III/ FWS-I Night Vision Mobility and Targeting System*, https://www.baesystems.com/en/product/envg-iii-fwsi-night-vision-mobility-and-targeting-system.

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advanced optical materials.

2.6 Communications

The advent of a body sensor network will provide real-time reporting of soldier health. Sensors embedded in the helmet, clothing, and smartwatch will monitor physical health and performance. Wirelessly linked to the soldier processing system, the availability of this data will allow the commander to make informed decisions during combat. If the soldier is seriously injured, information will enable medics to act faster during the 'golden hour' following trauma.

On communications, hand held Software Defined Radio (SDR) technologies are well-established, while the future of DSS communication systems will envisage cognitive radios employing adaptive bandwidth waveforms. On the wireless point of view, in the future 5G communications is expected to move voice, video, text and image data with bandwidth as fast as 300 GHz to create data on demand for the battlefield, replacing current 4G/4G LTE technologies. In a far future the technology will shift from 5G to 6G, today under study.

2.7 Command and control

In the command and control (C2) field, in the future commanders and troops will likely be provided with information across a set of connected devices covering visual, acoustic, and tactile interfaces to access voice, data, video, and background information. The information architecture will ensure commonality of data, with each device determining the appropriate means of presentation. Navigation system will probably incorporate simultaneous localisation and mapping technology, and therefore will be capable of operating in a global positioning system-denied environment. This is an important development considering the growing adversaries' ability to disrupt main Western C3 networks, and may be considered an element of resilience within a broader system of systems approach.

The next generation soldiers will be provided with a personal role computer with advanced HMIs (wearable watch, advanced glasses, touch screen devices). An important issue for future systems will be the standardisation of data and net protocols, interfaces, plugs, energy managers (and storage systems). Another crucial issue is cyber defence, considering the increased connectivity among soldier's devices and the growing role plaid by information communication technologies in the future equipment.

2.8 Robotics

Robotics is a cross functional theme, as unmanned systems are involved in lethality, recognition and mobility. Most of the UxS will be employed at a higher functional level such as platoon and above, but several unmanned systems are becoming smaller and smaller, therefore suitable in theory for squad and even single soldier employment. In that field nano-unmanned aerial systems (UAS) as the FLIR System

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PD-100 Black Hornet (weight 18 grams, length 10 centimetres, for 25 minutes of endurance and 1,600 metres of range) will probably be standard reconnaissance assets for a DCC or a squad and has been acquired also by France. Small UGVs are already used in theatre, but next generation soldiers will probably employ man-packable, miniature, highly mobile, unmanned systems with advanced sensors and mission modules for dismounted forces. They will be likely designed so that operators can quickly reconfigure for various missions by adding/removing modules and/or payloads.

Concerning control systems, a desirable solution would be a common console to control every kind of UxS. Indeed, the US Army is currently working on Universal Robotic Controller to manage every kind of UGV, including wheeled, tracked and leg robot).

2.9 Protection and new materials

In the field of protection, improvements in lethality due to wider diffusion of armour-piercing ammunition, and powerful cartridge for sniper rifles, will push towards further upgrades of body armour.

The key issue is to reach the best balance between weight and protection, assuring an optimal armour without limiting mobility. A possible solution is to tailor soldiers' protection according to the mission requirement, balancing the former with agility to provide optimal survivability. Probably, future systems will consist of tiered, modular protection providing enhanced capability without increasing weight. Design and integration with other elements of the soldier system should ensure compatibility between legacy and future equipment.

In the field of protective insert plates for body armour, new materials currently under study will improve performances of current systems made in boron carbide or silicon carbide ceramic. The liquid body armour employing non-Newtonian fluids to stay liquid under normal pressure and become solid under heavy pressures is under study in the US and Poland: it consists of kevlar soaked in a shear thickening fluid or a magnetorheological fluid. Other promising materials are tungsten and carbon nanotubes, as well as graphene composite.

Future helmets will probably be lighter in order to balance the extra weight of the goggles or the Helmet Mounted Display, but will offer a greater protection. The area covered by helmets is lowering: newer helmets do not protect around ears so to easily wear headphones. Future developments must consider a greater lateral protection with the integration of the headphones in the helmet, or the employment of other solutions for headphones, such as bone conducting headphones.

2.10 Human Machine Interface and synthetic training

On the HMIs improvements, one effort for next generation soldiers is around the "smart glasses concept": a helmet mounted system to access information without

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taking eyes off the battlefield. The presentation of real-time data will enable greater clarity and quality of information throughout the operational system.

Various projects are heading in the direction of developing Heads Up Display with augmented reality presentation. The US Army's Integrated Visual Augmentation System (IVAS)[40] programme is probably the most advanced. Together with NGSW and Enhanced Night Vision Goggle-Binocular (ENVG-B), IVAS is one of the three pillars of the US Army soldier lethality enchantment project. IVAS goggles (a ruggedised version of the Microsoft HoloLens 2[41] headsets bought commercial off-the-shelf – COTS) have the task to provide infantry with a wide variety of capabilities including digital display, thermal and low-light sensors, rapid target acquisition, and aided target identification. In addition, the headset's augmented reality "fight-rehearse-train" system, which incorporates real-time mapping, is applicable for training and rehearsing operations. The training events generally encompass land navigation, live fire, mission planning, rapid target acquisition, trench clearing, and even an after-action review.

2.11 Conclusions

While previous "Future Soldier" programmes totally excluded lethality from the improvements, this time weapons – not only rifles, machine guns and grenade launchers but also loitering munitions, mini missiles and others – will have a key role in next generation systems. UxS, from nano to small ones, will also be crucial in the future soldier systems. Near-peer conflicts will force to develop net-centric systems considering the adversaries' ability to disrupt main Western C3 structures. Broadly speaking, all future systems will have to take in great account the effectiveness of counter systems to be fielded by near-peer adversaries.

[40] Jared Keller, " The Army's Next-Generation Headset Is Almost Ready for Prime Time", in *Task & Purpose*, 3 November 2020, https://taskandpurpose.com/?p=751.

[41] Alex Kipman, "Army Moves Microsoft HoloLens-based Headset from Prototyping to Production Phase", in *Microsoft Blog*, 31 March 2021, https://blogs.microsoft.com/?p=52559564.

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3. The United States

by Scott Boston[42]

The beginning of the 2020s finds the US Army pushing forward in soldier equipment modernisation in two key areas that will form the basis for improved soldier lethality over the coming decade and beyond. The primary functions underlined here – enhanced soldier's and formation's situational awareness and improved weapon lethality – are part of a more comprehensive modernisation effort for soldier equipment, but are the clear areas of emphasis in official US Army statements in recent years.[43]

The US Army's development of infantry technology for much of the past two decades has taken place along two parallel tracks: advanced technology efforts with integrated approaches like Land Warrior and Future Force Warrior programmes, and rapid fielding efforts that have put new equipment into units being deployed for combat operations, primarily involving irregular adversaries in Iraq and Afghanistan. With the US military shifting towards a focus on deterring near-peer adversaries, there is a perceived need for more advanced capabilities, and a sense of urgency to "catch up" to more advanced threats. US Army leaders have identified "soldier lethality" as one of the six priority areas in equipment modernisation, and as such have assembled a cross-functional team to pursue breakthrough opportunities to enhance soldier weapons and equipment.[44]

The US Army's approach to modernisation at the infantry soldier level is shaped by a continued commitment to a common squad size and design across its considerable variety of formations, vehicles, and mission profiles. To date, across the US Army's armoured, Stryker, and infantry brigade combat teams, infantry squads have nine soldiers (two four-soldier fire teams and one squad leader) and efforts continue to achieve a standard six-person scout squad in cavalry (reconnaissance) platoons.

The following sections will cover two main areas where US soldier developments are taking place: situational awareness and improved soldier weapons. A further section will consider a range of other initiatives, including the use of robotic systems and other focus areas, and a concluding part will discuss implications for the future based on the direction set by the US Army's current plans.

[42] Scott Boston is Senior Defense Analyst at the RAND Corporation.

[43] This chapter's focus is on the US Army's soldier equipment modernisation efforts, and as such some parallel initiatives being conducted by the modernisation arms of the US Marine Corps and Special Operations Command will not be discussed here. However, it is also frequently the case that modernisation successes generate a demand for similar capabilities in the other services.

[44] Robert Purtiman, "Soldier Lethality Cross-Functional Team Bringing Next Generation Technologies to Soldiers", in *U.S. Army Articles*, 24 September 2018, https://www.army.mil/article/211454.

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3.1 Sensors and situational awareness

The US Army has placed a high priority on improving the situational awareness of its soldiers, and this has taken the form of a series of advanced vision devices and their integration into a battlefield network. The potential implications of this trend are considerable. This section outlines the general characteristics of these vision devices and their implications for how soldiers and the broader combined arms force will operate.

New, more sophisticated situational awareness goggles have already been fielded in the US Army in modest numbers; about five thousand ENVG-B have been fielded to deploying forces. This system fuses image intensification and thermal image data in a single goggle and is also able to accept battlefield network data in the form of waypoints, control measures, and friendly force locations.[45] The ENVG-B is able to link to a weapon sight, allowing soldiers to view through the weapon optic (which frequently may have a greater level of magnification) even when offset from the weapon itself, such that it may be employed around corners and enabling rapid targeting. The linkages between the goggles and the weapon sight and the battlefield network are all made through an individual soldier encrypted wireless network.[46]

Although ENVG-B is still being fielded, development is underway of a future headset called the Integrated Visual Augmentation System. IVAS is intended to serve as a "mixed reality" headset that permits a great deal more integration of the soldier with his or her unit. In addition to serving as a combined thermal and night vision goggle, IVAS will be able to accept video feeds from the sensors of networked vehicles, ground or aerial robots. Its mixed reality features include a variety of map and control measure functions, and it is being designed to include a virtual training environment.[47] It will also present a wider, 80 degrees field of view for soldiers, compared with 40 degrees on ENVG-B and other earlier night vision goggles.

The benefits of a system like IVAS, if fully realised, could be profound. Upon receiving a mission, soldiers riding aboard an infantry carrier vehicle could rehearse actions in augmented reality based on rendered images of the target area. As they approach the battlefield, they could view the sensor feeds from their vehicle so as to not exit from the vehicle unaware of its surroundings. Once on the ground, they can view

[45] Courtney Bacon, "Integrated Technology Takes Night Vision to a New Level", in *U.S. Army Articles*, 1 March 2021, https://www.army.mil/article/243798.

[46] Program Executive Office Soldier website: *Enhanced Night Vision Goggle-Binocular (ENVG-B)*, https://www.peosoldier.army.mil/Equipment/Equipment-Portfolio/Project-Manager-Soldier-Maneuver-and-Precision-Targeting-Portfolio/Enhanced-Night-Vision-Goggle-Binocular.

[47] Todd South, "Soldiers, Marines Try Out New Device That Puts 'Mixed Reality,' Multiple Functions Into Warfighters' Hands", in *Army Times*, 8 April 2019, https://www.armytimes.com/news/your-army/2019/04/08/soldiers-marines-try-out-new-device-that-puts-mixed-reality-multiple-functions-into-warfighters-hands.

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sensor feeds from unmanned ground or aerial systems, and informed by a network that identifies potential threat areas, the locations of civilians, or friendly forces. In combat, the headset permits the soldier to view through the higher-powered optic of their weapon, to quickly engage an emerging enemy or to fire from cover.

These innovations imply the presence of a modular architecture for soldier- and small-unit-level information sharing. It is clearly an ambitious vision that the US Army is attempting to develop. In March 2021, the Army awarded Microsoft a five-year production contract to build IVAS.[48] Despite a delay announced in October 2021, leaders at the US Army Futures Command have repeatedly stated their continued commitment to the goggles, which are intended to reach soldiers starting in September 2022.[49] Fully adopting augmented reality systems for combat and mixed and virtual reality systems for training and rehearsals is likely the work of a generation but the promise of these systems is immense.

3.2 Armament

Another major ongoing initiative is the development of a new family of infantry weapons. The NGSW programme is intended to replace the M4 carbine and M249 squad automatic weapon currently in service. As of July 2021, three different companies are competing for the NGSW rifle and automatic rifle contract, and two others are competing for a common optic, so the final forms of these weapons remain uncertain. However, based on comments by senior officials and common elements of all three submissions, it is possible to identify some of the required attributes:

- *New ammunition*. The NGSW will fire a common 6.8 mm projectile at a high velocity in order to achieve substantial improvements in range, accuracy, and penetration of modern body armour, as well as having less overall weight than legacy cartridges. The new round is said to exit the barrel with "two to five times" the muzzle energy of 5.56 mm projectiles, and a number of sources suggest the standard soldier rifle's effective range would double, to 600 metres.[50]
- *Sound suppressors*. All of the rifle and automatic rifle candidates are depicted with sound suppressors. In addition to reducing the firing signature of the weapon, suppressors permit better communication among soldiers during a firefight.[51]

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[48] Program Executive Office Soldier, "IVAS Production Contract Award", in *PEO Soldier News*, 31 March 2021, https://www.peosoldier.army.mil/News/Article-Display/Article/2556870. According to reports, the contract has a maximum potential value of almost 22 billion US dollars. For further information, see: Sydney J. Freedberg, "IVAS: Microsoft Award by Army Worth Up to $21.9B", in *Breaking Defense*, 31 March 2021, https://breakingdefense.com/?p=147785.

[49] Andrew Eversden, "Army Says Next-Gen AR Goggles Delayed over Field of View Issues", in *Breaking Defense*, 18 October 2021, https://breakingdefense.com/?p=184097.

[50] Todd South, "More Than a Rifle: How a New 6.8mm Round, Advanced Optics Will Make Soldiers, Marines a Lot Deadlier", in *Military Times*, 10 December 2018, https://www.militarytimes.com/news/your-army/2018/12/10/more-than-a-rifle-how-a-new-68mm-round-advanced-optics-will-make-soldiers-marines-a-lot-deadlier.

[51] US Army Acquisition Support Center website: *Next Generation Squad Weapons (NGSW)*, https://

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3.3 Other developments

In addition to the IVAS and NGSW programmes, the US Army continues to pursue many initiatives encompassing various soldier items. The acquisition office that manages soldier systems adopted a systematic approach to equipping the individual soldier in the context of his or her rifle squad. This "Adaptive Squad Architecture" defines the standards and interfaces for soldier equipment, enabling improvements like common batteries and wireless network formats. A central element of the approach is a priority on managing the weight of a soldier's combat load, but the common standards also enable more rapid fielding and integration of new items.[52]

Another important area of development has been in the provision of unmanned systems at the squad, fire team, and individual soldier levels. This notably includes an ongoing effort to eventually equip every squad with a micro-drone, as part of the "soldier borne sensor" system. The first purchases of systems for this programme were of the Black Hornet Nano personal reconnaissance system for deploying soldiers, but full fielding to the 7,000 squads in the US Army may require a more economical product.[53] Further programmes for small units include small unmanned ground vehicles that can be carried in a backpack as well as a robotic "mule" capability called the Squad Multipurpose Equipment Transport. The latter is not a soldier equipment item but could have a notable impact on soldier load by carrying additional gear and recharging batteries for a dismounted infantry squad.

Finally, developments continue in soldier protective gear. Much of the focus on new protection has been on improving the ergonomics and fit for soldiers. A modular vest has been issued to deploying units that better accommodates female and small-stature male soldiers; other improvements in flank protection, eye and face protection, and weight reduction have been slowly but steadily taking place.[54]

3.4 Conclusion and implications

In a broad sense the trend in US soldier equipment is towards integration of more and more features that are increasingly connected. IVAS and the squad architecture approach are the focal point of a system that soldiers will use for virtual reality

asc.army.mil/web/?p=34136.

[52] Ross Guckert, *PEO Soldier. Joint Advanced Planning Brief to Industry*, Keynote address, 6 November 2019, https://www.dla.mil/Portals/104/Documents/TroopSupport/CloTex/2019%20JAPBI/02%20Keynote%20Address.pdf. See also: Ross Guckert, "The Squad As an Integrated Platform", in *Army AL&T Magazine*, Fall 2019, p. 40-44, https://asc.army.mil/armyalt/Fall2019/html/index.html?page=42.

[53] Argie R. Sarantios-Perrin, "Army to Purchase Additional Soldier Borne Sensor Systems", in *U.S. Army Articles*, 21 August 2018, https://www.army.mil/article/210155.

[54] Todd South, "New Body Armor Carrier, Plates and Female-Focused Designs Headed to Soldiers", in *Army Times*, 8 June 2021, https://www.armytimes.com/news/your-army/2021/06/08/new-body-armor-carrier-plates-and-female-focused-designs-headed-to-soldiers.

training, rehearsals, and combat operations. This in effect raises the level at which the squad is required to integrate into the larger formation; soldiers will expect to be able to readily access networked sensors, vehicles, unmanned systems, and other communications. These are ambitious efforts, but they are also informed by frequent incremental improvements and experimentation with soldier inputs.[55] At the same time, refocus on near-peer conflict will mean more demanding requirements in some respects, as near-peer threat has better body armour, is more lethal, has better sensors, contests the electromagnetic spectrum much more than asymmetric ones.

Looking further out into the future, much of the work of the coming decade is likely to be the fielding and incremental improvement of IVAS and the associated network. A great deal of the potential of these systems will come from the development of the squad-level virtual training environment. The interaction between training, rehearsals, and combat through these new tools may have substantial benefits for soldier readiness and battlefield performance, if the complexity can be managed and if they prove suitably robust in practice.

Finally, the increasing role of robotic platforms over the course of the 2020s is very likely to have a growing impact on soldier equipment. The US Army is developing classes of unmanned aerial and ground vehicles from the 18g Black Hornet all the way up to robotic light tanks. The individual soldier will not soon be replaced by robots completely, but almost certainly these will work together more closely with time. This will bring, among others, an enormous problem of secure communications: soldier-level radio will necessarily have lower power than vehicles so they will have less range and ability to overcome jamming. At the same time, unmanned platforms require sound approaches for loss of communications and sensor degradation or are inherently fragile – especially with current human-in-the-loop policies. Moreover, cyber vulnerability of an augmented reality and manned-unmanned force is going to need a lot of attention.

[55] See, for example, Mark Schauer, "IVAS System Undergoes Extreme Cold-Weather Testing at U.S. Army Cold Regions Test Center", in *U.S. Army Articles*, 29 March 2021, https://www.army.mil/article/244769.

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4. France

by Bruno Lassalle[56]

The current world is displaying an unceasing competition between powers which further entails a significant change in the conflict's nature. The physical and non-physical spaces become fields for power struggle or sometimes confrontation and potential adversaries divert civilian's technologies as a means of intelligence or destruction. In this regard, the French Army can still fight in asymmetric conflicts like today in the Sahel, nevertheless, it can be ready for symmetrical engagements as well, States against States, within coalitions. This transformation of conflicts nature requires to develop new military capacities. In accordance with the prospective document "Future land operations" and the "Strategic vision" of the Chief of Staff of the French Army, France must have a battle-hardened army ready in a combined and joint operations context even in the harshest fields of conflicts and facing the toughest clashes, up to a major confrontation, and be capable of winning.

This operational superiority against adversaries with advanced technological capabilities and the ability to innovate is sought by the creation of the Synergy of Contact Reinforced by Polyvalence and Infovalorisation (*Synergie du COntact Renforcée par la Polyvalence et l'InfovalorisatiON* – SCORPION) force, which is the backbone of the modernisation of the Army's combat capacities. This programme, currently in progress, aims to create an evolutionary and flexible tactical combat system capable of fulfilling all present and future operational missions of the Army. It is pursued by adopting a comprehensive approach characterised by the development of versability and evaluation of information which will structure the rise in power of the SCORPION force today and over the coming decades. After the first step that strives to make the most of digital applications, a second step based on the progressive introduction of robotics and artificial intelligence in the SCORPION force will follow around 2035. This unprecedented short and long-term investment will substantially enhance the lethality, mobility, survivability sustainability and situational awareness of combatants.

In addition to the introduction of new combat vehicles and the renovation of old equipment, the ambition of this programme is to set up at the heart of SCORPION an outstanding information system, the SCORPION Information and Combat System (SICS). SICS is underpinned by the concept of "collaborative combat", which seeks to connect brigades, battle groups, squads, vehicles, in a single network and bring informational superiority over the adversary.

In this general framework of army transformation, the modernisation of the individual combatant equipment in accordance with the Military Programming

[56] Bruno Lassalle is Associate Fellow at the Fondation pour la Recherche Stratégique (FRS).

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Act (MPA) 2019–2025 is today achieved by the Individual Combatant Equipment (IEC) programme. This key element of the army modernisation is linked to the programme SCORPION with which it interacts and uses its features. This acquisition/procurement strategy will be supplemented by subsequent programmes between 2025 and 2035 and beyond in a logic of hosting innovations. The success of the individual soldier's modernisation is crucial. However, it encounters one challenge and is facilitated by three key catalysts.

The challenge is to ensure that the individual soldier will continue to benefit from essential links and data once he/she has left his/her vehicle and so that the individual soldier does not turn into the poor relative of SCORPION. This essential continuity between mounted and dismounted combat is provided by the necessary development of a complementary SICS dedicated to dismounted combat. The "SICS system dismounted" interoperable with the SICS SCORPION will provide all navigation, driving, tactical situation, tracking functions including the Blue Force Tracking (BFT) to locate friends and establish requests for support to contact avoiding fratricidal fire. If these conditions are met, the disembarked combatant will fight with a better awareness of the tactical situation, with effective guidance and protection. In light of these developments, the training of the individual soldier using SCORPION must allow him/her to benefit from the technological contributions to overmatch his enemy and being ready to continue the mission in degraded mode, even after the failure or the destruction of all or part of their information technology/communication systems.

The first factor contributing to a successful modernisation of the individual soldier is the experience gained since 2010 with the commissioning of 18,000 units of the Integrated Infantryman Equipment and Communications (*Fantassin à équipements et liaisons intégrés* – FÉLIN) system. It was the first system that, by optimising the operation and decision-making functions, provided a response to the needs of the dismounted infantryman. His successful fielding enabled the soldier to achieve an unprecedented leap forward regarding capacities and technology with enhanced day and night observation, aggression, protection, mobility, communications capabilities. However, from the conceptual point of view, the FÉLIN system with a limited number of modules belonging to the same technical generation, is aging faster and difficult to modernise. Furthermore, the enhanced integration led to the development of costly, complex, and sometimes difficult to implement multifunctional devices.

The lessons learned come from operations (i.e. in Afghanistan or in the Sahel) where the first versions of system FÉLIN where fielded. These lessons have been used to design the new Individual Combatant Equipment deployed in forces since 2020 and which is destined to evolve in the coming decades. Differently from FÉLIN, which is intended for the infantry, IEC has the ambition to equip all the combatants of the land forces. It is the result of close cooperation between the Service of the Army Commissariat (SCA), the Directorate General of Armaments (*Direction Générale de l'Armement* – DGA) and the Army to provide the future combatant with equipment adapted to his training and the exercise of its mission

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in accordance with the slogan of the military planning law 2019-2025 "*à hauteur d'homme*" – that means by respecting the human role in the specific military context.

Individual equipment has been completely re-designed avoiding the perverse effects of strong integration. It is now designed as a global, integrated and coherent system such as FÉLIN, but in a more flexible way, favouring modularity and adaptation to technological evolutions. The aim is to favour the incremental innovation processes of the modules over more rigid approach, to better manage obsolescence induced by new technologies, doctrinal evolutions or to welcome new modules. Such capacity building requires a three steps process.

Right now, the new outfit in delivery consists of a new combat clothing compatible with all combat equipment. Two versions are offered, one for dismounted combat and one with cold resistance capacities for mountain troops. The clothes are designed to be efficient and comfortable with more breathability. Air permeability obtained by the structure of the fabrics allows a good management of the humidity of the vestments and the fabric is tear resistant and non-flammable. In addition, a new combat vest called Ballistic Modular Structure (*Structure Modulaire Balistique* – SMB) constitutes a real technological advance in the field of combat equipment. This SMB is the result of the fusion of the current ballistic protection vest and the FÉLIN electronic vest into a single structure significantly lighter for the same level of protection. The BMS, which will withstand to small calibre ammunition will be able to adapt to different types of missions by adding protective plates. Head-protection is enhanced with a new composite helmet, which increased attachment surfaces. It also allows the integration of functions rails and the attachment of accessories and small tactical equipment (night vision binoculars, retained visors and maxillary protection). The individual armament consists of two weapons, a short one, a semi-automatic pistol Glock 17 (gen5) and a long one, the assault rifle HK 416F/FPSA which can neutralise enemies at up to 400m by day and 200m by night. More compact lasers will allow the illumination of targets to be engaged. All modules offered by the system (radio, computer, chargers, etc.), are compatible with each other enabling a tailored choice to adapt this ergonomic equipment to the mission with an emphasis on either mobility, protection or firepower.

At medium-term, this set of combat is called to be completed by various modules. Among them more efficient and miniaturised sensors as low-light-level sensor, active imagery laser, laser-focused optical detector, acoustic detector will be commissioned in the next 15 years. This device will speed up threat detection, reconnaissance, and identification cycle as well as the target acquisition. In the same way, the combatant will be better connected to dismounted SICS and will benefit from a better situation and environment awareness. These improvements will mainly rely on a light radio set as well as uninterrupted mounted/dismounted voice radio and data transmission. Head-up displays using augmented reality and accurate positioning systems working inside buildings complete these capabilities. Thanks to nanotechnology, ballistic modular structure will be lighter and more efficient. More efficient and lighter sources of energy, such as hydrogen batteries,

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will allow the combatant to charge easily the system when dismounted. The weaponry will be supplemented by electromagnetic or laser systems producing lethal or non-lethal effects against drones.

Looking ahead, long-term developments that will impact the individual fighter will give rise to the appearance of new applications, that will have to integrate harmoniously into the SCORPION program. These innovations exploiting artificial intelligence and nanotechnologies will materialise through exoskeletons of materials with changing shape and aspects and the multiplication of automated robotics system. In this perspective, the ethical issues of the augmented soldier and the development of autonomous lethal weapons systems must be addressed to avoid any military capability risk while complying with the rules issued by the Defence Ethics Committee.

The second factor impacting the modernisation of the individual soldier is linked with the commissioning of a device that enables short cycle-innovation. It is based on an open innovation model to be carried out together with the institutional innovation schemes characterised by longer cycles. To this end, within the framework of the Army innovation pole and the DGA, an innovation platform called the Innovation Acceleration Platform for the Combatant (CENTURION) was created in 2020. In the individual combatant ecosystem, CENTURION is a catalyst, a contractual tool, designed to detect, evaluate, develop technologies and integrate those with a demonstrated operational interest in the evolution of the fighter's equipment. More specifically, CENTURION contributes to capture innovation in various fields of interest (positioning and navigation, observation, weaponry, functionalised textiles, innovative interfaces, etc.) in both civilian and military sector and supports the innovation driver. Any civilian or military, with an idea or innovation that could contribute to the superiority of the French Army can make their project known by submitting their application on the CENTURION portal. If the project is selected, the innovator shall be accompanied by the industries Safran and Thales for the realisation of the project. Thus, CENTURION makes it possible to solve an emerging problem even before the strict expression of an operational need.

The third factor of a successful modernisation deals with robotics, aimed at the constitution of the force SCORPION. The VULCAIN project was launched on 10 June 2021 as part of the "Strategic vision" by the Chief of Staff of the Army. The decision to create a VULCAIN unit dedicated to the exploration and use of ground automated systems is the concretisation of the concept of "Army Automated System" published in 2019 to structure the realisation of a first robotic SCORPION capacity after the exploration phase. The aim is to complete the experience already acquired with the existing de-mining robots or mule-like robots and to launch new experimentations for the benefit of the combatant. These studies will demonstrate the relevance of accompanying the dismounted combatants with robot partners to contribute to increase mobility, agility, and protection of the combatant by lightening him from the ever-increasing weight of ammunition and equipment, limiting their exposure and allowing them to understand as accurately as possible

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the tactical situation.

The modernisation of the equipment of the individual soldier is linked to the constitution of a scalable set of modules to the SCORPION standard. These interoperable modules of all kinds carried by the combatant today or which will be evolving around it tomorrow are compatible with evolutionary connections and interfaces that guarantee the timelessness and efficacity of the system in the long term. Therefore, each individual combatant constitutes in fact a sub system of the SCORPION system. Each sub-system shares the features of SCORPION thanks to the dismounted SICS, but the man occupies always the central place. The SCORPION force thus formed will adapt to operational technical and doctrinal evolutions by making the most of the short-loop open innovation that efficiently complements the institutional long-term innovation resulting from the major arms programmes. In conclusion, France could effectively modernise the individual soldier equipment by drawing on experience and innovation, and by putting the man at the centre.

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5. Germany

by Ezio Bonsignore[57]

Similar to virtually all other Western and more specifically European countries, Germany's efforts to equip its infantry soldiers with up-to-date, innovative materiel trace their origins back to the NATO Soldier Modernisation Programme (also known as Future Soldier), launched back in 1994 by the NATO Land Capability Group 1 (NLCG1) with the original participation of 14 countries. The stated aim was to capitalise on very promising technological advances in the fields of individual protection (body armour), night vision and networked communications to introduce a series of significant improvements in the ways dismounted soldiers maintain tactical situation awareness to move and fight on the battlefield, while also significantly increasing their survivability.

The resulting German system, designated Infantryman of the Future (*Infanterist der Zukunft* – IdZ) was first introduced in 2005 in what has since become known as the Basic Version (*IdZ-Basissystem* – IdZ-BS), developed by then Cassidian (now part of Airbus). In-service troops feedbacks, particularly from units deployed to Afghanistan, listed various complains, most specifically about the excessive weight (up to 28-30 kilogrammes) and bulk. This led to the improved Future Soldier System-Enhanced System (*Infanterist der Zukunft-Erweitertes System* – IdZ-ES), also known as "Gladius",[58] developed by Rheinmetall Defence Electronics as prime contractor since 2006 and first deployed in Afghanistan in 2012/13 for operational tests, with weight reduced down to 18-22kg.[59] In June 2017 a 370 million euro contract[60] was signed to equip 68 platoons – 2,460 individual systems – with IdZ-ES systems. Deliveries started in 2019 and have since been completed. Armoured infantry units operating the new Puma Infantry Fighting Vehicle (IFV) were the first to receive the IdZ-ES, and this combination was formally declared "combat ready" by the Federal Office of Bundeswehr Equipment, Information Technology and In Service Support (*Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr* – BAAINBw) on 19 March 2021. Training is being progressively extended across all German Armed Forces (*Bundeswehr*) combat units, also including the Navy, through the participation of the Naval Maritime Battalion, and Air Force – Air Base Security Force – units.

[57] Ezio Bonsignore is a Berlin-based journalist and defence expert.

[58] Also referred to as IdZ-2 by the industry. See: Gerhard Heiming, "Gladius für die Infanterie der Zukunft" (in English), in *Europäische Sicherheit & Technik*, April 2013, p. 61, https://www.rheinmetall-defence.com/en/rheinmetall_defence/public_relations/themen_im_fokus/gladius.

[59] The original contract for the IdZ-ES was awarded back in 2006, with first deliveries in 2012, series order in 2017 and deliveries to be completed in 2021.

[60] 310 million euro without value added tax.

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5.1 Components and functions

The IdZ-ES is normally referred to as a system, but it should rather be seen as a modular set of different individual components and devices available to the soldier according to the tactical situation and the specific mission. While it is theoretically possible for a soldier to carry or wear at once everything under the IdZ-ES label, this would not normally be the case. In each case, however, every combination should be regarded as complete, coherent systems of its own.

The overall IdZ-ES system is comprised of some 20 elements, divided into three sub-systems: command, control, computers, communication and information (C4I); clothing, protection and carrying equipment (*Bekleidung, Schutz- und Trageausstattung* – BST); and weapons, optics and optronics (*Waffen, Optik und Optronik* – WOO).

5.1.1 C4I

The C4I sub-system is the core element, linking the overall system to the operations command. At the tactical level, all soldiers in the 10-man squad are interconnected with each other and with their immediate upper levels by means of the so-called Electronic Back (ER) attached to their Class 4 armour vest. The ER contains a computer, an ultrahigh frequency (UHF) squad radio (Thales Solar 400EG-E), a GPS transmitter/receiver, and batteries. The ER is controlled by the operating and display unit, replacing the IdZ-BS' keyboard and mouse which have proved highly unpractical in the field. This change is highly representative of the peculiar relationship, within the overall IdZ programme between tactical requirements on the one hand and technological possibilities on the other, that will be discussed in detail in the concluding notes. The system shows the current position of one's own forces, one's own location with direction of movement and the direction of view in the digital situation map (these informations can alternatively be presented by a helmet-mounted display). Every soldier further receives situation information, movement commands and messages from all other squad members. Communications are through an in-ear headset connected to the group radio (replacing the microphone), and push-to-talk buttons (*Push-to-talk-Tasten* – PTT) for the radio-intercom link are placed on the handguard/housing of the individual and squad weapons, allowing for communications while still handling them.

Squad leaders and deputies further have a very high frequency (VHF) radio and a portable command computer (*Tragbaren Führungsrechner* – TFR) at their disposal. The latter serves to represent the overall situation and helps the leader in planning and monitoring the battle. The TFR can access the Army Command Information System (*FüInfoSysH*) via the Puma or Boxer armoured fighting vehicles.

5.1.2 BST

The IdZ-ES' clothing, protection and load-carrying equipment is based on the layered ("onion") approach to combine the different, often self-contradictory requirements for ballistic and environmental/climatic protection, camouflage, and the often overlooked comfort in long-duration wear – the whole while maintaining weight and bulk to tolerable levels.

As to ballistic protection, a Class 1 (*Schutzklasse 1* – SK1) ballistic vest, able to stop splinters and 9mm Parabellum rounds is worn directly over the undergarment, and is supplemented by fragmentation protection sleeves as well as similar applications for the neck and abdomen and a new fragmentation protection goggle. A Class 4 (SK4) flak jacket is added for combat.

The camouflaged combat suit is made of flame-retardant fabric with sewn-in pads to protect the elbows and knees, and can be adapted with subsequent layers to remain comfortable from -32°C to +45°C. The new lighter suit (some 1.8 kg) has an integrated mount for night vision goggles, helmet mounted display and digital electronic compass.

5.1.3 WOO

The NLCG1-formulated guidelines for "Future Soldier" systems devoted little or no attention to individual weapons, as these have already been standardised within NATO as assault rifles chambered for the 5.56x45 ammunition. This implied for Germany being forced to cancel its programme for the revolutionary G11 rifle and the no less revolutionary 4.73x33 caseless ammunition, which would have arguably provided advances in overall combat effectiveness not unlike those offered by C4I and individual protection developments. Beyond the soldier's ability to carry a much higher ammunition reserve due to the caseless round low weight (6.5g, as against 11.2g for the NATO round), the G-11's phenomenal high rate of fire of 2,100 rounds/min enabled an innovative combat firing concept, whereby there was no single shot option and each trigger pull would rather result in a 3-round burst with controlled dispersion.

The basic systems thus remain the G36 5.56x45 assault rifle, to be replaced (after a tormented selection process which saw the original choice of an Haenel design being reversed due to patent infringement issues) by the new HK 416A8, whose future official designation is not yet known, the MG4 5.56x45 machine gun, the G82 (Barrett M82) 12.7x99 long-range rifle, the MP7 4.6x30 submachine gun, and the Panzerfaust 3 anti-tank weapon. Considerable attention has rather been devoted to optics and optronics, to include image intensifier goggles, thermal imaging observation devices, laser rangefinders, cooled thermal imaging sights, and more. The latest development in this field is a large order awarded in October 2021 to Leonardo Germany GmbH for up to 107,929 ELCAN Specter DR 1-4x daylight sights to equip the current and future assault rifles.[61] This order is not part of the IdZ

[61] Leonardo, *Leonardo Signs Contract to Supply Daylight Optics for Bundeswehr Assault Rifles*, 13 October 2021, https://www.leonardocompany.com/en/press-release-detail/-/detail/13-10-2021-leonardo-signs-contract-to-supply-daylight-optics-for-bundeswehr-assault-rifles.

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programme *per se*, but will of course influence it.

5.2 Further development(s)

Further development of the overall IdZ system is an ongoing process, this being carried out by the Army Development Office (*Amtes für Heeresentwicklung* – AHEntwg) and industry, reflecting feedbacks from troops as users.

Due to a variety of reasons, including most notably the rather slow Bundeswehr procurement procedures requiring parliamentary approval on the one hand, and the very fast pace of development of digital technologies on the other, a so-called "spiral procurement" approach has been adopted for the IdZ-ES programme, with procurement and deployment concurrent with further development – with all the positive and negative aspects that this implies (more about this in the final remarks).[62]

The next step ahead is the IdZ-ES Plus, intended for the German Army units to be assigned to the NATO Very High Readiness Joint Task Force (VJTF), expected to be activated in 2023 within the framework of the NATO Response Force. NATO VJTF is to rely on a completely new digital command and information system, building on the new Battle Management System introduced in May 2020 – and this will obviously impact on the required characteristics of the individual soldier equipment. To this end, the IdZ-ES system must become part of a networked command and control structure, in the framework of the digitisation of Bundeswehr land operations. The capabilities for information-processing, -collecting and -distributing that are currently vested in the Army Command Information System to provide a shared situation picture should be pursued down to the company level, which depends on the feasibility of simultaneous transmission of voice and data via UHF and VHF channels.

Rheinmetall Defence Systems was awarded a contract for IdZ-ES Plus in June 2019,[63] i.e. just two years after the series order for the original IdZ-ES and concurrent with the first deliveries on that order. All of the improvements and new features are concentrated in the digital C4I sector. First, the Electronic Back, which has not been very well accepted by the troops, is going to be replaced by a USB hub. Second, the dedicated command computer will be substituted by an adapted, commercially available tablet with TacNet-based command system (no such thing existed back in 2006, when the original contract was signed). Third, a new Elbit PNR 1000 UHF radio with in-ear headsets is going to be introduced. The new C4I subsystem for IdZ-ES Plus is being delivered in three variants that build on each other: "Light" (USB hub + UHF radio), "Basic" (as "Light" + command tablet) and "Enhanced" (as

[62] The original contract for the IdZ-ES was awarded back in 2006, with first deliveries in 2012, series order in 2017 and deliveries to be completed in 2021.

[63] Dorothee Frank, "Zwei Soldatensysteme für die Truppe", in *Europäische Sicherheit & Technik*, 3 March 2020, https://esut.de/2020/03/fachbeitraege/ruestung/18800.

"Basic" + Rohde & Schwarz Software Defined Handheld – SDHR VHF radio). The contract covers a total of 340 subsystems, split between 8 "Light," 170 "Basic" and 90 "Enhanced" variants. This fragmentation of a relatively small order into a series of microscopic sub-systems is very difficult to justify in operational terms, and it most probably rather reflect a certain uncertainty about the best (or anyway the most cost-effective) solution for standardised use, to be clarified through field tests.

And the "spiral development" saga continues. In March 2021, concurrent with the IdZ-ES being declared combat ready, the BAAINBw awarded Rheinmetall Electronics a risk reduction study contract for the definition of a follow-on 3rd IdZ-ES generation (IdZ-ES-3).[64] The study, which is to be completed by 30 May 2022, will address the further development potential of all the components of the IdZ system, and most particularly the C4I. In detail, Rheinmetall is to analyse ways to ensure that the C4I is compatible and interoperable with the overarching programme for the digitalisation of land-based operations (*Digitalisierung Landbasierter Operationen* – D-LBO). The so-called "Tactical Core", developed by blackned GmbH for the D-LBO[65] and intended to be integrated as a uniform software element on all tactical nodes of the land forces and enable the seamless exchange of information between all those involved, is to be delivered in a first pre-series version for field tests as part of IdZ-ES-3. Furthermore, for the first time the study is to cover not only the three existing development lines corresponding to the WOO, BST and C4I components, but also a new fourth one referring to integration with unmanned/autonomous platforms. First deliveries to combat units are tentatively planned in 2024.

5.3 Concluding remarks

To an external observer, the entire German approach to "Future Soldier" concepts, and thus the IdZ programme as such, appears to be very much based on a "work in progress" philosophy. There certainly is a considerable interest towards the exciting new tactical concepts as enabled (or at least promised) by technological developments, but this does not translate – at least not yet – into a firm requirement for the large-scale introduction of the relevant systems throughout operational field units. Rather, attention is being focused on the exploration and validation, through relatively small-scale production, of the possible/feasible military uses of the continuous process of very rapid advances in consumers' electronics, with new devices and gadgets becoming available every few years.

While defence equipment programme are normally the result of the formulation of new operational requirements driving (with due consideration to costs) the development of the relevant technologies, as regards the IdZ programme this is true for the WOO and to an extent the BST components but not the core C4I. Rather,

[64] Wolfgang Gelpke, "Erstes Gesamtkonzept für die 3. Generation des IdZ-ES vorgestellt", in *Soldat & Technik*, 19 July 2021, https://soldat-und-technik.de/?p=27823.

[65] GuardStack website: *Defense*, https://guardstack.com/defense.

advances in consumers' electronics, while totally unrelated to defence as to their original and initial goals, do open up new and previously unthinkable operational possibilities. Accordingly, there is a considerable reluctance towards committing the entire future equipment of the Bundeswehr to a given technological status – with the risk of such equipment being irremediably outdated by the time distribution to the troops is completed. Examples such as the previous Electronic Back and TFR Command Computer are highly significant in this regard.

The net result of the above is that while it would certainly be erroneous to regard the IdZ programme as being a low-priority effort, the exact moment for its transition into a standard-issue procurement plan remains difficult to predict, in that such a step would be strictly dependent on the Bundeswehr gaining sufficient confidence about "Future Soldier" technologies having levelled on plateau, whereby no dramatic further advances could be expected in the near/medium term.

The above will also have a decisive impact on the possible (some would rather say likely) integration of artificial intelligence solutions. The theoretical advantages of such solutions are very clear, but a dedicated effort to develop AI systems for the specific purposes of the IdZ programme is most definitely out of the question for financial reasons. On the other hand, it is a fair bet that any civil/commercial AI device or operating programme eventually becoming available, and suitable for tailoring according to "Future Soldier" requirements would promptly be adopted.

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6. Italy

by Alessandro Marrone and Ottavia Credi[66]

According to some observers, the year 2035 will probably represent a divide between the current and future level of technological advancement for the Italian Army.[67] By virtue of its high level of preparation and specialisation, the Army is investing a lot of effort in the next generation soldier architecture.

Through this path, Italy will need to demonstrate its readiness to face the challenges that will come from an ever-changing operating environment. To this end, the Army also aims to cultivate a strong collaborative relationship with both the industrial sector and academia, through an effort in innovation allowed by conceptual developments and technological enablers.

6.1 Future scenarios and technological advancements

In this context, it is worth recalling that while the Army General Staff (*Stato Maggiore dell'Esercito* – SME) establishes needs and requirements to be observed through the capability development, the Secretariat General of Defence/National Armament Directorate (*Segretariato Generale della Difesa/Direzione Nazionale Armamenti* – SGD/DNA) implements the defence industrial policy also by managing procurement and the relations with the private sector.

In 2019, the Army published the doctrinal document "Future Operating Environment Post 2035 – Implications for Land Forces", which outlines the operational scenarios land forces are likely to face in the future, as well as the capabilities needed to succeed in such scenarios.[68]

The document represents the doctrinal reference point for the Army, which needs to be translated into capabilities by the SME leadership steering the defence planning and capability development, especially considering the long term perspective and the constant evolution of scenarios, requirements, technologies.[69] Moreover, the Army is part of a broader, joint approach to both operations and procurement, which in 2021 made progresses with the enhancement of the Joint Operational Command (*Comando Operativo Vertice Interforze* – COVI) and the adoption of the ministerial directive on defence industrial policy.[70]

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66 Ottavia Credi is Junior Researcher in the Defence and Security Programmes at IAI.

67 Paolo Sandri, quoted in Luca Zorloni, "Quali sono le nuove tecnologie che l'esercito italiano vuole mettere alla prova", in *Wired*, 17 March 2021, https://www.wired.it/attualita/tech/2021/03/17/esercito-italia-tecnologie-droni-robot-intelligenza-artificiale.

68 Italian Army General Staff, *Future Operating Environment Post 2035 - Implications for Land Forces*, 2019, http://www.esercito.difesa.it/comunicazione/Le-5-Sfide/Documents/FOE-INGLESE191205.pdf.

69 Interview, 11 June 2021.

70 Italian Ministry of Defence, *Direttiva per la politica industriale della Difesa*, July 2021, https://www.difesa.it/Documents/Direttiva_Ministro_Guerini2907.pdf.

In this context, the document's findings concerning future operating environments identify three scenarios to be the most likely: the so-called "megacities",[71] coastal areas, and areas contested for the control over resources and energy reserves.[72] In such scenarios, future commanders will be at the centre of military operation, and will thus need to be able to rely on a substantial set of capabilities ranging from a comprehensive situational awareness, to strategic communication, from kinetic and non-kinetic effectors to a well-organised logistic support.[73] As a matter of fact, whilst acknowledging the advantaged brought by the employment of new concepts and technologies on the battlefield in terms of on agility and efficacy, the Army is committed to adhering to a human-in-the-loop approach, emphasising the importance of the human component.[74] The alternative option of the human-over-the-loop, whereby the military official supervises a decision-making performed by technological devices and can stop it, seems to be less convincing for a variety of reasons.

Its large scale, 30-years long experience in crisis management, counter-insurgency, counter-terrorism and stability operations, with more than 40 missions in three continents, has certainly influenced the way the Army looks at the near future.[75] Against this backdrop, further thinking is ongoing with regards to the strategic, operational and tactical implications for Italy and other NATO Allies of the international shift to great power competition and the increasing emphasis of the US on scenarios of near-peer conflicts. Indeed, according to the "Future Operating Environment Post 2035" document, Italian land forces may have to prove their ability to respond to situations ranging from symmetric conflicts to hybrid threats.[76] In order to face such challenges, the Army is committed to implementing NATO's strategic perspectives on the modernisation of military forces, which should be credible, agile, aware, networked and resilient.[77] Broadly speaking, the Army's approach reflects the level of ambitions of a middle power used to address high-intensity conflicts mainly – if not only – within NATO framework and which, in the past decades, has privileged light and medium forces over heavy ones. That is due to the fact that the former were constantly deployed and in high demand, and resources scarcity did not allow to start to rebuild the heavy components early

[71] The Italian Army defines "megacities" as a product of globalisation which, by favouring exchanges and collaborations between different cultures, has led to a progressive transformation of social and cultural norms, with inevitable consequences on urban planning and infrastructure development. For more information, see: Italian Army General Staff, *Future Operating Environment Post 2035*, cit., p. 17.

[72] Ibid., p. 12.

[73] Ibid., p. 7, 12.

[74] Ibid., p. 7.

[75] For an analysis of trends in the Army's operations abroad, see: Alessandro Marrone and Michele Nones, "Le forze italiane in missione all'estero: trend e rischi", in *Documenti IAI*, No. 20|03 (March 2020), https://www.iai.it/en/node/11378.

[76] Italian Army General Staff, *Future Operating Environment Post 2035*, cit., p. 10.

[77] Ibid., p. 5.

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on, at least since the Crimea Annexation back in 2014.

More recently, the Army presented a concept paper – *PROgramma Studio ProspettivE Crisi Tecnologie Abilitanti*, better known as *Prospecta 2021* – offering a comprehensive overview on the state of the art of Italian technological advancements in relation to the land component, and outlining the strategies that should be implemented in the next fifteen years in order to face the challenges posed by innovation.[78] *Prospecta 2021* is a good example of a dialogue between the Army and the national industries in order to compare the military requirements and the technological innovations at stake.[79]

The document identifies two fundamental procurement priorities for Italy, namely artificial intelligence applications and nano-, mini- and micro-unmanned vehicles (UxVs) – also known as drones. The employment of both aerial and ground UxVs will increase the Army's surveillance and target acquisitions capabilities. Moreover, by taking steps forward in the field of AI applications, the military will be able to employ these systems for the analysis of the data gathered by drones and the other assets and, in some cases, even for the implementation of pre-planned decisions based on those data. Such indications clearly illustrate the Army's emphasis not only on effectiveness and efficiency, but also on reducing the front-line risks for dismounted soldiers.[80]

6.2 The Individual Combat System (Sistema Individuale di Combattimento)

Against this backdrop, the main procurement channel for current and future innovation of the dismounted soldier equipment is the Individual Combat System (*Sistema Individuale di Combattimento* – ICS), a programme created through a tight collaboration between the military and the national industry.[81] In line with the System of System approach – which has been somehow a *leitmotiv* in the Italian Army in the last few years[82] – the ICS consists of an integrated weapon apparatus which envisions the soldier as its pivot. The different suppliers are grouped in an industrial consortium in order to establish a single interlocutor for the Army, and ensuring adequate management of both procurement and life-cycle maintenance, repair, overhaul and upgrade (MROU). The MROU is particularly important considering the high number of different elements necessary to ensure the operational readiness of dismounted soldiers. A spiral approach has been adopted to increase the effectiveness and efficiency of the ICS programme.

78 Italian Ministry of Defence, *Sinergie Esercito e Industrie Difesa*, 3 February 2021, https://www.difesa.it/Primo_Piano/Pagine/Sinergie-Esercito-Industrie-Difesa.aspx.

79 Interview, 11 June 2021.

80 Interview, 7 June 2021.

81 Previously known as Secure Soldier System (*Sistema Soldato Sicuro*). See Italian Army website: *Sistema Soldato Sicuro*, http://www.esercito.difesa.it/equipaggiamenti/sistema-soldato-sicuro.

82 Interview, 7 June 2021.

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The Individual Combat System represents a significant step towards the integration of the key elements that should be taken into consideration for next generation of soldiers,[83] as it aims to provide them with five main components: protection, survivability, command and control, nocturnal mobility and lethality.

The protection component consists of helmets and bulletproof vests.[84] The former provide optimal peripheral vision and prolonged wearability, besides protecting the soldier's head; the latter, being modular, allow great mobility and an easy access to weapons, and are equipped with a quick-release device with which soldiers can rapidly take the vest off whenever needed.

The Software Defined Radio Hand Held Evolution (SDR HH EVO) – a multi-band radio system able to provide secure services and data to the armed forces – and the Tactical Mobility-Night Vision Goggle (TM-NVG) – a binocular system for night vision through light intensification – respectively constitute the C2 and the night vision components of the Secure Soldier System.[85]

Lastly, the lethality factor consists of the ARX 200, ARX 160 A1 and ARX 160 A3 rifles – compact, relatively light and ergonomic state-of-the-art weapons – and a vision, positioning and engagement system which, through its daytime optics, red-dot sight reflector and thermal imaging camera, allows adequate visibility in various operative conditions.[86]

In the context of the Individual Combat System, in July 2019 Leonardo and Beretta formed a consortium aimed at promoting and marketing the Secure Soldier System programme. Since its foundation, the consortium has been expanded to encompass other businesses including Iveco, Mbda, Rafael Advanced Defense Systems, Larimart and Ares Cosmo.[87]

In January 2020, the Army announced the stipulation of a series of procurement and modernisation programmes for the Secure Soldier System, subscribed by the SGD/NAD, which allowed the acquisition of 20,000 Individual Combat Weapon

[83] Ibid.

[84] Italian Army website: *Componente Sopravvivenza*, http://www.esercito.difesa.it/equipaggiamenti/sistema-soldato-sicuro/componente-sopravvivenza; and *Componente Protezione*, http://www.esercito.difesa.it/equipaggiamenti/sistema-soldato-sicuro/componente-protezione.

[85] Italian Army website: *Componente Comando e Controllo C2*, http://www.esercito.difesa.it/equipaggiamenti/sistema-soldato-sicuro/componente-comando-e-controllo-c2; and *Componente Mobilità Notturna*, http://www.esercito.difesa.it/equipaggiamenti/sistema-soldato-sicuro/componente-mobilita-notturna.

[86] Italian Army website: *Componente Letalità*, http://www.esercito.difesa.it/equipaggiamenti/sistema-soldato-sicuro/Componente-Letalita.

[87] Chiara Rossi, "Leonardo, Beretta, Iveco-Oto Melara e Mbda ammodernano l'esercito italiano", in *Startmag*, 14 January 2020, https://www.startmag.it/?p=89668.

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Systems.[88]

In the context of the Secure Soldier System, Leonardo is also creating a system able to automatically identify a threat and select the type of weapon needed to counter it. Still, it will be up to the soldier to decide whether or not to use such weapon, thus ensuring a human-in-the-loop approach.[89]

6.3 Latest developments and cross-sector collaboration

The 2021 defence planning and financial framework (*Documento Programmatico Pluriennale* – DPP) presented by the Ministry of Defence included a consistent investment in the Secure Soldier System. It is estimated that approximately 900 million euro will be devolved to the programme between 2021 and 2034 – when it is expected to be completed.[90]

Thanks to the investments in this field, Italy is currently working on several technological applications which may have a considerable impact on the characters of the Army's future combat operations. They include laser weapons, swarm systems, rail guns and Enhanced Direct Kinetic Energy Weapons (EDKEW).[91] In the meantime, the employment of technologies such as conformal batteries able to provide soldiers with enhanced energy autonomy demonstrates Italy's experience and commitment to innovation in this regards.[92] The Army pays significant attention to the fact that AI will likely increase energy consumption, therefore advantages in this field should be balanced with the imperative to not overload dismounted soldiers and keep them agile.[93]

In the future, it is likely that machine learning techniques will greatly impact the functioning of military technologies. Against this backdrop, the Army is currently working on the development of Robotics and Autonomous Systems (RAS) in the context of the PROMETEO project.[94] The armed force considers RAS a remarkable advancement in the field of military modernisation, granting soldiers with enhanced agility, combat power, and situational awareness, whilst reducing risks.[95]

[88] Italian Army, *Firmata l'acquisizione di sistemi d'arma tecnologicamente avanzati per l'Esercito*, 13 January 2020, http://www.esercito.difesa.it/comunicazione/Pagine/Nuove-tecnologie-per-l-Esercito-Italiano20200113.aspx.

[89] Interview, 11 June 2021.

[90] Italian Ministry of Defence, *Documento Programmatico Pluriennale della Difesa per il Triennio 2021-2023*, August 2021, p. 120, https://www.difesa.it/Content/Documents/20210804%20DPP%202021-2023%20-ult.pdf.

[91] Italian Army General Staff, *Future Operating Environment Post 2035*, cit., p. 16.

[92] Interview, 18 June 2021.

[93] Ibid.

[94] Italian Army, *Esercito faro di tecnologia e di innovazione*, 30 October 2020, http://www.esercito.difesa.it/comunicazione/Pagine/Esercito-tecnologia-innovazione_201030.aspx.

[95] Italian Army General Staff, *Future Operating Environment Post 2035*, cit., p. 18-19.

The industrial sector is also investing significant effort and resources in soldiers' training, modelling and simulations – these are considered crucial enablers which both prepare soldiers to hostile scenarios and allow them to familiarise with the technology. Reaching such level of preparation through soldiers' training represents one of seven operational capabilities identified by the Army as fundamental for the development of land forces in the post 2035 future operating environment.[96]

Beyond current procurement programmes, broadly speaking the Italian Ministry of Defence repeatedly asserted to the importance of the synergy between industry and national institutions for the country's technological advancements in this field.[97] Currently, an interesting example is the cooperation between the Italian Institute of Technology (*Istituto Italiano di Tecnologia*) and the Polytechnic University of Milan (*Politecnico di Milano*) for the development of a photonic crystals for soldiers' camouflage and ductile amorphous materials. According to *Prospecta 2021*, future research activities will also include the development of AI applications and plasma antennas.

6.4 Open issues and future objectives

Going forward, Italy will need to further reflect upon its strategic thinking, military doctrine, and capability development – especially in light of broader technological development.[98] Only by framing all these elements into a holistic approach will Rome be able to experience serious improvements with regards to the land component and particularly the next generation soldier's equipment.

As mentioned, the Army considers soldiers as the essential elements of military activities – therefore, it sees the enhancement of their intellectual and cognitive abilities as a priority for gaining control over the technological and autonomous components.[99] The dismounted soldier represents *per se* a system of systems, by combining the tools that are personally held and mastered. Moreover, there is a widespread agreement over the fact that soldiers will become increasingly multi-role, thus needing to manage a higher amount of information.[100] Yet, the dismounted soldier is also obviously part of a broader SoS, the squad, with its different and complementary roles played by its members. The same approach applies to larger formations like platoons, involving a number of ground vehicles, helicopters, command, control and communications elements, up to brigades – and, ultimately, the whole Army when it comes to complex and large-scale

96 The seven fundamental operational capabilities are Prepare, Project, Engage, Protect, Sustain, Inform, Consult, Command and Control. See: Italian Army General Staff, *Future Operating Environment Post 2035*, cit., p. 23.

97 Italian Ministry of Defence, "Sinergie Esercito e Industrie Difesa", cit.

98 Interview, 7 June 2021.

99 Italian Army General Staff, *Future Operating Environment Post 2035*, cit., p. 8.

100 Interview, 11 June 2021.

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operations. In this context, Rome aims to create units able to operate according to a multi-domain approach in adverse conditions, all the while adopting a criterion of convergence which will ensure their success on the battlefield through the simultaneous use of a variety of performance-enhancing components.[101]

The military shares the view that its networks still need a top-down organisation with a clear-cut, hierarchical C3 system, not the least to ensure clear and efficient communication during conflict.[102] Though this is already the case at all levels, it poses challenges in leveraging the SoS potentialities at operational and tactical levels. Here, the squad and platoon seem to be the two most appropriate levels to implement a SoS which balance the need for vertical C3 with the benefits of horizontal networks. In particular, the squad enables the specialisation of its members and the differentiation of the soldier's wearable equipment in order to exploit its full potentialities, while the platoon achieve the sufficient mass for certain tasks and operations by leveraging a number of squads. Moreover, the organisation of C3 through squads and platoons prevent the individual soldier to be overloaded by information coming from all other soldiers and assets deployed in the operational theatre.[103]

In this context, there are different options to be managed through adequate C3. In some cases, a redistribution of capabilities among a higher number of squads and soldiers would be worthy,[104] while in others dispersed force would work effectively because enabled by technological innovations.[105]

Given the importance assigned to individual soldier, it is worth concluding by raising the issue of recruitment in the Italian military. Although, so far, the Army has not encountered serious obstacles in attracting recruits, a reflection should be made concerning the quality of the soldiers, the military's ability to hold on to its most qualified personnel, as well as possible drawbacks caused by the demographic stagnation that has been affecting Italy as a country.

101 Italian Army General Staff, *Future Operating Environment Post 2035*, cit., p. 20.
102 Interviews, 7 and 11 June 2021.
103 Interview, 7 June 2021.
104 Interview, 18 June 2021.
105 Interview, 7 June 2021.

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7. The United Kingdom

by Nick Reynolds[106]

7.1 The evolving British approach

The UK's soldier modernisation currently stands at an important juncture. As of late-2021, the Integrated Review and Defence Command Paper have yet to be implemented, but provide an uplift in funding and broad intent for substantial restructuring.[107] Several years of understated but persistent experimentation likewise indicate a discernible trajectory. This amounts to a serious exploration of and investment in unmanned systems, electronic warfare and cyber-capabilities, and an overhaul of the British military's command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) equipment and structures in general.

While this overhaul is long overdue, pessimism is warranted. Firstly, as part of the Integrated Review, the British military is losing much traditional capability, cutting personnel and retiring several armoured vehicles. Secondly, the UK's historical approach to defence procurement created problems. While an extra 188 billion pounds was allocated to defence over the next four years, an accumulated budget gap will absorb much of this.[108] Furthermore, the latest equipment plan is once again officially unaffordable.[109] British Army and Royal Marines modernisation beyond the 5 years time frame is also beyond current planning horizons, and predictions about developments in 15 to 20 years' time are largely speculative.

Nevertheless, the prospective soldier system of systems is intended to be transformational. There is an increased focus on persistent engagement through regular deployments to areas of interest abroad, and the future force looks to be more agile in some regards. Notably, much of the British Army will deploy independently in sub-platoon-sized small teams and independent company-scale formations generated by the new Special Operations Brigade and Ranger Regiment,[110] with teams required to inter-operate *ad hoc* with partners. As such, effective soldier systems are of even greater importance. Much of the groundwork was laid by the Future Integrated Soldier Technology (FIST) programme,[111] which

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106 Nick Reynolds is Research Analyst at the Royal United Services Institute (RUSI).

107 British Ministry of Defence, *Defence in a Competitive Age*, March 2021, https://www.gov.uk/government/publications/defence-in-a-competitive-age.

108 Larisa Brown, "Billions for Defence Plan May Be Lost to Black Hole", in *The Times*, 16 March 2021, https://www.thetimes.co.uk/article/billions-for-defence-plan-may-be-lost-to-black-hole-zw9fdwb9v.

109 National Audit Office, *The Equipment Plan 2020-2030*, 12 January 2021, https://www.nao.org.uk/?p=140177.

110 British Ministry of Defence, *Defence in a Competitive Age*, cit. p. 46.

111 A.M. Macnaughton, *The UK FIST Programme. Improving the Combat Effectiveness of the Dismounted Soldier*, presentation given at 50th Annual Joint Services Small Arms Systems Section

ran from 2003 until 2015 and established core aspirations that remain part of current programmes, particularly those of networked and integrated sensors and communications. However, while FIST delivered equipment such as night sights, thermal sights and other optics, the technology of the time left many of its integration aspirations unfulfilled. Furthermore, its traditional procurement cycle framework is now considered sluggish. Currently, the Infantry Trials and Development Unit (ITDU) and the TommyWorks programme are responsible for the British Army's dismounted soldier modernisation,[112] and have been driving experimentation and spiral development.[113] As with FIST, they are mostly focused around the benefits of networking at both the individual and small-unit level, though there is now an increasing focus on unmanned systems too.

As experienced with FIST, the British Army recognises that successful transformation must be underpinned by procurement reforms, for it will be reliant on leveraging commercially-available technology and systems quickly. There are promising signs of change. The Helmand campaign proved the usefulness of and highlighted hurdles with rapid commercial procurement under the Urgent Operational Requirements system.[114] This experience primed the military for rapid development, and the Army now aspires to agility and closer collaboration with industry.[115] Open architecture and utilising COTS where appropriate are both now critical requirements.

Complementing the roll-out of new equipment and systems to the whole force, by obtaining the latest equipment for individual units under the 'buy-and-try at scale' model, is a further change of approach intended to allow the British Army to better keep up with the latest developments, experiment, and gain experience.[116] 2nd Battalion The Yorkshire Regiment is currently the Enhanced Light Force Battalion, but set to become the Army Experimentation Force, a prototype warfare roles where the unit trains and conducts operations with new, untested equipment to provide evidence for future technological development, procurement, and concepts of operations.[117] This might occur at the battalion level, but much experimentation is focused at lower echelons. The new approach comes at the cost of less standardisation, making large-scale operations more difficult to logistically support, and will rely on personnel being adaptable, particularly if they are

Annual Symposium, Exhibition & Firing Demonstration, Las Vegas, 11 May 2004, https://ndia.dtic.mil/2004/2004arms.html.

[112] Harry Lye, "Connectivity: The Heart of the Future Soldier", in *Army Technology*, 20 April 2020, https://www.army-technology.com/?p=229378.

[113] Author interview with senior British Army officer serving with Army HQ, June 2021.

[114] British Ministry of Defence, *Standing Commitments*, 12 December 2012, https://www.gov.uk/guidance/standing-commitments.

[115] British Army, *The Army Warfighting Experiment is Evolving*, 24 March 2021, https://www.army.mod.uk/news-and-events/news/2021/03/army-warfighting-experiment-evolution.

[116] Author interview with senior British Army officer serving with Army HQ, June 2021.

[117] British Army, *New Experimentation Unit to Supercharge Army Transformation*, 27 March 2021, https://www.army.mod.uk/news-and-events/news/2021/03/experimentation-battlegroup.

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transferred or attached between units operating to different equipment standards. It also places increased emphasis on all three military services to gather lessons learned and determine which systems and new tactical adaptations that develop as a result should be retained and disseminated to the wider force.

7.2 Basic equipment and weaponry

Recent modernisation efforts have yielded some noticeable changes, particularly in terms of basic equipment. The Virtus Soldier System, which encompasses load-carrying and personal protective equipment, was first introduced in 2016 and is finally reaching Army-wide adoption in 2021. Designed to emphasise weight minimisation and modularity, it includes a much-improved helmet, body armour and accessory set, though other elements have not proven universally popular due to useability issues and initial manufacturing defects.[118] Likewise, there have been some changes to standard-issue small arms. The British Army's rifle received some minor ergonomic improvements when it was upgraded to the new SA80A3 standard. However, the recent drive by the Royal Marines to reequip themselves organisation-wide with the C8 as their primary rifle[119] now looks to have fallen a foul of budgetary constraints. Other changes include a phasing out process from 2018 onwards of the British Army's short-barrelled L110 LMG in favour of the L129A1 designated marksman rifle and L7A2 GPMG for fire support. Overall, changes to weapons have been modest, and are unlikely to see substantially change for the foreseeable future.

7.3 Command and control

The most fundamental part of the new system of systems is the C2 architecture, in order to integrate the other components. These sit under the umbrella Land Environment Tactical Communication Information Systems (LE TacCIS) programme.[120] Notably, developments are driven by perceived threats, not experience. The UK is increasingly aware that it has not fought a peer adversary in recent memory, where one of the principle challenges would be electronic warfare (EW). In particular, Russian EW capability has become formidable thanks to doctrinal importance and investments.[121]

The currently-fielded Bowman radio system fulfils tactical C2 requirements, providing a basic communications backbone by transmitting voice and data

[118] Jonathan Beale, "Army Soldiers Raise Concerns About New Body Armour", in *BBC News*, 19 May 2016, https://www.bbc.com/news/uk-36327103.

[119] Lucy Fisher, "Green Beret Is the Sole Survivor as Royal Marines Get a Modern Makeover", in *The Times*, 4 November 2019, https://www.thetimes.co.uk/article/green-beret-is-the-sole-survivor-as-royal-marines-get-a-modern-makeover-phns5qmxk.

[120] British Ministry of Defence, *LE TacCIS Programme*, 1 October 2020, https://www.gov.uk/guidance/le-taccis-programme; British Army, *LE TacCIS Programme Summary Version 3.0*, 21 July 2017.

[121] Madison Creery, "The Russian Edge in Electronic Warfare", in *Georgetown Security Studies Review*, 26 June 2019, https://wp.me/pb4Y1r-UP.

reasonably securely. By 2024–2025 Project Morpheus is intended to replace it.[122] Morpheus has been dogged by a reputation for unclear requirements and limited output, but the trickle of hardware options that have emerged indicate that the buy-and-try model of experimentation is working. Meanwhile Programme THEIA, a new initiative, covers the data aspects of the Digital Backbone and will explore artificial intelligence and machine learning support.[123] Whatever solutions are finally adopted, these will include or consist of ruggedised COTS user devices, radios and computing equipment.[124] The C2 system will also potentially abandon older centralised models in favour of mobile *ad hoc* networks (MANETs) and mesh nets capable of operating in the absence of fixed infrastructure. The Royal Marines have already been experimenting with mesh nets which are sufficiently advanced to be self-healing.[125] These types of networks require less dedicated support to establish themselves, and will instead automatically create a network and cloud that can share data when introduced to a new area of operations. These are versatile and in theory should require less management and maintenance, but have historically had issues with scaling. Their versatility also creates theoretical vectors for attack. Only time will tell whether these technical challenges can be overcome as the technology matures.

7.4 Unmanned systems

A subordinate aspect of modernisation, but the most radical in terms of impact, is the adoption of unmanned systems. Yet adoption is rooted in practical experience of traditional soldiering challenges. Unmanned ground vehicles are notable in that they are an emergent technology that fill a long-identified problem – how to keep units mobile while still carrying the right capabilities. In the more recent Helmand campaign in Afghanistan, dismounted soldiers and Royal Marines had been overburdened through the requirement to wear heavy body armour and carry electronic countermeasures. Many units were unable to effectively manoeuvre, and were certainly unable to keep pace with their irregular adversaries. Perhaps due to the Falklands and Afghanistan experiences, both difficult campaigns fought primarily dismounted, this problem was recognised as critical. Experimentation has prominently featured UGVs.[126] The initial round of spiral development focused on autonomous resupply, though intelligence, surveillance and reconnaissance (ISTAR) and armed UGVs have been tested too. Despite previous experience

[122] British Ministry of Defence, *Morpheus Programme: Next Generation Tactical Communication Information Systems for Defence*, last updated 18 April 2018, https://www.gov.uk/guidance/morpheus-project-next-generation-tactical-communication-information-systems-for-defence.

[123] British Ministry of Defence, *Army Digitalisation: THEIA*, last updated 9 July 2021, https://www.gov.uk/guidance/army-digitalisation-theia.

[124] Danielle Sheridan, "Army Finally Ready to Ditch Map and Compass and Head in New Direction", in *The Telegraph*, 22 June 2021, https://www.telegraph.co.uk/news/2021/06/22/army-finally-ready-ditch-map-compass-head-new-direction.

[125] British Army, "The Army Warfighting Experiment Is Evolving", cit.

[126] "UK Dstl Awards Contracts for Autonomous Land Vehicle Systems", in *Army Technology*, 16 March 2020, https://www.army-technology.com/?p=227727.

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highlighting the importance of UGV logistics support, it also intersects with predictions about the difficulty of maintaining ground lines of communication (GLOCs) in high-end warfighting.[127] Here, the threat level incentivises de-risking resupply operations for human logistics personnel through unmanned systems.

Meanwhile, UAS development has generally focused on ISTAR, initially testing nano-UAS such as Black Hornet before advancing to larger micro-UAS units able to carry organic effectors and mission payloads.[128] This has included efforts to coordinate them with ground combat units, linking UAS ISTAR sensors with more traditional fires.[129] However, this is still a nascent area of capability that remains underdeveloped.

7.5 Implications for the future

The changes detailed in this chapter are currently subject to experimentation intended to fundamentally reshape concepts of operations, but at present this remains incomplete.[130] For autonomous systems to fulfil their potential, perhaps the most obvious cornerstone of future transformation, the right C2 systems must already be in place. Currently, unmanned systems are both immature and not integrated into C2 systems, requiring one-to-one supervision which limits their utility.[131] Therefore, the current model whereby they are deployed to fulfil specific niche roles via supervised autonomy cannot evolve further until after Project Morpheus creates the C2 framework into which they can be integrated. This will not be in place at least before 2025, assuming no delays. Once autonomous systems can be integrated, developing and refining practical concepts of operation will occur.

Another issue that must be resolved stems from the British Army's increasing focus on partnered operations. These will raise serious challenges for communications and C2 interoperability. At present the technical solutions to problems such interfacing British C2 systems with untrusted partner C2 networks without inadvertently creating vectors for cyber-attacks or hostile information exploitation remain underdeveloped. Traditional cornerstones of partnered operations, such as employing liaison officers within a partner hierarchy and one party borrowing the other's communications equipment to access their network will continue for the foreseeable future.

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127 Nick Reynolds, "Learning Tactical and Operational Combat Lessons for High-End Warfighting from Counterinsurgency", in *The RUSI Journal*, Vol. 164, No. 7 (2019), p. 42-53.

128 Author interview with senior British Army officer serving with Army HQ, June 2021.

129 British Royal Navy, *Royal Marines Roll-Out New Vehicles on Mortar Exercises*, 3 December 2020, https://www.royalnavy.mod.uk/news-and-latest-activity/news/2020/december/03/201203-45-commando-mortars.

130 Author interview with senior British Army officer serving with Army HQ, June 2021.

131 Ibid.

7.6 Conclusion

Despite the problems with under-funding, short-termism and the equipment programme that have historically impacted upon modernisation, there are promising signs that the UK will create an effective system of systems. However, the overhaul of C2 structures will need to take place first to support and integrate sub-systems, particularly unmanned ones. This will probably take the rest of the 2020s. The 2030s are therefore likely to feature a great deal of further refinement, as concepts of operation that are being speculatively experimented with are subjected to robust testing and integration programmes. Given the number of technical issues to be overcome, both known and unknown, this will be challenging. However, the current conceptual focus appears to be in the right place.

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8. Israel

by Michael Shurkin[132]

The Israeli Army's approach to network-centric technologies and Israel's military and defence industries count among the most advanced in the world. They are at the cutting edge of network-centric warfare (NCW), digital command, control, and communications, and intelligence, surveillance, target acquisition, and reconnaissance technologies. This status reflects the country's early adoption of many of the concepts associated with the Revolution in Military Affairs (RMA) and "transformation", and the fact that the prevailing view within Israeli defence circles for several decades now is that the security threats Israel faces and the current operating environment of the Israel Defence Forces (IDF) require developing and fielding advanced technology.

8.1 Israel and the RMA

Israelis in the late 1990s and early 2000s worked to adapt the RMA concept to their own purposes, and it appears to be the case that RMA informed the development of Israel's Systemic Operation Design (SOD) concept, though for all intents and purposes, Israeli RMA thinking and SOD are the same thing. For the Israelis these concepts amounted to a strong belief that NCW associated with sensors, datalinks, ISR, and precision fires would bring about a quantum leap regarding the ability to identify and precisely strike targets and, ultimately, speed up significantly the famous Observe Orient Decide Act (OODA) loop popularised by John Boyd. RMA-related technology also promised to reduce casualties and collateral damage while lightening logistical burdens. These ideas found a particularly willing audience in Israel given the Israeli military's long-standing emphasis on speed and leveraging what it considered to be a significant advantage over its Arab adversaries, namely its better ability to manage operations and adroitly adapt to changing circumstances. The Israelis in the early initiated a series of force structure reforms and budget cuts that boosted spending on technology while reducing the size of the country's ground forces, especially the heavy armour units. A cornerstone of this effort was a modernisation programme known as "Digital Ground Army", or Tsayad, with Elbit as the principal contractor and a reorganisation of the Army's structure intended to boost combined arms synergies.[133]

The Second Lebanon War in 2006, widely perceived as a disaster for the IDF, cooled Israeli's enthusiasm for SOD/RMA at least at a strategic level, however in an important way it endorsed a requirement for which the new technology seemed

[132] Michael Shurkin is Founder and President of Shurbros Global Strategies (SGS).

[133] Anthony H. Cordesman, *Israel and Syria: The Military Balance and Prospects of War*, Washington, Center for Strategic and International Studies (CSIS), 15 April 2007, p. 86, https://www.csis.org/analysis/israel-and-syria; "Israel Aims for Net-Centric Warfare with the Tsayad Program", in *Defense Industry Daily*, 16 May 2005, https://www.defenseindustrydaily.com/?p=523.

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perfect. Namely, the war revealed that the IDF had become overly centralised owing to political requirements to review fire missions for collateral damage risk and other political factors. This slowed down operations and ran counter to the IDF's ethos of "mission command" or command by intent. In a quickly evolving urban battle, it is a significant impediment to precisely the kind of fast-paced, improvised maneuvers at which the IDF historically has excelled.[134] The IDF saw in new technologies a way to help restore the Army's capacity for decentralised operations and maximise the coordination of combined and joint capabilities by increasing integration and giving lower echelons the ability to coordinate joint assets while increasing the flow of information at lower levels.

At the same time there was a growing conviction within the IDF that urban warfare was eclipsing in importance the kind of sweeping Blitzkrieg style manoeuvre warfare at which it had excelled, requiring it to think differently about the battlefield and how to operate on it. The results can be seen in a study undertaken by the Israeli Army, "Land on the Horizon", which stressed the need to think in three dimensions, owing to the rise of subterranean operations, the challenges of fighting among multi-story structures, and the imperative of controlling and saturating the low airspace, with large numbers of small and medium-sized unmanned aerial systems operated directly by the Army. Another is the need to speed up significantly the ground forces' own OODA loop considering the threat posed by, for example, anti-tank guided missiles (ATGM) gunners operating in an urban setting.[135] This made the necessity for precision an absolute imperative. Lastly, the IDF determined that it needed to push combined and joint capabilities to smaller echelons. Smaller task forces ideally would do a better job of leveraging the synergies of combined and joint fires, and, ideally, they would be able to increase their effectiveness through collaborative warfare. Collaborative warfare refers to the ability to share targeting information regarding a threat to everyone on the network, with whoever is best suited for dealing with the threat pulling the trigger.

8.2 From Tsayad to Fire Weaver: The Israeli Army's big investment in NCW

In the early 2000s the IDF invested in several parallel network warfare programmes. The most important of these was Tsayad.[136] Tsayad itself is often described as a network of networks intended to link all echelons from the individual soldier and infantry squads to the division level.[137] In 2014 the IDF announced that Tsayad was "fully deployed".[138]

[134] David E. Johnson, *Hard Fighting. Israel in Lebanon and Gaza*, Santa Monica, RAND, 2011, p. 100, https://www.rand.org/pubs/monographs/MG1085.html.

[135] Ami Rojkes Dombe, "A Measurable War Opposite Terrorism", in *IsraelDefense*, 25 August 2017, https://www.israeldefense.co.il/en/node/30864.

[136] Tal Inbar, "The 'Tzayad' is Fully Deployed", in *IsraelDefense*, 20 February 2014, https://www.israeldefense.co.il/en/node/22038.

[137] Ibid.

[138] Ibid.

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Overtime the IDF's understanding of Tsayad evolved. Tsayad users in the IDF began to want to go beyond sharing data to manipulating it for specific functions. During the conflicts in Gaza on 2012-2014, all battalions and brigades for the first time had the technology and were connected to the military headquarters in Tel Aviv. IDF users now were operating with Tsayad on a large scale, involving, for example, hundreds of tanks, with each tank's position and general activity captured by the network and made visible to everyone from the battalion level on up. The IDF also deduced from the experience the need for a second phase of Tsayad to involve extending Tsayad's reach to provide C2 for smaller units. Now every crew commander or company commander would have their own computer. This is what Elbit's current Torch 750 system achieves.[139] Torch 750 reportedly allows a "platoon commander to see not only infantry and tank units in a certain area, but what's in the air and at sea".[140]

Another way to think about Tsayad is comparing it to the Android or iOS operating system on smart phones, which create an ecosystem in which various "apps". In this case, Elbit has played the role of Google or Apple by creating the OS and the ecosystem in the form of the battle management software (BMS) at the heart of Tsayad. Within that ecosystem, contractors build apps for specific functions. A notable example is Fire Weaver, which is for company-level fires. Rafael designed Fire Weaver to provide infantrymen with easy access to fires by facilitating the sharing of targeting information with combined and even joint fires. Fire Weaver works in a manner analogous to the Uber app, which uses AI to figure out which driver should be tasked with taking a user from point A to point B. Fire Weaver enables the user to designate a target and share the information with the network. Fire Weaver then uses AI to task the weapon system best suited for the job according to various criteria, which include rules of engagement and collateral damage risk. One can presume the system knows, for example, not to task a system that will flatten a house when a particular target requires something with more finesse.

The system is geared above all for speed and precision: whereas before it might take 10 minutes or more for an infantry company to communicate to a tank the need to shoot a target and the target's location, now the task was nearly instantaneous. Indeed, the entire sensor-to-shooter loop could be closed in a matter of milliseconds if it were not for IDF policy which insisted on a man-in-the-loop as opposed to fully autonomous systems. The IDF in 2020 announced that it would field a brigade equipped with Fire Weaver by 2022.[141]

[139] Interview with a retired Army general.

[140] Amir Buchbot, "The IDF's New System of Control Can Lead to a Revolution. Only the Budget is Missing" (in Hebrew), in *Walla!*, 12 September 2020, https://news.walla.co.il/item/3386198; Yaakov Lappin, "IDF Officer Post-Conflict: Clear Picture of Battlefield Top Priority", in *Jewish News Syndicate*, 14 June 2021, https://www.jns.org/?p=172236.

[141] Samuel Cranny-Evans, "IDF Orders Fire Weaver Network Fire Control System", in *Jane's*, 4 February 2020, https://www.janes.com/defence-news/news-detail/idf-orders-fire-weaver-network-fire-control-system.

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8.3 Bringing the revolution to dismounted infantry

The IDF was keen to extend the presumed benefits of NCW to dismounted infantry, with the urban environment foremost in mind. In the early 2000s the IDF, working closely with contractors such as Elbit, began developing equipment for dismounted infantry. The idea was to "treat the soldier as another tactical platform", meaning that soldiers would be nodes on the network as much as, for example, a tank.[142] They began developing a suite of gear that included the Red Rock ultrahigh frequency radios, Bluetooth headsets, night vision equipment, a helmet mounted display, and a "ruggedised personal digital assistant".[143] It was in that context that IDF began taking steps to replace its M16/M4s with the Tavor assault rifle. Development of a "complete infantry system"— sometimes referred as the "Infantry 2000" concept — was set for 2005. Development and testing continued for what by that time had come to be known as the Integrated Advanced Soldier (IAS) programme, the development of which was led by Elbit and the IDF's Defense Directorate for Research and Development (DDRD). Among other things, IAS aimed to link the infantry systems fully with Tsayad.[144] The system featured evolving technology related to display screens, handheld devices, and the basic computer system undergirding everything, which of course changed apace with developments in the commercial market. One of the newer features of IAS was the QuietOps software connected to infantry radios and headsets that provided passive and active hearing protection while also improving hearing and enabling soldiers to communicate at a whisper.[145] Also developed as part of IAS was new navigation and target acquisition technology.

In recent years the IDF clearly has continued in its embrace of high-technology as a response to battlefield requirements. Reinforcing the trend is the concept of "multi-domain operations" (MDO), a new American import. MDO boils down to ramping up joint capabilities in search of ever greater synergies, largely by integrating Tsayad with the IDF's other services. The Israeli take on MDO can be seen in the multi-year "*Tenufa*" or "Momentum Plan," unveiled in 2019, which largely affirms the idea that what the IDF needs to do is speed up the OODA loop even more and use technology for greatly enhanced "multi-domain" operations. The idea quite simply is to create "a networked force that can destroy enemy capabilities in as little time and at as low a cost as possible".[146]

142 Adam Baddeley, "Israel Builds New Soldier System", in *SIGNAL Magazine*, November 2003, https://www.afcea.org/content/israel-builds-new-soldier-system.

143 Ibid.

144 "Israel's Integrated Advanced Soldier (IAS) Program – ANOG", in *Defense Update*, 2 March 2007, https://defense-update.com/20070302_inf-200.html.

145 Ibid.

146 Yaakov Lappin, "The IDF's Momentum Plan Aims to Create a New Type of War Machine", in *BESA Center Perspectives Papers*, No. 1,497 (22 March 2020), https://besacenter.org/?p=30027.

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For the infantry, there is a particular emphasis on enabling soldiers and small units to leverage fully (and quickly) the full panoply of IDF capabilities, namely be enhancing their ability to detect and see threats and then pass that information to the network that quickly deals with the threat, all the while feeding information laterally and vertically.[147] Rafael, for example, is developing something called Automatic Target Recognition (ATR), which ostensibly will enable infantrymen equipped with ATR goggles to share a common operating picture with fighter pilots, with targets marked and identified, and with relevant targeting information shared out to relevant actors. The system interacts with Rafael' Smart, Precise Impact, Cost-Effective (SPICE) family of precision munitions so that infantry men can guide them to their targets.[148] IDF infantry similarly is being outfitted with tactical drones and small loitering munitions, among them Rafael's Firefly loitering munition said to be designed particularly for urban settings, where fixed-wing drones are less useful.[149] Elbit similarly has developed the Hattorix, which is a portable ISTAR system that allows infantry to surveil and identify targets and pass targeting information instantly to available firing platforms. One of Elbit's latest offerings is the Assault Rifle Combat App System (ARCAS), which is designed to network assault rifles and dismounted infantry via optics and a helmet-mounted display that through enhanced reality provides navigation, friend or foe, and targeting information, and also shares information with others on the network.[150]

8.4 Conclusion

Israelis think it to their advantage to leverage technology to enhance the speed with which they adapt to battlefield realities and deal with even the most fleeting of targets while reducing casualties and collateral damage, especially in an urban setting. On the agenda moving forward is greater integration of all the new unmanned aviation platforms, and, inevitably, greater automation.

[147] Seth J. Frantzman, "Israel Reveals Progress, Challenges As It Implements New War-Fighting Concept", in *Defense News*, 22 January 2021, https://www.defensenews.com/global/mideast-africa/2021/01/22/israel-reveals-progress-challenges-as-it-implements-new-war-fighting-concept; Hanan Greenwood, "For the IDF, the Line Between Reality and Science Fiction Is Already Blurring", in *Jewish News Syndicate*, 12 October 2021, https://www.jns.org/?p=188322.

[148] Udi Shaham, "Rafael Unveils AI, Deep Learning Tech for IDF Infantry Troops", in *The Jerusalem Post*, 27 December 2020, https://www.jpost.com/israel-news/rafael-unveils-ai-deep-learning-tech-for-idf-infantry-troops-653389.

[149] Jane's, *IAV 2020: Rafael's Spike Firefly Latest Developments* (video), 30 January 2020, https://youtu.be/tm8YmMm2Its.

[150] Elbit, *Elbit Systems Unveils ARCAS: AI-Powered, Computerized Solution for Assault Rifles*, 9 September 2021, https://elbitsystems.com/?p=14977.

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9. The EU and NATO frameworks

by Ottavia Credi

The internationalisation of capability development offers several advantages, such as the opportunity to share costs and risks and to understand each other's strengths, technological capacities and doctrinal precepts.[151] Yet, internationalisation also brings along a series of disadvantages, such as limits to a single state's individual aspirations, which must somehow be consistent with the collective goal and the rules of the whole organisation.[152]

This is the context in which EU and NATO countries operate. Through the following paragraphs, this chapter will provide an overview of programmes, intentions and gaps of both organisations, with respect to their work on military innovation and in particular the next generation soldier equipment.

9.1 The EU framework

9.1.1 EDA initiatives and EDF opportunities

In the last few years, the EU has been investing a certain effort on the next generation soldier architecture.[153] In 2010, the European Defence Agency (EDA) initiated the Project Team 21st Century Soldier System (PT 21st CSS), which aimed to identify and address capability gaps in soldier equipment modernisation programmes and outline future capability requirements.[154] The project was especially oriented towards the improvement of two EDA programmes: Soldier Centric Identification for Dismounted Soldier (SCIS) and Combat Equipment for Dismounted Soldier (CEDS). Through a Feasibility Study Programme (CEDS-FSP), the latter investigated technology and proposed solutions for future soldier systems in the areas of energy, survivability, human factors and observation.[155] Despite the EDA's effort, the CEDS project was unsuccessful, due to conflicting national aspirations concerning competing industrial solutions.[156]

The EDA was also involved in the Joint Investment Programme on Innovative Concept and Emerging Technologies (JIP-ICET), in the context of which the Agency explored innovative technologies able to provide considerable advantages

[151] Interview, 18 June 2021.

[152] Interview, 7 June 2021.

[153] Interview, 11 June 2021.

[154] European Defence Agency (EDA), *Indoor Navigation for Soldiers*, 23 January 2012, https://eda.europa.eu/news-and-events/news/2012/01/23/Indoor_Navigation_for_Soldiers.

[155] EDA, *Future Soldier Systems*, 21 January 2013, https://eda.europa.eu/news-and-events/news/2013/01/21/future-soldier-systems.

[156] Interview, 25 August 2021.

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to the military system.[157] Such technologies included energy storage and energy harvesting technologies, remote detection systems, and health monitoring applications.

Several European countries have been involved in two 2017 Preparatory Action on Defence Research (PADR) projects: VESTLIFE, for the development of Ultralight Modular Bullet Proof Integral Solution for Dismounted Soldier Protection, and GOSSRA, namely a Generic Open Soldier Systems Architecture.[158] The two ventures received a grant of roughly 2.4 and 1.5 million euro respectively. GOSSRA posed three main objectives: the development of new and innovative devices, the improvement of European networking capability and C2 systems at platoon level, and the enhancement of the soldier's interaction with existing vehicles. Led by Rheinmetall Electronics (Germany), the consortium included GMV Aerospace & Defence (Spain), iTTi (Poland), Tekever (Portugal), Larimart (Italy), Leonardo (Italy), SAAB (Sweden), Indra (Spain) and TNO (Netherlands). Throughout the duration of the project, the consortium performed an analysis of the trends deemed likely to characterise the future dismounted soldier equipment – especially in terms of operational and technological capabilities – resulting in a comprehensive document providing an architecture for standardisation.[159]

In the context of the European Defence Industrial Development Programme (EDIDP), an Action grant was launched with the title "Innovative and future-oriented defence solutions", for a total value of 17.5 million euro between the 2019 and the 2020 call. The project – currently under development – aims at encouraging small and medium-sized enterprises to contribute to the modernisation of defence technologies and applications, thus making European forces more prepared, deployable and sustainable.[160]

Last but not least, the European Commission is currently working on European Defence Fund (EDF) calls for action on military innovation, providing a significant opportunity for cooperation in this field among different European

[157] The JIP-ICET saw its first edition in 2010 and its second edition in 2013. For further information, see: EDA, "Joint Investment Project on Innovative Concepts and Emerging Technologies", in *EDA Factsheets*, last update 15 March 2012, https://eda.europa.eu/publications-and-data/factsheets/jip-icet-factsheet; EDA, "Second Joint Investment Programme on Innovative Concepts and Emerging Technologies (ICET 2)", in *EDA Factsheets*, last update 30 January 2013, https://eda.europa.eu/publications-and-data/factsheets/factsheet-jip-icet-2.

[158] EDA website: *Ultralight Modular Bullet Proof Integral Solution for Dismounted Soldier Protection (VESTLIFE)*, https://eda.europa.eu/docs/default-source/padr/padr-vestlife-projectweb_v5.pdf; and *Generic Open Soldier System Reference Architecture (GOSSRA)*, https://eda.europa.eu/docs/default-source/documents/padr-gossra-projectweb_v4.pdf.

[159] GOSSRA website: https://gossra.net.

[160] The same Action grant was launched in 2019 and 2020. See European Commission Funding & Tenders Portal: *Innovative Defence Products, Solutions, Materials and Technologies*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edidp-sme-2019; and *Innovative and Future-Oriented Defence Solutions*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edidp-sme-2020.

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member states.[161] In particular, the 2021 round of calls includes proposals for the development of innovative military personal protective equipment (40 million euro),[162] beyond line of sight (BLOS) military systems (41 million euro),[163] and applications for the enhancement of soldiers' force protection and mobility (50 million euro).[164] These are just some of the projects through which the EDF intends to increase the autonomy of EU member states in terms of mobility, availability of tools, energy management and situational awareness. Looking forward, EDF projects could play a valuable role in defining Concept of Operations (CONOPS) for the next generation soldier architecture in the EU, thus favouring standardisation and interoperability among member nations.

9.1.2 Policy debate and developments

Through the aforementioned EDA, PADR, EDIDP and EDF activities, the EU has been working on the development and update on innovative technologies employable in the military domain in relation to next generation soldier equipment, including unmanned systems and AI applications. This is also demonstrated by the EDA's decision to list Ground Combat Capabilities among the top priorities of its Capability Development Plan (CDP).[165]

At conceptual and policy level, there is a growing recognition within the EU that the digitalisation of European armed forces is gradually changing the way in which EU member states will plan and conduct future conflicts.[166] In this context, the Commission's Directorate-General for Defence Industry and Space (DG DEFIS) and EDA are investing in Emerging and Disruptive Technologies (EDTs) for military uses. For instance, through the most recent round of EDF calls the Commission demonstrated a serious interest in further research in the field of new materials and technologies for additive manufactured defence applications – especially quantum technologies –, non-line-of-sight (NLOS) optical sensors and over-the-horizon (OTH) radars applications for defence – for a total investment of 60 million

[161] European Commission, "European Defence Fund (EDF) Calls 2021", in *Factsheets*, 30 June 2021, https://ec.europa.eu/defence-industry-space/edf-calls-2021-factsheet_en.

[162] European Commission Funding & Tenders Portal: *Materials and Structures for Enhanced Protection in Hostile Environments*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-matcomp-r-phe.

[163] European Commission Funding & Tenders Portal: *BLOS Collaborative Close Combat Architecture*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-ground-d-3ca.

[164] European Commission Funding & Tenders Portal: *Development of Full-Size Demonstrators for Soldier Systems*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-protmob-d-ss; and *Development of Digital System for the Secure and Quick Exchange of Information Related to Military Mobility*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-protmob-d-dmm.

[165] EDA, *The EU Capability Development Priorities*, December 2018, https://eda.europa.eu/docs/default-source/eda-publications/eda-brochure-cdp.

[166] Daniel Fiott, "Digitalising Defence. Protecting Europe in the Age of Quantum Computing and the Cloud", in EUISS Briefs, No. 4 (March 2020), p. 2, https://www.iss.europa.eu/node/2417.

euro. Through a wider reflection on the needs of future military end-users, EDTs will also be considered by the EU Strategic Compass, currently in the making.[167] Yet, European investments in this area are still insufficient, indicating the lack of an overarching and coherent vision for their applications in the defence field.[168] Against this backdrop, the EU should consider EDTs as an element for further cooperation with the Atlantic Alliance, as well as partners like the United Kingdom and the United States.[169]

There is also a debate within the EU concerning the extent to which, in the future, autonomous weapon systems could replace and/or team with traditional, human-operated platforms. For instance, in January 2021 the European Parliament adopted a resolution urging the Union to establish clear rules concerning the development and use of AI applications, both in the civilian and military sector.[170] Defence ministers of EU member states have agreed on the importance of keeping a human-in-the-loop approach with respect to AI-enabled systems.[171] European militaries are indeed focused on the teaming between manned and unmanned systems whereby the human remains in the loop, and both artificial intelligence and UxS support operations mainly regarding intelligence surveillance reconnaissance, mobility and logistics. In this perspective, unmanned systems bring along substantial improvements, both in terms of soldiers and sensors mobility and opportunity for reducing the number of personnel operating in dangerous theatres of conflict.[172]

Notwithstanding all the aforementioned activities, the EU lacks a data picture for the digitalisation of its armed forces, as well as a clear understanding of how they could resort to Big Data to counter attacks from adversaries.[173] Moreover, despite the increased resort to UxS, the EU suffers the fragmentation of both the UxS market and of the systems to counter them, and it has yet to figure out what should

[167] European Union Institute for Security Studies (EUISS), *A Strategic Compass for EU Defence: What Implications for the European Defence Industry* (Report), May 2021, p. 3, https://www.iss.europa.eu/node/2585.

[168] Ester Sabatino and Alessandro Marrone, "Emerging Disruptive Technologies: The Achilles' Heel for EU Strategic Autonomy?", in *IAI Commentaries*, No. 21|31 (June 2021), https://www.iai.it/en/node/13569.

[169] Ibid., p. 2.

[170] European Parliament, *Resolution of 20 January 2021 on Artificial Intelligence*... (P9_TA(2021)0009), https://www.europarl.europa.eu/doceo/document/TA-9-2021-0009_EN.html. This measure follows a previous resolution, adopted in September 2018, which called for the ban of lethal autonomous weapons. For more information, see: European Parliament, *Decision of 18 June 2020 on Setting Up a Special Committee on Artificial Intelligence in a Digital Age*... (P9_TA(2020)0162), https://www.europarl.europa.eu/doceo/document/TA-9-2020-0162_EN.html.

[171] Vincent Boulanin et al., *Responsible Military Use of Artificial Intelligence. Can the European Union Lead the Way in Developing Best Practice?*, Stockholm, Stockholm International Peace Research Institute (SIPRI), November 2020, p. 6, 13, https://www.sipri.org/node/5285.

[172] Jeroen Franssen in Finabel webinar "New Trends in Army Innovation" (video), 13 November 2020, https://youtu.be/3etUscgovxA; Miguel Gonzalez Buitrago, Lucia Santabarbara and Simone Rinaldi, "Land Forces Modernisation: Challenges of Transformation", in *Finabel Food for Thought*, March 2021, p. 17, https://wp.me/paDUqP-1zE.

[173] Daniel Fiott, "Digitalising Defence", cit., p. 6-7.

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be the optimal interaction between soldiers and their unmanned equipment.[174]

In order to track and record each other's progress on defence digitalisation, European countries could take advantage of the platforms offered by the Coordinated Annual Review on Defence (CARD) – which recently identified soldier systems as "most promising, most needed or most pressing" area for collaborative opportunities[175] – and the Permanent Structured Cooperation (PESCO). With respect to the latter initiative, there are already ongoing activities addressing the future of land warfare. An example is offered by the EU Collaborative Warfare Capabilities (ECoWAR) project, aimed at enhancing the ability of European armed forces to resort to a wide range of technological applications, ranging from sensors to effectors, to face modern challenges in a more efficient, interoperable and collective manner.[176] Coordinated by France, the project encompasses Belgium, Hungary, Poland, Romania, Spain and Sweden.

To be able to rely on innovative technologies on the battlefield, the EU will need to improve interoperability among member states' militaries, which will necessarily require further work on data sharing among EU countries.[177] Such goal might be hindered by rapid technological advances in the sector, together with the proliferation of tools and platform which are bound to partly alter the current functioning of European armed forces.[178]

The failure of the CEDS project demonstrated the difficulty, among EU member states, to establish a degree of interdependency which would allow an efficient division of labour.[179] With regard to the specific case of the next generation soldier, such aspiration might be even harder to attain, given its nature as a System of Systems (SoS) made of multiple layers, thus possibly requiring a larger industrial agreement.[180] Moreover, in the land sector market access barriers are relatively low in terms of investments, also considering the need by all European armies to provide individual equipment kit to thousands of dismounted soldiers. Such dynamics, in turn, encourages the protection and promotion of national solutions, including within cooperative attempts. If, on the one hand, this poses a considerable organisational challenge, on the other hand collaborative activities could lead to significant industrial opportunities among EU member states, besides boosting

[174] Miguel Gonzalez Buitrago, Lucia Santabarbara and Simone Rinaldi, "Land Forces Modernisation", cit., p. 18.

[175] EDA website: *Coordinated Annual Review on Defence (CARD)*, https://eda.europa.eu/what-we-do/EU-defence-initiatives/coordinated-annual-review-on-defence-(card).

[176] PESCO website: *EU Collaborative Warfare Capabilities (ECoWAR)*, https://pesco.europa.eu/project/eu-collaborative-warfare-capabilities-ecowar.

[177] Daniel Fiott, "Digitalising Defence", cit., p. 6, 7.

[178] Jacopo Bellasio et al., "Innovative Technologies Shaping the 2040 Battlefield", in *EPRS Studies*, August 2021, p. 20, https://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_STU(2021)690038.

[179] Interview, 25 August 2021.

[180] Ibid.

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the competitiveness of the European Defence Technology and Industrial Base (EDTIB).[181] In the end, the EU as a whole should encourage capability development initiatives among its members in the field of future soldiers' equipment, favouring programmes and activities in research, development, technology and innovation (RDT&I).[182]

9.2 The role of NATO: Setting standards, establishing requirements, stimulating innovation

As an alliance among sovereign members without supranational powers or competencies, NATO's role can be understood as a fusion of all national positions, of course considering the different weight of its member.[183] When it comes to military capabilities, Allies must first agree upon certain standards through NATO processes; then, national efforts of military planning and capability development must be compliant with such specifications. The Alliance's role as a standard-setting organisation is ultimately aimed at enhancing the interoperability and operational effectiveness of its members' military forces. NATO does not impose its members to acquire a certain type of equipment. It rather indicates which standards must be observed in order to be compliant with the Alliance's requirements, and this has an indirect impact over Allies' procurement activities.[184]

The NATO Standardization Office (NSO) is the agency appointed at coordinating standardisation activities within the Alliance and outlining the Standardisation Agreements – better known as STANAGs. In developing military operational standards, the NSO works closely with NATO's International Military Staff (IMS), the executive body of the Military Committee (MC). Standards established by the NSO and the IMS must then be approved by the North Atlantic Council (NAC), where all Allies are represented in order to be finally implemented at national level. True standardisation can only occur with a genuine agreement on shared intentions: when a state ratifies a standard, it takes on the responsibility to implement it both in terms of defence planning, capability development and doctrine adaptation.[185]

So far, not much attention has been paid to the field of the soldier system within the Alliance: though NATO did inspire its members to invest on their respective next generation soldier programmes, at present time there are no relevant initiatives on this topic within the NATO framework.[186] NATO inaugurated a programme called "Soldier Modernisation" in 1994, aiming to enhance soldiers' ability to fight whilst ensuring a high degree of protection.[187] In line with the SoS approach,

[181] Interview, 18 June 2021.

[182] Jacopo Bellasio et al., "Innovative Technologies Shaping the 2040 Battlefield", cit., p. 53.

[183] Interview, 7 June 2021.

[184] Interviews, 7 and 18 June 2021.

[185] Interview, 7 June 2021.

[186] Interviews, 18 June and 25 August 2021.

[187] See Chapter 6.

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the programme considered soldiers' equipment as a whole rather than separate, autonomous elements. The Alliance's latest attempt to address this issue occurred in the context of the NATO's Research and Technology Organisation (RTO), which ceased to exist in 2012.[188] Against this backdrop, the Alliance is currently investigating the possibility to outline a standard for the next generation soldier equipment, namely the NATO Generic Soldier Architecture (NGSA).[189] For instance, NATO could have a key role in the definition of standards for the calibres of Allies' weapons – a process that could turn out to be particularly important regarding the future replacement of the 5.56 cartridges used by several allies.[190]

9.2.1 NATO & military technology innovation

Within NATO, the bodies driving the defence technology innovation are primarily the Science & Technology Organization (STO) and the Allied Command Transformation (ACT).[191]

NATO includes a series of committees and sub-committees working in the field of military innovation, including the NATO Army Armaments Group (NAAG), which encourages Allies to implement successful collaboration in the field of land forces armaments, with the ultimate objective of achieving allied interoperability.[192] Another example is offered by the Land Capability Group Dismounted Soldier Systems (LCG DSS), which provides constant updates on individual allied capabilities.

In the last few years, the Alliance has made an effort in understanding the impact of EDTs on its military operations, both in terms of risks and opportunities.[193] The recently published *Science & Technology Trends 2020-2040* report, elaborated by NATO's STO, examines how EDTs are likely to radically alter the ways in which Allies' militaries will operate in the next twenty years.[194] Among such innovations relevant for individual soldier equipment, the Alliance lists AI, Novel Materials and Manufacturing (NMM), and Bio & Human Enhancement Technologies (BHETs) – including, for instance, applications in bioinformatics, biosensors and

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188 Interview, 25 August 2021. For more information, see NATO, *NATO Research and Technology Organisation (archived)*, 9 August 2017, https://www.nato.int/cps/en/natolive/topics_65174.htm.

189 Interview, 7 June 2021.

190 For further and more detailed information, see Chapter 2.

191 Leona Alleslev, *Defence Innovation*, NATO Science and Technology Committee (STC) Special Report, 20 November 2020, p. 9, https://www.nato-pa.int/node/93356.

192 For further information on NAAG, see: https://diweb.hq.nato.int/naag.

193 In February 2021, NATO adopted an implementation strategy for EDTs. For further information, see: NATO, *New Focus on Emerging and Disruptive Technologies Helps Prepare NATO for the Future*, 3 March 2021, https://www.nato.int/cps/en/natohq/news_181901.htm. The 2020 Annual Report of NATO's Advisory Group on EDTs can be found here: https://www.nato.int/nato_static_fl2014/assets/pdf/2021/3/pdf/210303-EDT-adv-grp-annual-report-2020.pdf.

194 Dale F. Reding and Jacqueline Eaton, *Science & Technology Trends 2020-2040. Exploring the S&T Edge*, Brussels, NATO Science & Technology Organization (STO), March 2020, https://www.sto.nato.int/pages/tech-trends.aspx.

human augmentation. Moreover, the report suggests that possible combinations of different types of EDTs – such as a crossover between Big Data and quantum technologies – may highly affect the development of future military capabilities within the Alliance.[195]

NATO is currently working on the Military Uses of Artificial Intelligence, Automation, and Robotics (MUAAR) project, aimed at investigating uses of these technologies in the military domain and propose possible military activities that could benefit from these capabilities.[196] In this context, the Alliance should explore the possibility of establishing interoperability standards for the use of military applications of AI, as well as define a common approach for the Verification, Validation and Accreditation (VV&A) of AI applications used in the context of military operations.[197]

9.2.2 Next steps for the Alliance

There is certainly a lot of room for improvement in NATO's work on the next generation soldier equipment. For one, despite its commitment to anticipate trends in military technologies, the Alliance is facing a challenge posed by the trade-off between the speed at which technological change takes place and the time required by the procurement and introduction of new equipment in the military field.[198] To address this issue, NATO is working on policies promoting the development of high risk/high pay-off projects able to translate abstract concepts into concrete military capabilities whilst the innovation cycle is still at its early stages.[199] Once such challenge will be completed, it will be necessary for Allies to agree over STANAGs for the development of the next generation soldier system.[200] NATO's capability dossier is currently under definition, and states that are both NATO and EU members are likely to have a high degree of freedom to operate in the context of both frameworks.[201]

Given the multinational nature of allied missions, NATO should enhance its internal cooperation in terms of information sharing and technology transfer.[202]

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[195] Ibid., p. vii.

[196] NATO Allied Command Transformation (ACT), "Military Uses of Artificial Intelligence, Automation, and Robotics (MUAAR)", in *OPEX Fact Sheets*, February 2020, https://www.act.nato.int/download_file/920/0. The project takes place in the context of the US-led Multinational Capability Development Campaign (MCDC). For more information on MCDC, see the official website: https://wss.apan.org/public/MCDCpub/default.aspx.

[197] Dale F. Reding and Jacqueline Eaton, Science & Technology Trends 2020-2040, cit., p. 15, 57; Erica Pepe, "NATO and Collective Thinking on AI", in *Military Balance Blog*, 13 November 2020, https://www.iiss.org/blogs/military-balance/2020/11/nato-artificial-intelligence.

[198] Leona Alleslev, *Defence Innovation*, cit., p. 5, 7.

[199] Ibid., p. 6.

[200] Interview, 25 August 2021.

[201] Interview, 18 June 2021.

[202] Leona Alleslev, *Defence Innovation*, cit., p. 12.

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To attain real interoperability, the Alliance needs to ensure systems employed by its members' armed forces are, indeed, interoperable also at the lower tactical level. Only by investing in cooperative technological innovation will NATO achieve its goal of maintaining a truly transatlantic set of military capabilities and ensure Allies' sovereignty on military technology.

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10. Conclusion

by Alessandro Marrone and Michele Nones[203]

The set of previous chapters aims to provide an overview of strategic trends, technological developments and NATO/EU frameworks, as well as an analysis of national realities in major NATO countries and Israel. The resulting landscape is rather complex and variegated. Yet some key, common themes and challenges can be outlined, with a view to the way ahead particularly for Italy and other European allies:

- The lessons learned from military history and wishful thinking on technological innovation;
- The Army's unique difficulties in dealing with technologies;
- The complicated relation between ICT and the military;
- The requirement: to ensure soldier's superiority against near-peer adversaries;
- The way ahead: a renewed System of Systems approach;
- Near-peer adversaries and Multi Domain Operations;
- The NATO and EU dimensions: opportunities for Italy.

10.1 The lessons learned from military history and wishful thinking on technological innovation

In NATO countries the path of the next generation soldier will be challenging as the person, the various formations and the whole Army have to deal with different factors when it comes to both operations and technologies. These factors are hard to assess and may lead to incremental changes or to surprises and shocks. However, this is not new in military history. Over the centuries, the introduction of longbows, firepower, rifles, rifled rifles and machine guns, did mark a number of turning points for the infantry towards new characters of land warfare. Tragically, they also implied bloody defeats on the battlefields for those armies falling behind the innovation and transformation curve – notably but not only during World War II or the 1991 Gulf War. Moreover, the introduction of new technologies must be preceded by the proper doctrinal training, organisational changes in order to succeed – including Tactics, Techniques and Procedures (TTP). The most advanced technology cannot guarantee the operational success if it is not properly and timely addressed, mastered and introduced. In the 1870 Battle of Sedan, where a superiorly equipped French Army, featuring the first machine guns, advanced chassepots breach-loader and small calibre rifles was defeated by the Prussian Army equipped with inferior rifles and with no machine gun.

Against this backdrop, in the post-Cold War period the promises of some technological innovations have been overestimated in the West up to the point of a wishful thinking. The expectation that ICT would bring an information superiority

[203] Michele Nones is Vice President of IAI.

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able to misspell Clausewitz's fog of war proved wrong on several occasions, from the 2001 terrorist attacks to Russia's invasions of Georgia (2008) and Ukraine (2014). The assumption that disarticulating opponents C3 systems would let the adversaries to surrender have been buried under the Iraqi desert from 2003 onwards. The hope that a small force made of light and medium brigades could control a wide, wild territory and its population thanks to technological superiority terribly crashed on Afghan mountains. One of the main lessons learned from operational experience is that friction and risk cannot be deleted by a full information superiority nor by the best situational awareness.[204]

10.2 The Army's unique difficulties in dealing with technologies

The never-ending dynamic between technological innovation and operational realities applies to the whole military, but it is particularly challenging for the land component because of three main reasons. First, the Navy and Air Force are trained and used to think, plan and operate in a technology-oriented way, since by default they and their opponents cannot walk through the respective operational environment without advanced platforms. In contrast, Afghan insurgents can effectively challenge NATO soldiers with the likes of widespread Russian individual weapons chambered in 7.62x54R cartridge, and Western armies have had to fight on the enemy's ground in the given circumstances.

The second reason for the Army's unique difficulty in coping with technological innovation is that they are not-platform centric as the other services. The panoply of warships, submarines and aircraft are all complex platforms equipped with sensors and weapon systems at disposal of their crew, and represent the bulk of navies and air forces. For sure the Army relies on important assets such as main battle tanks, infantry fighting vehicles and helicopters, but none of them *per se* is the centre of gravity of the Army: the individual soldier is the centre of gravity, is somehow the weapon system for excellence. Accordingly, the Army deploys larger personnel as well as wider number of different types of individual equipment – including protective armour, helmets, weapons, goggles, radios, etc – than the Navy or Air Force.

Third, the land domain is *per se* more varied in terms of both geography and environments, including the urban one, than the air or naval one, and it is more congested by state and non-state actors, combatants and non-combatants, up to the point where is extremely difficult to timely distinguish friendly and adversary forces.

These three reasons in turn bring obvious but sometimes underestimated implications for both operations and procurement. On the first side, the manoeuvre

[204] Alessandro Marrone, Michele Nones and Alessandro R. Ungaro (eds), "Technological Innovation and Defence: The Forza NEC Program in the Euro-Atlantic Framework", in *IAI Research Papers*, No. 23 (April 2016), p. 149, https://www.iai.it/en/node/6335.

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of formations on the ground involves more assets, is more complicated, complex and unpredictable that a sea or in the air, and communications will remain an issue in difficult terrains. The contemporary theatre of conflict appears to be a complex, multilevel and cross-sectoral environment, where the physical, information technology and cognitive dimensions need to be smoothly integrated to be effective: this proves to be a significant challenge even for the most advanced armed forces when it comes to C3 and connectivity.[205] On the procurement side, in the land sector Research, Technology and Innovation (R&T&I) activities as well as acquisition are fragmented across different components and suppliers, ranging from the dismounted soldier equipment to the variety of ground vehicles and rotary wings platforms. It is not by chance that over the last two decades unmanned vehicles have made much more progresses in military operations in the air and now on and below the seas than their ground counterparts. Moreover, while Navy or Air Force platforms are in range of hundreds, soldier equipment has to be procured in terms of hundreds of thousands, thus adding further complexity and difficulties.

10.3 The complicated relation between ICT and the military

The Army's unique difficulties in dealing with technologies somehow helps to explain the modest and sometimes disappointing results brought by ICT innovation in this field over the last three decades. From the British FIST and French FÉLIN to the Italian Forza NEC,[206] to the various programmes launched in the US and then delayed or cancelled, among NATO countries the benefits of net-centric or network enabled capabilities have often proved significant, but surely inferior to the early expectations. For instance, FIST delivered to British Army equipment such as night sights, thermal sights and other optics, but the technology of the time left many of its integration aspirations unfulfilled.[207] In France, the FÉLIN system with a limited number of modules belonging to the same technical generation is aging faster and is difficult to modernise.[208] Germany has adopted a very cautious approach in this regards, focused on the exploration and validation, through relatively small-scale production, of the possible/feasible military uses of very rapid advances in civilian electronics, without so far a firm requirement for the large-scale introduction of the relevant systems.[209] The most disappoint initiative was probably the US Army Future Combat System, launched in 1999 and then cancelled ten years later, which should have brought major advances also in terms of interconnected and more lethal and survivable soldiers.

[205] See in this regards Chapter 1.

[206] For a comprehensive analysis of Forza NEC see: Alessandro Marrone, Michele Nones and Alessandro R. Ungaro (eds), "Technological Innovation and Defence", cit.

[207] See in this regards Chapter 8.

[208] Ibid.

[209] See in this regards Chapter 4.

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A structural reason for this expectations-results gap lies in the specific features of ICT and their complicated relation with the military world. Being developed primarily for the civilian market and by civilian companies, they respond to a rationale opposite to the traditional defence procurement: short time-to-market cycles, widespread risk acceptance, planned obsolescence, extremely frequent need for update and replacement. European countries found it particularly difficult to deal with the pace of ICT innovation through traditional procurement procedures, which by default are long-term, risk adverse, and aim for equipment to be in service for decades.[210]

In this context, today the British Army recognises that successful transformation must be underpinned by procurement reforms, for it will be reliant on leveraging commercially-available technology and systems quickly.[211] In France, within the framework of the Army innovation pole and the DGA, an innovation platform called CENTURION was created in 2020 as catalyst and contractual tool designed to detect, evaluate, develop technologies and integrate those with a demonstrated operational interest in the evolution of the fighter's equipment. The US case is structurally different because the Pentagon benefits from the unique American technological and industrial ecosystem, but still it encounters major setbacks and difficulties in bringing state of the art ICT to dismounted soldiers and tries to adapt the military procurement accordingly.

A common challenge for all NATO militaries lies *ab origine* in the difference of approaches between those who develop technologies – particularly but not only ICT – and the military users. The engineers are by default optimistic on the fact the new technology will be better than the previous ones. The soldiers are by default worried that the novelty will not work in the extreme, deadly circumstances they will use it. Those in charge of technological innovation are often keen to accuracy, speed and new performances. Those using it care about weight, power management and sustainability, usability and resilience. It may seem a trivial dilemma, but it is not when it comes to ergonomics and the loads a war-fighter has to bear while running and firing: heavier/not ergonomic loads decrease stamina, strength, acceleration and agility, as epitomised by the problems encountered in Afghanistan by NATO troops. For instance, German soldiers' feedbacks from Kabul listed various complains, most specifically about the excessive weight and bulk of the IdZ system.[212] And in upcoming operational scenarios the featured opponent is not anymore an insurgent from the Taliban[213] or the so-called Islamic State militias without adequate C3 or logistics.

210 On the structural difficulties of public bureaucracies and particularly the military to cope with private-led ICT innovation see: Alessandro Marrone, Michele Nones and Alessandro R. Ungaro, "The Challenges of Netcentric Capabilities", in Alessandro Marrone, Michele Nones and Alessandro R. Ungaro (eds), "Technological Innovation and Defence", cit., p. 139-149.

211 See in this regards Chapter 4.

212 See in this regards Chapter 5.

213 Meanwhile, following NATO retreat from Afghanistan the Taliban regime has gained all the modern Western equipment previously provided at the Afghan National Security Forces.

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10.4 The requirement: To ensure soldier superiority against near-peer adversaries

Despite such complicated relation between ICT and the military, NATO armies have to exploit the possible advantages of technologies – particularly but not only new and disruptive ones. The pace of innovation in artificial intelligence, robotics, nano- and bio-technologies, unmanned systems, materials, quantum computing as well as post-quantum, is going to change the contemporary battlefield, in manners that are still hard to grasp and fully understand. On top of that, a leap forward is needed for soldiers' individual weapons when it comes to range and lethality: lighter and more effective and lethal weapons and ammunition currently are among the main solutions designed to regain overmatch over adversary (Russian and Chinese) small arms[214] and soldiers. The US Army is running a major initiative for the development of a new family of infantry weapons through the Next Generation Squad Weapons programme.[215] As mentioned before, the concrete risk is to suffer tragic shocks on the battlefield when it is too late to discover that the balance in terms of mobility, protection and lethality is not satisfactory. The superiority enjoyed by Allies has been eroded on a number of fields by near-peer competitors such as Russia and China, and this applies to the land warfare too.[216] This is indeed the real requirement driving next generation soldier systems efforts in the NATO camp: to re-gain or actually establish overmatch capability against the most advanced and best equipped soldiers.

The related investments on novel individual weapons, body armours made of new materials, helmets and googles fit for augmented reality, cognitive radios, enhanced multi-spectral sensors enabled by modular integration, data fusion and human-machine interface, batteries and/or portable wearable fuel cells (hydrogen or methanol feed),[217] are all steps of a path to be undertaken not only by the US but also by European countries. The US Army explicitly aims to regain the close combat tactical overmatch, i.e. the ability of a squad sized unit (around 10 soldiers) to impose its will on similar sized opponent under all conditions and operational environments.[218] Similar requirements are shared by NATO and Western armies alike.

Europeans are compounded by their security interests to deter and defend to the East, to militarily intervene in the South and South East of Europe where the operational theatres become less and less permissive because of aggressive

214 See in this regards Chapter 2.

215 See in this regards Chapter 4.

216 This is one of the reasons for European renewed investments on main battle tanks. See in this regards: Alessandro Marrone and Ester Sabatino (eds), "Main Battle Tanks, Europe and Implications for Italy", in *Documenti IAI*, No. 20|07 (April 2020), https://www.iai.it/en/node/11536.

217 See in this regards Chapters 2 and 4.

218 See in this regards Chapter 2.

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regional and extra-regional powers[219] and to stand united with the US and NATO on a global geopolitical competition vis-à-vis China. Such an international security environment has important, direct implications for the European armies. For instance, the British Army is particularly worried of Russian electronic warfare (EW),[220] while French Army can still fight in asymmetric conflicts like in the Sahel, but must have a battle-hardened Army ready for joint operations even in the harshest conflicts and facing the toughest clashes, up to a major confrontation, and be capable of winning.[221] For instance the rapid deployment of Russian Army forces of about 90-100,000 soldiers with heavy armour and artillery at the Ukrainian border deeply worried French Army circles, both in terms of quality and quantity. In Italy, the Army is committed to implementing NATO's strategic perspectives on the modernisation of military forces, which should be credible, agile, aware, networked and resilient.[222]

Moreover, the demographic trends in the West, and particularly Europe, point towards an ageing and either stable or declining population, whereby the pool for Army's recruitment of high-quality human resources – in both physical and cognitive terms – will be increasingly limited[223] despite the enrolment of female soldiers. Other sociological trends further challenge the Army's ability to recruit and retain skilled forces. This in turn will require investments on unmanned systems: the individual soldier will not soon be replaced by robots completely, but almost certainly these will work together more closely over time[224] starting ISTAR but also loads carrying and logistic support[225] – for instance in the US and Germany there are plans for a future introduction of exoskeletons. Working together necessitates secure C3 architecture bearing in mind that all future systems will have to take in higher consideration the effectiveness of counter systems to be fielded by near-peer adversaries.

10.5 The way ahead: A renewed System of Systems approach

European armies, including the Italian one, can better walk through the challenging path towards next generation soldier's equipment by adopting a renewed System of Systems approach. The SoS concept is not new, but it needs to be renovated. Its original formulation in the military domain was rather top-down, striving for a seamless integration of devices and capabilities to achieve better performances through a holistic approach. Because of the aforementioned Army's difficulties

[219] Concerning Italian case, see: Alessandro Marrone, "Italian Military Operations: Coping with Rising Threats and Declining US Leadership, in *IAI Commentaries*, No. 20|15 (March 2020), https://www.iai.it/en/node/11439.
[220] See in this regards Chapter 8.
[221] See in this regards Chapter 5.
[222] See in this regards Chapter 7.
[223] See in this regards Chapter 1.
[224] See in this regards Chapter 4.
[225] See in this regards Chapter 8.

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and difficult relation between ICT and the military, the SoS approach experienced a hard reality check over the 2010s, alongside with net-centric and network enabled capabilities concepts. The SoS principle is still valid, even more thanks to progresses on sensors, robotics, computing, big data and AI, and it is being pursued both by the Anglo-Saxon allies and by France's "collaborative combat".[226] Yet a pragmatic adjustment is necessary to renew this approach and make it fir for current and future land warfare.

From an Italian perspective the dismounted soldier is *per se* the first SoS since he/she operationally integrates all the wearable devices including helmet, weapon, radio, goggles, nano or micro UAV, etc.[227] As such, the soldier should be entrusted with an appropriate degree of autonomy and sustainability, compatible with his/her war-fighting tasks. That means tailoring the amount of information to be received according to human being's cognitive capacity, as well as the loads to his/her physical might. In other words, it is always necessary to make the dismounted soldier equipment "*a misura d'uomo*":[228] similarly to the Italian approach featuring the soldier as centre of gravity,[229] or to what the French doctrine currently defines "*à hauteur d'homme*".[230] Bottom line is that technology has to reduce the workload and risks for soldiers and increase its combat effectiveness, while the human-machine interface has to be improved, designed and developed accordingly to support decision-making with a human-in-the-loop.

Against this backdrop, the squad has to be considered the second, crucial SoS. Such formation level seems to be more appropriate for a division of labour and therefore an allocation of technologies and information among commander, gunner, communication officer, etc. This has important implications for instance when it comes to unmanned air or ground vehicles. Most of the UxS will be employed at a higher functional level such as platoon and above, but several ones are becoming smaller and smaller, therefore suitable in theory for squad and even single soldier employment.[231] The fact they *can* be used by the dismounted soldier does not mean they *should* be used at this level: a pragmatic SoS approach should rather look at the most appropriate formation's levels, such as squad and platoon, for this and other technologies. Notably, the US Army's approach to modernisation at the infantry soldier level is shaped by a continued commitment to a common squad size and design across its considerable variety of formations, vehicles, and mission profiles.[232]

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[226] See in this regards Chapter 5.

[227] See in this regards Chapter 7.

[228] This is an Italian Renaissance expression from the 15th century referring to the human being's approach to nature, science, culture and broadly speaking the world. As such, it cannot have any contemporary gender implication.

[229] See in this regards Chapter 3.

[230] See in this regards Chapter 5.

[231] See in this regards Chapter 2.

[232] See in this regards Chapter 4.

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The same SoS approach to soldier and squad should apply, *mutatis mutandis*, to the platoon and then to the higher echelons to be considered as further system of systems, raising the level at which the squad is required to integrate into the larger formations. For instance, the platoon is particularly important from the Italian Army's perspective. In this context, the Army vehicles support should evolve to ensure better support to soldiers in terms of C3, energy, firepower and shelter.

In other words, a renewed SoS approach should be implemented more bottom up than top down, and the intrinsic horizontal character of the net should be balanced by the necessary vertical hierarchy which makes the military effective and resilient in a conflict. The ICT advancements leads the military towards a compression of both levels and timing of decision-making, but the related adaptation should be managed by avoiding micromanagement and at the same time safeguarding the unity of command. To restate the obvious, proper education and training of military officials will be crucial to make the best of current and future technologies in military operations.

10.6 Near-peer adversaries and Multi Domain Operations

Against this backdrop, a further challenge comes by the ongoing shift from asymmetric to near-peer conflict scenarios. Indeed, opponents like Russia and China are able to influence and/or disrupt Western C3 infrastructures and/or infostructures through a combination of cyber, EW and kinetic attacks. Therefore, units at various levels – from dismounted soldiers up to brigades – have to be able to operate even with a degraded network of communications, sensors and effectors. For example, the US Army is looking at a navigation system incorporating simultaneous localisation and mapping technology, and therefore capable of operating in a GPS-denied environment. To a certain extent, the near-peer threat in turn does question the very same benefits of the SoS approach in a scenario where the various systems, or subsystems, cannot be connected anymore in a secure way.

Here comes the long shadow of cyber warfare. Given the nature of the threat and the classification of relevant information, the cyber threat to NATO military operations is extremely hard to assess. The emphasis put over the last decade by the Atlantic Alliance and individual allies on cyber defence hits towards a very high risk of intrusion into allied networks. This in turn calls for a leap forward in the reflection on offensive cyber operations by NATO members, or at least advanced defence, in order to accompany the development of ICT capabilities for Western armies which are secure by design. Encryption technology will be key in this regard. The more the dismounted soldier relies on wireless connection to weapon, augmented reality goggles, networks of sensors, robotics and alike, the more the stove-piping of land warfare from cyber warfare is a recipe for disaster. Once again, this is particularly challenging for European countries like Italy which do not master the fundamentals of the cyber domain as the US or – increasingly – China do.

The concept of Multi Domain Operations could help NATO militaries to factor in the new operational domains, cyber and space, in the joint planning and conduct of military operations, as well as in the defence planning, capability development and defence industrial policy. Recently conceived in the US, is it founding its way in both NATO and national level debates.[233] From the Italian Army it is also understood as a way for commanders to generate effects across other domains to gain an operational advantage, for instance against anti-access/area denial (A2/AD) capabilities of a near-peer competitor.[234]

However, an old saying reminds that "Not all that is gold does glitter": after the disillusions brought by the implementation of concepts like revolution in military affairs and network enabled capabilities, MDO should be taken *cum grano salis* at least with regards to certain extreme aspects. For example, despite Israel seems to move towards this direction with Tsayad and Fire Weaver,[235] the idea that an operation command can autonomously and immediately call firepower from sea and air domains, as well as cyber-attacks and satellite jamming, without going for a politico-military process at strategic level, rises pros and cons, as well as a number of unintended and dangerous consequences. Military history shows that Napoleon won a number of land battles also thanks to the integration of infantry, artillery and cavalry under a single chain of command – the modern Army – while granting a relatively autonomous role of the *armées* commanders. And a greater reliance on the lower level commanders capability to carry out their assigned operation without relying on the flow of information, direction and support by higher echelons is mandatory, re-discovering the German concept of *Auftragstaktik* – where the emphasis is on the mission's outcome rather than orders.[236] For European militaries still somehow struggling to overcome the single services' resistance to an effective joint approach,[237] probably the best solution is a pragmatic, bottom up path to make the best of available technological improvements, from the dismounted soldier up to various echelons.

10.7 The NATO and EU dimensions: Opportunities for Italy

A final, crucial point regards both NATO and EU roles. Within the transatlantic Alliance, the dismounted soldier equipment is likely to see an increased technological and operational divide between the "haves" and "haves not" of next generation technology, as for technologies like big data and AI whereby the US

[233] For an Italian perspective on multi domain operations see: Stefano Cont, "Ecco la guerra del futuro. Arrivano le Multi domain operations", in *Formiche.net*, 2 February 2020, https://formiche.net/?p=1255462.

[234] Interview, 7 June 2021.

[235] See in this regards Chapter 9.

[236] Donald E. Vandergriff, "How the Germans Defined Auftragstaktik: What Mission Command is – AND – is Not", in *Small Wars Journal*, 21 June 2018, https://smallwarsjournal.com/node/96977.

[237] In Italy, a positive step in this regard is the 2021 enhancement of the *Comando Operativo di Vertice Interforze* (COVI). See in this regards Chapter 7.

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lead the technological race and fragmented European allies lags behind,[238] with negative implications in terms of both military interoperability and political cohesion. Here NATO has an important role to play as standard-setting organisation is ultimately aimed at enhancing the interoperability and operational effectiveness of its members' military forces.[239] For instance, NATO could have a key role in the definition of standards for the calibres of dismounted soldier's weapons, a process that could turn out to be particularly important regarding the future replacement of the 5.56 cartridges used by several allies. NATO has also a role to play when it comes to data sharing, because this has huge implications for both allied operations and the creation of datasets to develop military applications of AI. This is particularly true for European countries, thus EU too should contribute to this sharing of data from its missions and operations, as well as work to change those regulations (i.e. on data treatment) which often have a negative impact in this regard.

Within the European Union, efforts have been undertaken first within the EDA, which listed Ground Combat Capabilities among the top priorities of its Capability Development Plan, and then through the PADR project GOSSRA. Through the former, an industrial consortium[240] performed an analysis of the trends deemed likely to characterise the future dismounted soldier equipment – especially in terms of operational and technological capabilities – resulting in a comprehensive document providing an architecture for standardisation. The European Commission has further invested in this field through the EDIDP calls and currently with the EDF 2021 round of calls for the development of innovative military personal protective equipment, BLOS military systems, and applications for the enhancement of soldiers' force protection and mobility.[241] The soldier equipment issue will most likely be included in the subsequent annual work programmes through the EDF.

In the land sector market access barriers are relatively low in terms of investments, also considering the need by all European armies to provide individual equipment kit to thousands of dismounted soldiers and the EDTIB fragmentation in this sector. This in turn encourages the protection and promotion of national solutions, even if this increase costs and complexity, and delivers sub-optimal results which are not marketable abroad and thus not sustainable in the long term. This situation should be overcome through intra-EU cooperation: despite the considerable organisational challenges, collaborative activities would lead to significant benefits for European armies in terms of standardisation, operational commonality, risk sharing on new technologies, economies of scale, common MROU and logistics

[238] For a comprehensive analysis of NATO difficulties in coping with Big Data and AI see: Sonia Lucarelli, Alessandro Marrone and Francesco N. Moro (eds), *NATO Decision-Making in the Age of Big Data and Artificial Intelligence*, Brussels, NATO, March 2021, https://www.iai.it/en/node/12844.

[239] See in this regards Chapter 9.

[240] Led by Rheinmetall Electronics (Germany), the consortium included GMV Aerospace & Defence (Spain), iTTi (Poland), Tekever (Portugal), Larimart (Italy), Leonardo (Italy), SAAB (Sweden), Indra (Spain) and TNO (Netherlands).

[241] See in this regards Chapter 3.

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and, above all, technological leaps forward to face near-peer competitors and remain interoperable with the US and within NATO. Such a step forward in intra-EU cooperation in turn would increase the efficiency and competitiveness of the EDTIB's land sector. Bottom line is that both military and industrial cooperation in Europe in mandatory to pursue really advanced technologies in a cost-effective manner, and deploy them incrementally by the start of the next decade to achieve greater combat effectiveness.

The EU opportunities via EDF, the PESCO and EDA are particularly important for Italy, which has to move forward from the current Individual Combat System programme to next generation soldier equipment in a steady, incremental and pragmatic manner. In recent years the Italian Army has demonstrated a renewed awareness, commitment and pro-activism on this field, while national industries have made progresses through the Individual Combat System programme. Building on such basis, Italy has to bring its military needs and industrial niches of excellence to EU cooperation frameworks in order to achieve together with European partners quality breakthroughs for the soldier's equipment. A renewed system of systems approach is probably for Italy the best way to implement lessons learned from previous mixed experiences, move towards the overmatch capability sought by NATO, and advance national programmes hands in hands with European cooperation.

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List of acronyms

A2/AD	Anti-access/Area denial
ACT	Allied Command Transformation
AHEntwg	Amtes für Heeresentwicklung
AI	Artificial Intelligence
ARC	Advanced Rifle Cartridge
ARCAS	Assault Rifle Combat App System
ATGM	Anti-Tank Guided Missile
ATR	Automatic Target Recognition
BAAINBw	Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr
BFT	Blue Force Tracking
BHET	Bio & Human Enhancement Technology
BLOS	Beyond Line of Sight
BMS	Battle Management Software
BST	Bekleidung, Schutz- und Trageausstattung
C2	Command and Control
C3	Command, Control and Communications
C4I	Command, Control, Computers, Communication and Information
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CARD	Coordinated Annual Review on Defence
CDP	Capability Development Plan
CEDS	Combat Equipment for Dismounted Soldier
CEDS-FSP	Combat Equipment for Dismounted Soldier Feasibility Study Programme
Cm	Centimetre
CONOPS	Concept of operations
COTS	Commercial off-the-shelf
COVI	Comando Operativo Vertice Interforze
DCC	Dismounted Close Combat
DDRD	Defense Directorate for Research and Development
DG-DEFIS	Directorate-General for Defence Industry and Space
DGA	Direction Générale de l'Armement
D-LBO	Digitalisierung Landbasierter Operationen
DMR	Designed Marksman Rifle
DPP	Documento Programmatico Pluriennale
ECoWAR	EU Collaborative Warfare Capabilities
EDA	European Defence Agency

EDF	European Defence Fund
EDIP	European Defence Industrial Programme
EDKEW	Enhanced Direct Kinetic Energy Weapons
EDT	Emerging and Disruptive Technology
EDTIB	European Defence Technology and Industrial Base
ENVG-B	Enhanced Night Vision Goggle-Binocular
ER	Electronic Back
EU	European Union
EW	Electronic Warfare
FCS	Fire Control System
FÉLIN	Fantassin à équipements et liaisons intégrés
FIST	Future Integrated Soldier Technology
G	Gramme
GLOC	Ground Lines of Communications
GOSSRA	Generic Open Soldier Systems Architecture
GPMG	General-Purpose Machine Gun
HMI	Human Machine Interface
IAS	Integrated Advanced Soldier
ICS	Sistema di Combattimento Individuale
ICT	Information Communication Technology
IDF	Israel Defence Forces
IdZ	Infanterist der Zukunft
IdZ-BS	Infanterist der Zukunft-Basissystem
IdZ-ES-3	3rd IdZ-ES generation
IEC	Individual Combatant Equipment
IFV	Infantry Fighting Vehicle
IMS	International Military Staff
IR	Infrared Signature
ISTAR	Intelligence, Surveillance and Reconnaissance
ITDU	Infantry Trials and Development Unit
IVAS	Integrated Visual Augmentation System
JIP-ICET	Joint Investment Programme on Innovative Concept and Emerging Technologies
Kg	Kilogramme
LCG DSS	Land Capability Group Dismounted Soldier Systems
LE TacCIS	Land Environment Tactical Communication Information Systems
MANET	Mobile ad hoc Network
MC	Military Committee
MCDC	Multinational Capability Development Campaign
MDO	Multi-Domain Operation

ML	Machine Learning
Mm	millimetre
MOLLE	Modular Lightweight Load-carrying Equipment
MPA	Military Programming Act
MROU	Maintenance, Repair, Overhaul and Upgrade
MUAAR	Military Uses of Artificial Intelligence, Automation and Robotics
MUV	Micro Utility Vehicle
NAAG	NATO Army Armaments Group
NAC	North Atlantic Council
NCW	Network Centric Warfare
NGSA	NATO Generic Soldier Architecture
NGSW	Next Generation Squad Weapon
NGSW-AR	Next Generation Squad Weapon Automatic Rifle
NGSW-FC	Next Generation Squad Weapon Fire control
NGSW-R	Next Generation Squad Weapon Rifle
NLCG1	NATO Land Capability Group 1
NLOS	Non-Line-of-Sight
NMM	Novel Materials and Manufacturing
NSO	NATO Standardization Office
OODA	Observe Orient Decide Act
OPEX	Operational Experimentation
OS	Operating System
OTH	Over-the-Horizon
PADR	Preparatory Action on Defence Research
PESCO	Permanent Structured Cooperation
PT 21st	CSS Project Team 21st Century Soldier System
PTT	Push-to-talk-Tasten
RAS	Robotics and Autonomous Systems
RDT&I	Research, Development, Technology and Innovation
RMA	Revolution in Military Affairs
R&T&I	Research, Technology and Innovation
RTO	Research and Technology Organisation
SAL	Semi-Active Laser
SALW	Small Arms and Light Weapon
SAW	Squad Automatic Weapon
SCA	Service of the Army Commissariat
SCIS	Soldier Centric Identification for Dismounted Soldier
SCORPION	Synergie du contact renforcée par la polyvalence et l'infovalorisation
SDHR	Software Defined Handheld Radio

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SDR	Software Defined Radio
SDR HH EVO	Software Defined Radio Hand Held Evolution
SGD/DNA	Segretariato Generale della Difesa/Direzione Nazionale Armamenti
SICS	SCORPION Information and Combat System
SK 1	Schutzklasse 1
SK 4	Schutzklasse 4
SMB	Structure Modulaire Balistique
SME	Stato Maggiore dell'Esercito
SMET	Squad Mission Equipment Transporter
SMSS	Squad Mission Support System
SOD	Systemic Operation Design
SoS	System of Systems
SPICE	Smart, Precise Impact, Cost-Effective
STANAG	NATO Standardization Agreement
STO	Science & Technology Organization
TFR	Tragbaren Führungsrechner
TM-NVG	Tactical Mobility-Night Vision Goggle
TTP	Tactics, Techniques and Procedures
UAS	Unmanned aerial system
UGV	Unmanned ground vehicle
UxS	Unmanned system
UxV	Unmanned vehicle
VHF	Very High Frequency
VJTF	Very High Readiness Joint Task Force
VV&A	Verification, Validation and Accreditation
WOO	Waffen, Optik und Optronik

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Via dei Montecatini, 17 - I-00186 Rome, Italy
T +39 06 6976831
iai@iai.it
www.iai.it

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