French Symposium on Soldier Enhancement

Part 5

Editor's note:

A symposium on French army initiatives to enhance soldier capabilities was held in Paris 19 June 2017 at the headquarters of the French Armed Forces titled "The Enhanced Soldier: The Needs and Prospects of Increasing the Fighter's Abilities." The Army University Press at Fort Leavenworth, Kansas, agreed to publish translated versions of the presentations given in seven parts as *Military Review* Online Exclusive articles to promote broader understanding of allied views and initiatives on a subject of intense collective interest. The below is the fifth of the seven presentations. The other presentations are published in separate documents.

The Hexagone Balard, headquarters of the French Armed Forces and the Ministry of the Armed Forces, 19 December 2015 in Paris.
(Photo courtesy of Wikipedia)

Enhancing the Combatant

Requirements Based on Battlefield Experience

Capt. Louis-Joseph Maynié, French Army

This is a translation of a lecture given during the conference called "The Enhanced Soldier: The Needs and Prospects of Increasing the Fighter's Abilities," held in the headquarters of the French Armed Forces, in Paris, 19 June 2017.

Soldiers do not question the need for enhancement because it is usually something obvious to them. From fiddling with military equipment to using medicine that reduces fatigue, everything that can make it easier to live in the field and make them more effective in combat is welcome. Such empirical enhancements cover areas that directly affect the soldier (e.g., individual training, personal equipment, and interactions with other soldiers). As was the case with Spartan soldiers who were trained from their youth, war fighters recognize the need for physical improvement and seek to enhance their bodies using physical exercise to increase resistance to fatigue and pain. The materiel aspect, on the other hand, belongs to the multisecular opposition between weapons and armor, the improvement of one leading to the adaptation of the other. Additionally, the coordinate actions linking soldiers in battles have always influenced the way weapons and armors improved, integrating the synergies developed to limit and eventually annihilate the enemy with technological advantage. Alexander the Great, at the Gaugamela battlefield in 331 BCE, provides a clear example by neutralizing the advantage of Persian scythed chariots as Darius's key asset through a clever positioning of his phalanx.

Andre Castaigne, *The Charge of the Persian Scythed Chariots At the Battle of Gaugamela;* 1898–1899, engraving. (Image courtesy of Wikimedia Commons)

If the debate on soldier enhancement is ongoing, analyzing it in the longer term is not that simple. The history of warfare has been marked by tactical changes and the rise of great military leaders. It has also been characterized by the advent of new technologies, which undermined the capabilities of the armed forces. However, beyond tactical and technological changes, we can make a twofold observation: man remains and will remain at the heart of every battle, and combat is essentially the combination of fire and movement.[1]

In this regard, we should distinguish between the role of tactical commanders, who have to decide on the movement of their soldiers to start shooting in the right place, and the role of the soldiers, who have to move with their weapons and wage war on the enemy wherever it can be destroyed.

For each of the actors, an understanding of the environment is vital. There is a "local" understanding for the combatant who moves and reports on a given situation, but there is a "global" understanding for the tactical commander depending on his or her level of responsibility and prior analysis. It also relies on the interaction of the parties involved to rapidly understand a situation as well as to analyze and channel information during combat. All of this has an impact on the battle because maneuver must be made in due time to ensure effective firing.

At the beginning of the twenty-first century, as we witness growing technological progress in everyday life, transhumanism offers numerous prospects of enhancing the human being, but enhancements come with serious ethical controversies. What sort of enhancement do we want, for which type of soldier, and how far should we go?

It would be a good idea to address the issues in a few lines, especially for the soldier who, upon discovering the different spheres of thought, will realize to what extent the issues are complex and diverse, involving the brightest minds and having already led to many experiments and innovations.

In contrast, it is surprising to observe the difficulties in creating a link between the world of research and design and the soldier's world. This is all the more apparent because the soldier, cunning as he or she might be, has developed highly practical skills by long and painful hours spent on the battlefield. For example, a master corporal of the 1st Tirailleur dismantled the whole of his FÉLIN system and incorporated it into his bulletproof vest worn during operations to avoid superimposing the FÉLIN vest over his bulletproof vest.[2] Aside from his ingenuity, which surely earned him a letter of commendation, the question is why the original designer had not envisioned an action of this kind well before marketing the system.

The aim of this article is to enable the think tanks to better understand what soldiers encounter in the field in order to meet their needs in the most pragmatic way possible. This article is thus structured in two parts: the first offers two scenarios, and the second provides resulting needs and related enhancements.

Scenario 1: Afghanistan

(Provided by Maj. Jean-Thomas Rubino, tactical instructor at the Écoles de Saint-Cyr Coëtquidan)

Capt. X, commander of a subgroup of opérations extérieures de l'armée française (French army deployed on overseas missions, or OPEX) military operations, is ordered to occupy and conduct missions out of a combat outpost (COP) for one week. The first difficulty is joining the outpost. There is only one road, and it has serious improvised explosive device (IED) threats. Potential danger zones enroute are well known. There is no viable way to cross these zones but to continue on foot and monitor the road with IED detectors. Infantry soldiers disembark and secure their progression on both sides of the road. However, the range of visibility is limited because of dense vegetation and homes lining the road. Thermal vision equipment is insufficient, and progress is slow because the men from the group must advance over the full width of the road with no cover, leaving them exposed to the enemy. IED jammers are activated. Apparently, an exposure to electromagnetic wave emittance is a health hazard so an exposure register for each person must be kept. Moreover, electromagnetic waves can also jam transmissions; soldiers thus communicate with voices and gestures.

D-Day–0700 hrs. Deployed on the side of a hill, the *sous-groupement tactique interarmés* (joint services tactical subgroup, or SGTIA) is in surveillance mode.[3] Every day, the position is threatened from a long distance (between eight hundred and one thousand meters) by an insurgent sniper, but it is impossible to determine the area from where the shots are fired. The soldiers take their positions, observe, and wait. They cannot shoot indiscriminately for fear of causing collateral damage to the population. Someone requests information, medical care perhaps. The soldiers try obtaining intelligence on the local environment and some intelligence concerning the sniper, but they do not understand what is being said, even with the help of an interpreter. From

Capt. Louis-Joseph Maynié, French army, is a tactical instructor at the Écoles de Saint-Cyr Coëtquidan.

the facial expressions and the embarrassed silence, they gather that what is translated has nothing to do with what is actually said.

D+3. A drone under *groupement tactique interarmés* (joint services tactical group, or GTIA) command flies over the zone between 1100 and 1200. Since the unit's arrival, this is the time when snipers start shooting at the forward operating base (FOB). The Joint Operations Center sends reports every time the drone flies over the area where a sniper could hide, but there is no digital image transmission in real time. Yet, such images would be useful in order to acquire knowledge about the zone; having a bird's-eye view of enemy infiltration routes would reveal the pathways that cannot be seen from the outpost, including those hidden behind low walls, houses, or gardens. In fact, it would also be ideal during any movement to observe beyond the next terrain feature or obstacle to see what is behind it before sending in troops. The drone will return for part of the night because the day before, soldiers on guard detected three individuals walking on the road; the guards detected no weapons on the individuals, only bags and shovels. In any case, it is difficult to notice such details as concealed weapons, even when equipped with night-vision or thermal binoculars. On the other hand, shovels are easy to identify. Someone could be placing IEDs, or villagers could be maintaining the irrigation canals. However, the unit is not authorized to conduct search missions. Consequently, the potential IED threat will have to be tackled in tomorrow's operation.

French soldiers with an Afghan translator return to their rallying point 18 October 2008 after securing an area during International Security Assistance Force (ISAF) mission Operation Eagle in Afghanistan. (Photo courtesy Wikimedia Commons)

D+4-1100 hrs. The GTIA has decided on an operation near the COP, in the "green zone," as nicknamed the area of thick woods and bush owed to wadis (rivers) in plain. The objective is to search houses and find weapons and thus lower the strain on the outpost. Already on duty, Capt. X is assigned to support two companies deployed in the green zone; this is a difficult mission because his unit cannot see the infantry soldiers' maneuvers. They can only see a succession of rooftops interspersed with vegetation and a few open areas bordered by low walls where insurgents can hide. These walls served as a firing points after soldiers drilled nearly invisible holes in them that they could fit the barrels of their weapons through. Initial skirmishes are low; soldiers need no immediate support. But, the two companies have come into contact with the enemy and stress has increased.

1400 hrs. In the early afternoon, it is very hot even for those standing still. Soldiers advance from house to house, from one garden to the next. They have to take positions on each street corner, get up, and start over and over again. Progression is slow, legs tire, the body suffers due to repetitive movements and the load carried. The heat gets even worse. In fact, a soldier was evacuated a little earlier due to heat injury. He never saw it coming; it was dehydration at a minimum, and perhaps sunstroke. In any case, it is hot under the heavy helmet, and sweat sometimes creeps into the soldiers' eyes. There is one group to evacuate the injured soldier on a stretcher, another group ensuring security, and the rest of the section on surveillance. Carrying a comrade on a stretcher is no easy task, and with ballistic protection, weapon, and equipment, it is even more challenging. The unit will need to catch up on lost time to achieve our search objectives. It's physically tiresome to search houses when turning over stacks of wood, moving furniture, searching wardrobes, inspecting flowerpots, exploring wells, etc. It is psychologically tiresome as well when villagers shout and protest.

1632 hrs. It is the end of the day, and the unit has completed the search. The insurgents have observed and located the friendly positions and their associated vulnerabilities in the green zone. Fatigue is creeping in. Everyone must be awake and attentive. Up until now it has been calm; the tension and heat have caused, at one moment or another, everyone to fall asleep for a few minutes. Those resting in vehicles are happily asleep, and they must rapidly reorient themselves when shooting starts. Others must be shaken by their comrades; the routine noise and shootings as well as general fatigue make it harder to wake them up. Both companies are in contact with the enemy at the same time, making coordination and response even more difficult. About twenty attackers armed with Kalashnikov rifles and RPG-7 rocket-propelled grenade launchers are in front of the unit.

Capt. X needs a clear picture of friendly positions to avoid friendly-fire fratricide, as the enemy will seek cover from his unit's supporting fire. The unit cannot see the sections in contact with the enemy and can only figure out certain zones by tracking the soldiers' positions over the radio and follow their reports on the enemy. Officially, Capt. X can use two radio networks, his own network and the GTIA network liaising with all companies, but the command station is taking too long transferring reports from the companies facing the enemy. Capt. X equips himself with two extra radio sets; he listens to the GTIA network, controls the support on his own network, and has two extra stations in order to listen to both companies in contact with the enemy. He can thus obtain reliable and immediate information on friendly and enemy positions. This is the only way to get a clear picture of the battlefield. At the same time, positions have to be noted on maps, objectives of the companies facing the enemy must be confirmed, and orders must be given to Capt. X's own units who also prepare situational and shooting reports that have to be submitted and analyzed.

For the third time, the joint terminal attack controller requests the coordinates of the house to which he can guide a missile launch from TIGER helicopters flying in as reinforcements. The sniper continues to harass friendly positions to suppress their fire. He is supported by a PKM machine gun (a customized Kalashnikov with powerful ammunition). From time to time, an RPG rocket lands a few meters away from the unit. It is impossible to leave the command vehicle to visually assess the situation. It is dangerous for a leader to remain blind in that situation, but if he left the vehicle, he could miss an important change of situation or a key report. It is also too complicated to be replaced by a second-in-command when under enemy fire. The latter may be useful for some back-up vision, but the priority is to analyze incoming situation reports. A

noncommissioned officer is in charge of the high-speed network (together with the GTIA) to receive messages and prepare situation reports. Otherwise, Capt. X would have to abandon this network and focus on support operations. Suddenly, on one of the company networks, he hears, "Stop firing, friendly fire!" The captain immediately orders a cease-fire. There are no casualties; what a relief! The shots fired were close to friendly positions and risked hitting friendly soldiers. It is too difficult to discern between friend and foe to be certain where to start shooting.

At night, a support section was airlifted by helicopter to the hilltops overlooking the zone, but a six-kilometer infiltration was necessary to get them from the drop point to their position. Initially, supplies had to be dropped by helicopter (cargo capacity is limited due to heat and altitude), but it was sent on another high-priority mission. Supplies were hence moved the traditional way, from the COP, with water bottles from its reserves, on men's backs, and on foot.

1714 hrs. The situation calms down when the helicopters arrive. A rocket explodes in one of the support positions. A soldier has been hit in the leg with rocket shrapnel. Fortunately, it is not too serious. No one can be protected everywhere because that is impossible; a bulletproof vest is already heavy enough. What about some Iron Man air-conditioned armor? A dream …

1830 hrs. End of action. The companies have cut off communications and find themselves alone in their positions. Villagers bring in a fifteen-year-old boy with a bullet wound in a wheelbarrow. It is our fault "naturally," and "of course," he is innocent and has done nothing at all. One soldier recognizes the boy's attire and suspects he took part in the attack. But there is no way of knowing; there is no way to test whether he has traces of gunpowder on his hands, etc. The unit must offer him medical treatment despite its anger. He will go back home despite a request to the local police to intervene but who never do. An order was given to set him free. A photo of him is taken, but how can he be identified by others in the future?

1900 hrs. Fatigue hits the unit full in the face due to stress and decreased adrenaline levels. Yet, they still have to prepare a report for the command post and narrate all the events of the day. This can be complicated because each soldier has a different and partial vision of the same battle. Each soldier concentrates on his own sector, and they discover many things that actually happened when each individual describes his personal experience. Reports are collected, and then leaders have to distinguish facts from personal interpretations or misinterpretations because of fallible memories.

In the heat of combat, there is no time to register all the messages sent and received with schedules. The unit will complete the information later … whenever it can. The results obtained were minor. Three soldiers were evacuated; one with heat exhaustion, another with a case of depression, and the third suffered a shrapnel wound. There are also cases of noise trauma, which happens frequently; they will be addressed at the next medical check-up as the unit has other fish to fry for the moment.

What next? Capt. X's SGTIA remains isolated in its base for over a month because replacement troops are delayed for security reasons. Fortunately, the *véhicule de l'avant blindé* (armored personnel carrier) is equipped with a satellite radio that reaches to France, and the soldiers are able to contact their families, which helps their morale. However, they are unable to recharge the batteries on some of their equipment, so it is necessary to work in a diminished capacity (as they always seemed to do in the past). The soldiers find several spare batteries, but there is no standard battery for all equipment, so they are of no use. It's a shame. A full operation is needed to replace the unit, and the local army will now take over. The handover is likely to be complicated both in terms of understanding and the totally different approach in planning operations. The handover promises to be memorable.

Scenario 2: Mali

The French intervention in Mali began when the Serval Brigade was deployed in January 2013 to initiate offensive operations against armed terrorist groups. It would be interesting to gather accounts from soldiers having taken part in the 2013 conquest of the Adrar des Ifoghas. Many foot soldiers reached a peak of physical effort during this operation, and their individual experience would provide valuable learning opportunities for effective enhancement. This very difficult first mission was followed by a stabilization phase (Operation Barkhane) in which the French army has been engaged since August 2014. Soldiers still operate in extreme weather conditions, travel in vehicles to cover long

distances, and always finish on foot with nearly forty-kilogram loads on their backs. They interact with the Malian army and the *Mission Multidimensionnelle Intégrée des Nations Unies pour la Stabilisation au Mali* (The United Nations Multidimensional Integrated Stabilisation Mission in Mali).

The following scenario is an example of what can occur during an ordinary mission where a chain of events can cause exhaustion, although to a lesser degree than moving on foot in the Ifoghas region. This scenario, covering an eighteen-day period, focuses on a French detachment of thirty paratroopers stationed in Northern Mali who are collaborating with African partner troops during Operation Licorne, a peacekeeping mission.

D+1. The Licorne Detachment operates out of a FOB; for half of the detachment, day-to-day life consists of instructing Malian sections on ways to succeed in combat and conducting intelligence patrols in neighboring villages. The other half secures the stronghold, ensures repairs, manages maintenance, and accomplishes general chores (preparing meals, filling the water tank, cleaning and emptying toilets, etc.). Nothing is very bad at first, except that the local temperature can exceed 40°C (104°F) as early as 0800. Any outing from the FOB requires soldiers to be equipped with a bulletproof vest and a thirty-kilogram load.

Meanwhile, tactical leaders begin assessing the next mission. Together with Malian units, they have to secure the site of a plane crash within eight days. The time limit is adequate for thorough preparation for the mission.

D+2. The Licorne Detachment liaises with the FOB from the military base in Gao. It is on a routine mission for logistical purposes, and it is preparing for a nearly two-hundred-kilometer move on a relatively safe route but where vigilance still remains paramount. During the stopover at Gao, there is some breaking news: a European national has been kidnapped, the area is close to the Licorne Detachment, and a search mission is assigned to the unit.

D+3. The Licorne Detachment returns to its base, sets aside the plane crash mission, and focuses on its new hostage search mission. At the same time, it prepares a Malian section for the new mission, and it welcomes and refuels the helicopter assigned to the search. Preparations are stepped up.

D+4. Mission deployment, "Hostage Rescue." It was planned for four full days. However, the mission was not as successful as expected. The four days spent on tactical movements by vehicle and on foot, carrying out searches from one village to the next, depleted the soldiers' energy. Missions like this are never easy physical endeavors. For example, crossing the Niger River safely on a makeshift ferry lasted from 1100 until 1600 while soldiers secured riverbanks, carried out reconnaissance of the opposite bank, reformed, etc. Even with no enemy action against the unit, the soldiers are all hollow-eyed after carrying out this assignment in 50°C (122°F) heat.

Movements with vehicles may seem restful, but the difficult terrain causes breakdowns and traffic jams. The problems must be resolved in a combat environment, and always under intense heat. In this context, a soldier assigned to the vehicle turret is required to maintain heightened

Previous page: French soldiers ride in an armored personnel carrier April 2003 during Operation Licorne (Unicorn) in the Ivory Coast. (Photo courtesy Wikimedia Commons)

awareness over time (enhanced cognitive capacity), evaluate the topography, and ensure the detachment's safety with the onboard weapon (ability to counter uncertainty). Last but not least, the sun scorches the vehicle's metal armor and the heat from the engine raises the turret temperature to over 60°C (140°F) (enhanced physical resistance).

D+7. The Licorne Detachment returns to base around noon. The afternoon, evening, and early morning are for refurbishing equipment, weapons, and vehicles, so they depart for Gao the next day at 1300 in order to pre-position for the initial mission, which is to secure the site of the plane crash (physical recovery enhancement). Despite the tempting appeal of an air-conditioned tent, everyone is scrambling to be operational by noon the next day.

D+8–1125 hrs. The detachment commander is in the command post tent with all team leaders for a pre-mission briefing. Outside, paratroopers are ready to leave and awaiting their orders. Suddenly, there is an enormous explosion that knocks people to the ground and creates instant confusion. An allied detachment's automatic weapons start shooting. The base is under attack. In fact, a VBIED attack has just been executed. It cancels the detachment's departure as the unit must respond to the threat, secure the surrounding area, bring medical care to the high number of wounded and dead caused by the attack, and carry out evacuations by helicopter.

This unplanned operation will last until 1800. It will have a lasting effect on the minds and bodies of all concerned. Despite the security system in place, nobody foresaw the vehicle's attack (cognitive capacity enhancement), and enemy actions in the zone are largely unknown (capacity in offsetting uncertainty). Additionally, many children are among the wounded and dead. A soldier cannot accept this as easily as the death of a foe (moral resiliency enhancement). The medical team will work long hours in a pool of blood, protected by the rest of the detachment, and always under a temperature of 50°C (122°F) (enhanced physical resistance). This causes physical and psychological fatigue briefly suppressed by adrenaline rush but which reappears in the hours and days that follow.

At the end of the day, the results are favorable for the Licorne Detachment. There are no French casualties nor wounded to mourn, and many lives were saved. However, one paratrooper, a quiet man who was marked by his mission in Afghanistan, could not bear the sight of dead children. He gave up and lost his mind. It is a real case of posttraumatic stress disorder, for he is a brave man and had proved it many times. In this instance, his psychological barrier had been broken. He will be rapidly evacuated and taken care of by medical staff and will later recover much more quickly than the average soldier (psychological resistance enhancement).

The overall outcome of the day has, nonetheless, serious consequences on the detachment's initial mission for securing the plane crash. That is the way things are in OPEX operations. Despite what happened, it would be unthinkable for the detachment to abandon the mission because it operationally important for partner forces.

2200 hrs. After resting to regain some strength, the detachment commander starts drafting his report. The authorities expect facts and photos in order to analyze recent events. Fatigue is always a bad advisor, and a report drafted under such conditions turns into a heavy saga instead of a concise military report. The commander will understand this later (mobilizing intellectual capacity enhancement).

D+9. The detachment departs for Gao, one hundred kilometers away. There is a general rehearsal for the GTIA ahead of the operation. The Licorne Detachment liaises with the Malian unit it will be mentoring during the mission. The aim is to acquire initial information (cognitive capacity enhancement), swiftly create a strong connection with partner troops, and promptly implement the procedures that will guide them. Fortunately, the detachment has been well drilled even if the fatigue caused by recent events is still intense (recovering and mobilizing intellectual capacity enhancement).

1330 hrs. The detachment is off again for an eight-day mission. The Malians are ahead. The Licorne Detachment teams up with them during the advance until reaching the crash location.

D+10. Once arriving in the area, a reconnaissance of the site is required and security is emplaced. During the entire operation, Malians will secure the outer cordon, supported by the detachment in combat formation. Tension on the front line replaces the tension of the recent attack on the base. The medical officer is attentive for any physical or psychological assistance that may be needed (physical resistance enhancement). He spends most of his time with soldiers, sharing the

task with the detachment commander, because there is a palpable tension among paratroopers.

At night, the detachment sleeps tightly together with a two-person team keeping watch over the group (enhanced resistance to the lack of sleep). The level of fatigue is high, and night watches are shortened so that no one falls asleep during guard (sleep quality enhancement).

D+14. The GTIA leaves the area of operations. The Licorne Detachment is still ahead with the Malian units. The return trip is comprised of the same technical and tactical characteristics as before. It ends with exhausted paratroopers.

D+18. After spending a night at Gao, the Licorne Detachment arrives at its FOB where it has a few days of rest before the next operation.

The next day, one paratrooper decides to weigh himself and realizes he has lost seven kilograms since last stepping on the scale eighteen days earlier! As a result, everyone wanted to check their weight. On average, the detachment lost five kilograms, and overweight paratroopers are few.

The events and the heat caused problems for the health of the soldiers, and the doctor observed muscle loss in most cases. (enhanced nutrition)

What next? The OPEX mission does not stop here. However, the eighteen days highlighted in this scenario mark the detachment and affect its capacity to finish its mission, though its rhythm has fallen only slightly.

Based on the needs highlighted in both scenarios, let us now see how enhancements can optimize performance.

Needs and Related Enhancements

The requirements identified in the scenarios can be broken down into several categories, including tactics, physical needs, rest and recuperation, and climate.

Tactics. If the multisecular sword versus armor debate favors the concept that technical improvements can bring tactical benefits, we shall not discuss matters pertaining to the sword because weaponry does not fit in with the definition of enhancement proposed by Gérard de Boisboissel and Chief Medical Officer Jean-Michel Le Masson. Instead, let us reflect upon three senses: touch, hearing, and sight.

Sense of touch. Surprisingly, touch is an essential factor in combat, but soldiers only realize this if they are deprived of it. Soldiers need enhanced hand protection so they do not constantly put their gloves on and take them off. If great progress has been made in the last decade on combat gloves, the irony here is that the more a glove protects, the more it decreases the sense of touch and dexterity.

The ideal glove would be almost as thin as surgeon's gloves. It would protect against fire and frost, and it would allow dexterity and touch equivalent to bare hands. Our scenarios also discuss overheated shielding, and it is a similar situation with weapons. Such gloves would help the soldier handle vehicle weaponry even if it has been scorched by the sun or frozen in colder climates.

Sense of hearing. Protection against sound pollution is critical. Here too, enormous progress has been made. A small-scale example is an ear plug that can block certain frequencies while letting others pass through. In this way, a gunshot can be blocked while a whisper can be heard. On a larger scale, anti-noise helmets offer the same advantages as ear plugs do. However, because some of them are much larger, they are electrically supplied to amplify unfiltered sounds. This is ideal in terms of sound, especially for night combat. On the other hand, helmets can be painful to wear because they cause the soldier to sweat, which can then enter the ear canal.

The ideal solution, if it has not yet been reached, requires a good degree of miniaturization in which ear plugs could hold filtering and amplifying technology as well as a power supply.

Sense of sight. This area has undoubtedly benefited from the most extensive research. Night vision technology, thermal detection, remote vision sensors, and virtual reality have brought vast improvements to vision capability. Moreover, as described in the preface, sight is vital at all stages and levels of combat command.

The soldier performing observation, surveillance, or shooting needs to increase their distance from objects or persons. By zooming in and out, he or she should be able to better recognize and identify targets. In this respect, contact lenses would do wonders by enhancing vision with the most adaptable and least stringent interface. But they are not enough. On the one hand, they need daily care and constant cleaning (especially in dusty environments), and on the other hand, like other sensory organs, our eyes need serious protection that lenses cannot provide.

An ideal enhancement would gather existing technologies within a single object. This object would be similar to

the now famous ballistic eyeglasses but with a larger and more resistant glass surface. There would be no ski-mask-type visor, simply because we cannot march and fight for a long time with this type of equipment without sweating. This visor should be worn either as eyeglasses or by using the fastening grip on the front of the helmet. The visor would serve several purposes:

- To protect the eyes.
- To display virtual reality images. A soldier observes their sector through the visor, but a thermal image appears on the shield from a microcamera fixed to the helmet. In this way, a soldier can thermally perceive an enemy that might be hidden by an obstacle.
- To display practical and tactical data and even physiological data for the medical auxiliary; for example, the amount of ammunition, a heartbeat, neighboring units' positions, etc.
- To display images taken by a drone flying ahead of the soldier's position, thus eliminating uncertainties due to the nature of the terrain.

This equipment would require a selection mode that can be adapted according to combat needs and avoid saturating a soldier's field of vision. Information flows can be massive and obtrusive when combat intensity increases. It is therefore important to be able to easily switch from one mode to the next or deactivate the virtual reality mode and revert to simple reality.

For a combatant in a moving tactical vehicle that is supporting other vehicles of the same unit, we can then have the following conditions:

- The driver and vehicle commander can see both the route and the position of other vehicles from the section displayed.
- With the help of a thermal camera and/or a camera with a high magnification lens, the gunner can see better and fire faster and farther, potentially at the weapon's maximum range.
- The vehicle commander can anticipate terrain difficulties or detect potential enemy positions via an offset display from a minidrone flying one or two kilometers ahead.

From a practical point of view, we should ensure the following:

- The visor is compatible with night vision goggles.
- The light halo is undetectable at night (from an enemy's perspective).
- The visor is not at all similar to virtual reality helmets commercially available, such as a waterproof ski mask where only digital data is visible. It is not an option for a combatant not to have a direct view of the surrounding environment.
- The visor's electronic motherboard is embedded in the soldier's helmet. It should fit the helmet's curved shape and be large and reasonably thin to avoid a protuberance at the back.
- The visor's power supply does not go through cables that connect the helmet to the rest of the body. It should not hinder neck movements.
- The system is powered by a light, long-life battery or by an LR6-type battery that can be found anywhere (even in the desert).
- The helmet's batteries need to be balanced so the combatant avoids neck pain after a full day's use.

This type of visor is already undergoing study in France. Feedback from experiments conducted with night vision devices of the FÉLIN system should be considered during development. Those devices offer a high-quality image but have unfortunately been designed with a bulky power pack located at the back of the helmet and connected by cables to batteries embedded in the vest. This is why all units requested a separate battery compartment to get rid of the power pack and its cables.

In general, any technology enhancing a combatant's senses should be able to interface with the helmet without any material connection to the rest of the equipment because a helmet never leaves the head in combat.

Finally, any form of artificial intelligence enhancing the technology described above is desirable. It would, for instance, enable a soldier on guard duty to detect a human form or identify a type of vehicle more quickly, similar to the advantages provided by a drone flying over the area.

Protection. No bulletproof vest fully protects soldiers, unless we can find some hyper-resistant mesh that could be worn as a T-shirt or unless we suddenly have the opportunity to equip soldiers with Iron Man's legendary armor, provided that it is air conditioned!

Weight and mobility are key problems related to protection. It is therefore necessary to refocus ballistic protection solely on vital organs to lighten the soldier's load and allow for easier maneuverability when facing the enemy. The enemy may not have the same attitude

toward death and is in many cases both agile and elusive because of light equipment. Of course, bulletproof vests used in Afghanistan are a great improvement over older models, which were ill-adapted for combat. But the recent vests are still too heavy, too thick, too bulky, and too constraining. This is why most units of the Special Forces have chosen to limit their ballistic protection to small protective plates that only cover their vital organs in order to lighten their load. The latest vest equipping the French infantry is an improvement, but it is still too cumbersome.

Apart from its bulletproof design, a soldier's vest is used for packing everything needed in combat. Without going into greater details, we should note that a bulletproof vest weighs seventeen kilograms when empty and over thirty kilograms when its pockets are filled with magazines, ammunition, water, grenades, etc. Essentially, a soldier should be able to take the bare essentials with them without having to carry an extra backpack in combat. In that respect, any kilo saved in the vest's weight directly enhances the soldier's capability to move more effectively.

In any case, intelligent clothing-even if it fails to stop a bullet but can place a compressive bandage on a blood wound–would always be welcome as a complement to the bulletproof vest.

Strength and endurance. The challenges in this section are similar to those in the one above. There are two possible options to increase an individual's strength and endurance: exterior enhancements (exoskeletons) and interior enhancements (chemical substances).

Many exoskeletons are undergoing development and testing, but prototypes have demonstrated poor performance and need further testing to reach satisfactory results. However, one finding emerges from such tests: whatever type of exoskeleton has been created so far must always be connected to the body to enhance strength and speed.

This is where the problem lies. In hot weather conditions, whether in Afghanistan or in the Sahel region, it is unlikely a soldier could cope with exoskeleton buckles or fasteners for a whole day. It is important to realize that hot conditions affect physical effort and hygiene. A soldier under such conditions can have their skin torn just from rubbing against the bulletproof vest; soldiers wearing their vests in the Sahel region can confirm this. A lasting solution for body-exoskeleton interfaces is needed; or otherwise, affected areas will turn into wounds in less than a day, with dire impacts on the soldier's health and mobility.

> “Whatever the future of Western forces, enhancement cannot become a basis for training. Future soldiers must first discover their physical, psychological, and moral limits, and then work to overcome them.”

A sustainable solution for physical enhancement occurs with athletes who use substances that promote muscle mass, faster recovery, and a better metabolism. The use of such substances is generally banned for professional athletes in compliance with sporting ethics, but their use is authorized for the military if regulated by health professionals. It is not simply a matter of the combatant climbing onto the podium of a bodybuilding competition but more a quest to enhance efficient, serious, and focused physical conditioning. For example, one priority is to strengthen the back and the legs.

It would be unwise to proceed further on this matter without comparing the opinions of medical professionals and the professionals of the *Institut d'éducation physique militaire et sportive* (French Military Institute of Physical Education and Sports) who have sufficient knowledge in assessing the feasibility of such large-scale programs. Moreover, opinions will need to adapt and accept this type of "legal doping."

We should finally note that certain technologies developed in the civil sector could be of immediate interest to the enhanced soldier. Some smart clothes, for example, have recently appeared, including a T-shirt that helps straighten the spine and limit back pain when certain fibers are tightened. For the soldier, such a T-shirt could soothe back pain, as opposed to a lumbar belt

that is too warm and disabling. However, although the T-shirt might suit an office employee with a sedentary lifestyle, it remains to be seen whether it can be adapted to the field of combat.

Recovery/psychology/concentration. Sleep is essential for humans, as recent studies and publications have confirmed. If recovery is essential for physiological reasons, it is important for psychological reasons as well. In this case, the purpose of enhancement here is to increase the quality of sleep.

In the missions described in our two scenarios, commanders and soldiers only slept an average of five hours per night over a four-to-six-month period, which is insufficient according to medical recommendations. Moreover, the observations are based on nights spent in a secure area and exclude nights spent in combat. Sleep is the key to recovery and to sustaining sound psychological balance. It is command's responsibility to ensure that soldiers get quality sleep. Science and medical research can bring ideas to achieve optimum recovery sleep.

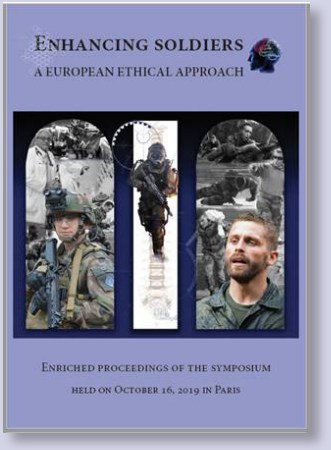
It is unlikely that the environment responsible for limiting sufficient sleep will evolve. The combatant could be allowed restorative sleep by the administration of substances that would rapidly plunge him or her into the sleep cycles responsible for body regeneration. This may be different during phases of combat or operations. A lack of sleep is acceptable over shorter periods of time, proportionate to the level of thinking required during hours of alertness. In this case, substances that boost microrestorative sleep, harness intellectual capacities, and stimulate concentration are desirable.

In terms of physiology, nutrition also plays a crucial role. In the scenarios presented, we mentioned significant weight loss in some cases and a general loss of muscle mass. Certain individuals, probably overweight from the start, lost between fifteen and twenty kilograms during missions in the Sahel region. With the improvement of professional sports diets and the advent of nutritional supplements, we can reasonably foresee that such supplements, easily consumed with water, could be supplied to our soldiers. This would compensate for the growing deficiencies arising when battle rhythm, heat, and fatigue cause a soldier's appetite suppression. Radio technicians often mentioned that they had to act like nurturing mothers and feed section leaders or unit commanders because in the heat of action, they forgot to sustain themselves.

Finally, a number of chemical substances can also help soldiers manage their emotions and stress. This is a different problem than the requirement for restorative sleep. In fact, emotions and stress can act as stimulants, but they might sometimes require an artificial inhibitor since they cannot change our human nature. Wars are fought by men, not cold-hearted monsters. If a soldier is hardly affected by the sight of children slaughtered by the enemy and he continues his mission unabated, what is the risk that same soldier, insensitive to the suffering around him, will trample the values for which he is risking his life?

Climate. As described in our two scenarios, a soldier's first enemy during operations is climate and general weather conditions. If the body could tolerate high or low temperatures and be indifferent to humid conditions, it would constitute a true enhancement and be a factor in physical superiority. However, lacking this ability, the soldier fights extreme climatic conditions with two linked natural attributes: adaptation and fortitude.

Enhancing Soldiers, A European Ethical Approach is a compendium of the proceedings of a symposium sponsored by the International Society for Military Ethics in Europe, held 16 October 2019 in Paris, that provided a venue for the presentation of papers by a variety of international scholars discussing research on topics related to initiatives associated with efforts to enhance soldier capabilities. The symposium revisited and updated issues that were previously examined in a similar symposium titled "The Enhanced Soldier: The Needs and Prospects of Increasing the Fighter's Abilities," sponsored by the French army 19 June 2017 at the headquarters of the French Armed Forces. The compendium is available online at: https://www.euroisme.eu/images/Documents/pdf_cahiers/Le%20soldat%20augmenté%2019-06-2020-web%20VFinal.pdf.



The creation of new textile and clothing products has made it possible for soldiers to effectively contend with heat and cold. Such creations encompass a different range of products, and a soldier still requires bulky outdoor clothing to protect themself from the cold. A sort of air-conditioned, dry body suit, impervious to heat and cold, would be an ideal solution. However, it seems unrealistic, even with our most advanced technologies, that such clothing will be produced for some time yet. A body suit of this type should be easily and quickly put on in the case of an unexpected alert. It should also allow for good physical hygiene.

Beyond the prospects of such exterior enhancements, an interesting internal enhancement would be the reduction in sensitivity to physical pain. Even if we are all unequal in this area, we should remember that pain is an indicator of bodily malfunction or a sign of physical danger. There are hence pain thresholds that should not be exceeded, or they may lead soldiers to become dangers to themselves.

Concluding Thoughts

Enhancements are prima facie desirable provided that certain principles are observed. First, our physical integrity cannot be changed. This means, for example, there is no discussion of clinically amputating a soldier's arm to replace it with a stronger bionic one. (This has nothing to do with the need for a prosthesis for someone having lost an arm in an accident.)

Second, whatever the future of Western forces, enhancement cannot become a basis for training. Future soldiers must first discover their physical, psychological, and moral limits and then work to overcome them They must become disciplined and hardened to harsh climates and to adverse conditions. Only then will they be ready to access various enhancement techniques. They will be able to perceive the sense and significance of enhancement and even get by without it if necessary, which is far better than obtaining everything right away.

Finally, this article does not claim to be fully comprehensive, nor does it summarize enhancement needs for all types of soldiers. Moreover, a number of enhancements mentioned herein already exist or are currently under development. It may, however, help researchers better understand the requirements of the soldier. In other words, they may be able to envision themselves in the place of the combatants who have marched through many theaters of operations. Research can itself be enhanced along these lines. ■

Notes

1. Christian Malis, Guerre et stratégie au XXIe siècle [War and peace in the XXI century] (Paris: Fayard, 2014), 130.
2. French FÉLIN System: Fantassin à équipements et liaisons intégrés (Integrated infantryman equipment and communications).
3. An SGTIA is a French army company-size unit of about 150 men.

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