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Digital Hoplites

Infantry Combat in the Information Age

Pierre Chareyron

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Abstract

Le *FELIN*, premier « système fantassin » mondial entre en service cette année dans l'armée de Terre française. Au cours de l'histoire, les fantassins ont cherché à tirer profit de la technologie en arbitrant au mieux parmi les trois exigences fondamentales que sont *mobilité*, *puissance de feu* et *protection* du combattant. Les sociétés occidentales étant sensibles aux pertes, l'exigence de protection est devenue un facteur essentiel. Le combat débarqué moderne se caractérise donc par un retour de l'armure tout en mettant l'accent sur la puissance de feu. En outre, l'avènement d'une nouvelle génération d'équipements, permettant de tirer profit des technologies de l'information au niveau du combattant individuel, impose désormais d'aborder la question de l'évolution du combat d'infanterie sous l'angle de la *supériorité informationnelle*.

* * *

FELIN, the world's first "integrated soldier system," will enter service in the French Army this year. Throughout history, infantrymen have sought to capitalize on technology while seeking the best compromise between three basic requirements: *mobility, firepower* and *protection* of combatants. As Western societies are sensitive to losses, the requirement for protection has become critical. Modern dismounted combat is thus characterized by the return of armor as well as by a greater emphasis on firepower. Furthermore, the emergence of a new generation of equipment allowing information technologies to be exploited at the level of the individual soldier is now making it necessary to address the issue of changes in infantry combat from the perspective of information superiority.

Introduction

Infantry is without doubt the oldest operational role in the art of war. When the first hominid grabbed hold of a tool to fight his fellows, he invented the infantryman. Since then he has never stopped perfecting the techniques and resources of infantry combat. With the triumph of armor and the appearance of the tank, mechanization, the advent of air power, then nuclear weapons, the infantryman seemed to be reduced to the level of a mere “interested spectator"[1] of the battlefield, at least in major conflicts. However, the lessons of the Second World War highlighted a sometimes critical shortage of infantry for conducting operations: two months after Operation Overlord, the American infantry reserves available in France reached the astonishing level of a single infantryman[2]. After the wars of decolonization, infantry units decreased in number in parallel with the general reduction in the sizes of armed forces[3].

Today, infantry combat is destined to evolve considerably as a consequence of the information revolution and the digitization of the battlefield. The infantryman's equipment, and as a result his methods, organization and perhaps even his culture, are about to undergo profound changes. This is all the more significant because the “grunt” has often been the poor relation where technology is concerned. The French Army was aware of this, and in 2001 commenced the most significant reform of its infantry since 1917 with the Integrated Infantryman Equipment and Communications program FELIN (*Fantassin à Equipements et Liaisons Intégrés*). These changes have given rise, both inside and outside the military apparatus, to numerous debates that revolve around the physical and cognitive loads induced.

Moreover, the return of “war amongst the people” has renewed the need for infantry whenever it becomes necessary to maintain a presence over time and exercise the greatest possible discrimination in the use of force. The infantry “remains the arm that is used to control the environment over time, an essential requirement in the current conflicts where it may be necessary to act over the full spectrum of operations.”[4] Within his combined arms environment, from Sarajevo to Kabul the infantryman has therefore

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[1] Expression used by John F.C. Fuller, quoted by par John A. English and Bruce I. Gudmundsson, *On Infantry*, Westport, Praeger, 1994, p. 46.
[2] Samuel L. A. Marshall, *Men against Fire*, Gloucester, Peter Smith, 1947, p. 16.
[3] 2 000 French infantry battalions in 1914, 20 now. Address by Army General Elrick Irastorza, CEMAT, 5e rencontres terre-défense, Paris, March 1, 2011.
[4] General Elrick Irastorza, “Editorial du CEMAT”, Cahier Spécial Infanterie 2015, *Fantassins*, no. 25, June 2010.

resumed his central role as a vector of military effectiveness. However, in the current context of limited wars and post-heroic societies, political decision makers, military commanders and public opinion make it necessary to keep casualties to a minimum. At this point, a fundamental contradiction arises where contemporary infantries are concerned. They must be able to maintain their mobility, a crucial tactical requirement if they are to retain their superiority in dismounted combat, while at the same time protecting the individual soldier, which results in a substantial increase in the weight of his equipment.

This aim of this study is to put these questions into perspective at a time when the first “integrated soldier system”[5] in the world is entering service. The *FELIN* program will structure France's infantry for several decades. The scope of the study is confined to “individual-l and collective equipment,” in other words what the soldier carries on his person when he leaves his vehicle and commences dismounted combat, which is the core function and *raison d'être* of the infantry[6]. It relates to the micro-tactical level, at which combat is ultimately fairly similar whether one is facing regular armies or guerillas, albeit without neglecting the implications of the current political and strategic context.

Analyzing innovation in the infantry is the first step in understanding how the current changes fit in a long historical process. This process has always attempted to take advantage of technology while continuing to meet three fundamental requirements: mobility, firepower and protection. Dismounted combat has the particularity that it cancels out the advantages of mechanization and is constrained by the physiological limits of the individual. Today's infantryman is in an unbalanced situation, one which favors firepower and protection at the expense of mobility. The new equipment will allow greater advantage to be taken of information technologies at the level of the individual soldier, and highlights a new requirement: *information superiority*. Within the foreseeable future, and without a proactive policy, the infantry systems will not correct this imbalance. Indeed, the sociopolitical context remains the deciding factor, given the requirement for protection.

[5] A program aimed at integrating all the personal equipment of the infantryman into a coherent whole.

[6] By extension, we will use the term infantry/infantryman to describe the "dismounted combatant". The current problems of weight, mobility and protection are not the monopoly of a single arm, but affect all those who fight on foot within a combined arms tactical unit, whatever their specialism.

Innovation in the Infantry

Regarded as the Queen of the Battlefield until the First World War, infantry is the decisive arm, responsible for making victory concrete by physically occupying the ground. However, technical innovations at the end of the 19th century increased the lethality of fire to such an extent that mass infantry tactics became obsolete. As Paul Valéry said to Marshal Pétain: "You have discovered this: that fire kills... I would not say that we did not know that until you came along. We were simply inclined to want to ignore it."[7] For 3,000 years the process of innovation in the infantry, whether tactical or technical, sought the best compromise between the three key factors: mobility, firepower[8] and protection. The Romans arrived at the first optimum[9], before cavalry called the model of the Legions into question. While it restored the infantry's pre-eminence, the appearance of firearms brought with it a dilemma between shock and firepower, giving rise to a long phase of trial and error which culminated in the Napoleonic optimum. The acceleration in technological progress generated by the Industrial Revolution, coupled with the resulting increase in firepower, gradually made tactics subordinate to technological innovation, to the point where the latter currently seems to be the dominant factor in innovation.

To begin with, it is necessary to recall the aims of infantry maneuver:

- to advance within firing range of the enemy without suffering too many casualties;
- to change as quickly as possible from this movement formation to a combat formation allowing fire or shock to be concentrated on a chosen point in the enemy force, then maneuver into contact;
- to include the individual in a collective in order to better control fear and maintain discipline.

The art of combat on foot therefore inevitably gives rise to a debate between the advocates of fire and those of shock. While the latter is certainly physical, it also includes a strong psychological dimension on

[7] Paul Valéry, « Réponse au remerciement du maréchal Pétain à l'Académie française », in Paul Valéry, *Variété*, Paris, Gallimard, 1938.
[8] A concept combining the number of weapons and their effectiveness.
[9] In the sense used by the economist Pareto, in other words the best allocation of the resources available, in which it is not possible to improve one aspect without making another worse.

which numerous theories exist[10]. Where tactics are concerned, it is important to make a distinction between two types first. On the one hand, combat in close (or tight) order, where infantrymen maneuver “shoulder to shoulder,” and on the other, combat in loose or open order, where the groupings allow greater autonomy. Close order can be divided into two more precise categories: deep order, where soldiers are grouped in many ranks, and shallow order, where the infantry line is thinner. The distinction between close and open order already contrasts the way hoplites fought with the way gymnetes or peltasts fought[11]. In order to understand this dialectic and shed light on contemporary issues, we first need to immerse ourselves in the battles of antiquity.

The Roman Optimum

In many respects the Western model of warfare was inherited from the hoplites of the Greek cities, with their preference for decisive pitched battles[12]. Throughout antiquity the role of infantry, the weapons available and the means of command – at that time commands had to be issued by voice – argued in favor of close, deep order. This made it possible to fight effectively in hand-to-hand combat, because each man protected his neighbor with his shield, and to withstand charges by chariots and cavalry. It also allowed the infantryman to be compartmentalized and even, in the case of phalanxes, to be literally pushed into hand-to-hand combat[13]. The Greek phalanx of infantrymen, committing itself in a single mass, is the symbol of this shock. Its strength lies in this ability to maintain the disposition in line – the *τάξις*, the term that gives us the word “tactic” – which gives the whole its protection and force. The phalanx was deployed in a large number of ranks, up to 50 at the Battle of Leuctra between the Thebans and the Lacedaemonians. The hoplite was protected by a helmet, a shield, and heavy bronze armor comprising greaves and a breastplate[14]. This tactic was originally a decisive advantage, and Herodotus analyzed the victory at Plataea in 479 BC as a demonstration of the superiority of Greek arms and discipline[15]. The phalanx thus dominated the battlefields of the Mediterranean and Middle East from the 5th to the 3rd centuries BC.

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[10] For some "spiritualist" authors, this psychological element is actually predominant, and tactical training must allow the effects of human weaknesses to be kept to a minimum. With the study of crowd psychology at the end of the 19th century, the spiritualist current was to lead in part to the offensive theories of Grandmaison. See Michel Goya, *La chair et l'acier*. *L'armée française et l'invention de la guerre moderne, 1914-1918*, Paris, Tallandier, 2004, p. 59. For the "spiritualists" and their heirs, see Charles Ardant du Picq, *Etudes sur le combat. Combat antique et Combat moderne*, Paris, Economica, 2004 (1st edition 1880), and John Keegan, The Face of Battle, New York, The Viking Press, 1973.

[11] For the light infantry of Ancient Greece, see Pierre Vidal-Naquet, "La tradition de l’hoplite athénien", in Jean-Pierre Vernant (dir.), *Problèmes de la guerre en Grèce ancienne*, Paris, Seuil, 1968, pp. 214-241.

[12] Victor Davis Hanson, *Le modèle occidental de la guerre*, Paris, Belles Lettres, 1990.

[13] In battles involving phalanxes, on average casualties represented 5% of the forces committed and 14% of the losers. See Victor D. Hanson, *op. cit.,* p. 262.

[14] He fought with a spear and sword, and carried some 35 kg in all.

[15] Herodotus, *L'Enquête*. *Livres V à IX*, Paris, Gallimard, 1990.

However, from the Pelopponesian War onwards, the peltast, a light infantryman, came to play an increasingly important role in battles[16] because a greater demand for mobility arose. The poor mobility of the hoplites and their very close formation made the phalanx badly suited to maneuvering, especially across broken ground, and this proved to be a serious handicap when facing cavalry and ranged weapons. Once it had been outflanked or surrounded, a phalanx easily gave in to panic. Hannibal's maneuver at Cannae in 216 BC was a magnificent demonstration of this. In the end it was the Romans, who had inherited the Greek model, who best reconciled the requirements for mobility and shock power by remedying the shortcomings of the phalanx formation.

The legions originated in the reforms introduced by Servius Tullius (middle of 6th century BC)[17]. Unlike the phalanx, the legion fought in three ranks based on age: *triarii*, *principes* and *hastati.* Tactical mobility was introduced by dividing the legion into maniples made up of two centuries[18]. Even though the manipular Legion only adopted a single formation, the *triplex acies*, with three lines of heavy infantry, each three ranks deep, its structure had a decisive advantage over the phalanx, as illustrated by the Battle of Pydna on June 22, 168 BC. From the 2nd century BC onwards, the cohort (600 men) of three maniples became the basic tactical unit. It was easier for a general to coordinate ten cohorts than thirty maniples, and this structure, which ultimately prefigured a system that has lasted until our time[19], offered greater flexibility, especially for the Republic's “pacification” operations, such as those conducted in the Iberian Peninsula. During the consulate of Marius in about 107 BC, the system of social classes was gradually abolished in favor of a long-term volunteer army[20]. The Legion became a professional unit of some 6,000 men. Equipment was no longer supplied by the legionary but manufactured by the Republic.

This standardization made replacements and repairs easier, and allowed the first steps to be taken in logistics, primarily thanks to the modular structure of the *lorica segmentata*, the armor made of riveted metal plates. It was probably not until the reforms of Gustavus Adolphus in Europe and those of Louvois in the French armies in 1666 that a comparable standardization appeared. The legionary lived and fought virtually autonomously, moving with supplies for three days, his fortification tools and his personal camping equipment. He marched at a speed of 5 km/h, five to seven hours a day. He was capable of covering 30 km a day, then establishing a strong retrenchment before nightfall[21]. This tactical and strategic mobility of the infantry, at the cost of less protection compared with the “unitary” armor of the hoplite, was not to be equaled until the time of the Napoleonic armies. Ultimately, the Roman infantryman represents a

[16] Victor Davis Hanson, *La guerre du Péloponnèse*, Paris, Flammarion, 2008.
[17] Adrian Goldsworthy, *Les guerres romaines. 281 av. J.-C. - 476 ap. J.-C*, Paris, Autrement, 2001, pp. 42-54 and 96-100.
[18] A tactical unit of about a hundred men, Adrian Goldsworthy, *op. cit*., p. 44.
[19] Company, battalion, regiment, division.
[20] Pierre Cosme, *L'armée romaine. VIIIe siècle av. J.-C. - Ve siècle apr. J.-C*., Paris, Armand Colin, 2007.
[21] Adrian Goldsworthy, *op. cit.,* p. 122.

benchmark in terms of organization and mobility. Essentially, at the level of the soldier on foot, the space-time framework has not changed much. The Roman model therefore represents a kind of optimum in the trade-off between protection, firepower and tactical mobility. The Legion remains an example of discipline and flexibility, a sort of golden age of infantry.

Firearms: Opportunities and Constraints

This golden age ended in the High Middle Ages, when light cavalry made up of mounted archers, then heavy cavalry in the West, with its tutelary figure the knight, gradually relegated infantry to an auxiliary role[22]. We would have to wait until Crecy on August 26, 1346, which, according to some analyses, marks the advent of the ranged weapon as a decisive element in the battle[23], to see the beginning of a new age of infantry. The use of the longbow as a weapon system by the English and at the same time the appearance, from the beginning of the 14th century onwards, of Scots and Flemish pikemen, infantrymen armed with a pike several meters long, gave the infantry the means to reestablish its supremacy. The successors of the phalanx, formations of pikemen, which were spread by the Swiss who served as mercenaries all over Europe, were now capable of defeating heavy cavalry charges. However, this innovation was at the expense of mobility, because in order to be effective the infantrymen had to fight in close formations.

The invention of black powder and firearms accelerated the process of domination by the infantry. From the 16th century onwards, archers were gradually replaced by units of arquebusiers, such as the *espingarderos* that joined the Spanish *Tercios*. The proportion of firearms continued to grow because of the falling cost of producing them and the ease of use of this new weapon[24]. This fall in cost, coupled with the increase in firepower, allowed infantry to be deployed both in greater numbers and more effectively, and ultimately spelled the end of the knight as a model. From a tactical point of view, the firearm did not change matters fundamentally at first, because the effectiveness of the early weapons remained limited. Within the tactical triangle[25], and even though the balance was shifting in favor of firepower, deep order remained the rule, and mobility was poor. The Spanish *Tercios* placed the pikemen at the center and the units armed with muskets on the sides of an infantry square 56 meters wide and 24 ranks deep[26]. The cohesion of these squares was a guarantee of safety,

[22] On medieval warfare, see Philippe Contamine, *La Guerre au Moyen Age*, Paris, Presses Universitaires de France, 1980, 6th edition, 2003.
[23] Martin Van Creveld, *Command in War*, Cambridge, Harvard University Press, 1987, p. 51.
[24] An arquebusier needed less training than an archer. See Geoffrey Parker, T*he Military revolution: Military Innovation and the Rise of the West 1500-1800*, Cambridge, Cambridge University Press, 1996, p. 17.
[25] The author is indebted to Etienne de Durand for introducing this interpretative framework into our problem. See Etienne de Durand, Rapport de DEA, EHESS, 1994, pp. 16, 66-67.
[26] On the *Tercios*, see René Quatrefages, *Los tercios*, Madrid, Coleccion Ediciones Ejercito, 1983.

because once the square broke up the infantryman was extremely vulnerable to “exploitation” by cavalry.

The proliferation of firearms highlighted two tactical problems that were only resolved after a long period of trial and error. First of all, it was necessary to find the correct balance between the weapon of shock, the pike, and the ranged weapon, the arquebus and then the musket. The invention of the socket bayonet at the beginning of the 18th century provided the technical solution by giving a single weapon a combined projectile and shock capability. Fusiliers, who were more multi-role, able to fire from far away while armed with a weapon equivalent to the pike for close-quarters combat, replaced the old formations of musketeers and pikemen and led to the standardization of the infantry.

The second problem was to adapt battle formations to derive maximum benefit from the power of modern weapons and avoid losses from the emerging artillery, which was generating a “fire revolution.”[27] The reforms of Maurice de Nassau in the Dutch infantry at the beginning of the 16th century introduced ten-rank squares of musketeers firing by rank and by file[28], maintaining sustained fire at 40 rounds per minute. Gustavus Adolphus II, the King of Sweden at the time of the Thirty Years' War (1618-1648), developed an infantry that finally equaled the tactical clockwork of the Romans. He created the thin order, positioning his troops in six ranks, and introduced salvo or volley firing, which allowed several ranks to fire simultaneously while the others were reloading. He organized brigades which were easier to handle than squares, and his infantrymen were trained to fire three times faster than their European adversaries. However, this “fine machine” required constant training and meticulous coordination. Drills made their appearance, and from 1660 onwards uniforms made it possible to tell troops apart on the battlefield.

The Swedish standard, which provided a better balance between mobility and firepower, was borrowed by the European armies, which all adopted the thin order. However, the longer the line is stretched, the more “power”[29] is lost at the moment of shock, and the harder it becomes to coordinate troops. At the Battle of Leuthen in 1757, Frederick II used oblique order, which made it possible to switch quickly from marching order to battle order, thus combining the advantages of firepower and the conditions required for shock. However, the requirement for mobility increased because of the need to reconnoiter and protect flanks against cavalry or artillery. Open order was therefore gradually and partially reintroduced in the form of units of more mobile skirmishers. Nevertheless, the decision remained in the hands of the line infantry. Despite the introduction of firearms, with the adoption of thin order rates of losses fell until the French Revolution, from 15% (for the victors) and 30% (for the

[27] See Colonel Trevor N. Dupuy, *The Evolution Of Weapons And Warfare*, New York, Da Capo Press, 1990.
[28] Fire by rank involves having the first rank fire, then return inside the formation to make way for the next rank. Fire by file involves putting a column in line to fire, then having it return as a column to its place in the grouping.
[29] Including psychological power.

losers) in a battle in the Thirty Years' War to 9% and 16% respectively in a battle in the Wars of the Revolution[30].

The French Revolution marked a turning point with the advent of the "nation in arms." Napoleon had masses of infantry whose spirit was galvanized by patriotism, so he no longer had to worry about casualties. The Wars of the Empire thus saw a significant increase in loss rates: 15% among the victors and 20% among the losers per battle on average[31]. However, the number of conscripts to be coordinated and their lack of training made it necessary to abandon the meticulous maneuvering in line of the "war in lace." The armies of the Revolution fought "in disarray," in other words by adopting skirmishing order. At the same time a movement critical of thin order, initiated by the Chevalier de Folard and Maurice de Saxe, led to the adoption of mixed order. Napoleon's line infantry was deployed in three ranks, but up to the moment of shock the front line alternated deployed battalions with others in columns. Advancing in a column favored speed – which made it possible to outflank – and hence shock effect, while being covered by the firepower of the battalions deployed in line. The aim was to control fear by reducing the length of exposure in the "death zone."

While it was primarily founded on the use of artillery, logistics, the qualities of a Berthier, and on maneuver[32], the "Napoleonic revolution" marked a second optimum for infantry combat as far as the compromise between mobility and firepower was concerned. Napoleon's soldiers were capable of extraordinary mobility for the time, which suggests that they possessed remarkable physical endurance. Davout's corps completed the 120 km march from Vienna to Austerlitz in 36 hours before joining the battle[33]. The requirement for protection took a back seat. It is true that infantry fire was not very lethal at more than about a hundred meters. Tests carried out by Gerhard von Scharnhorst in 1813 showed that a battalion scored direct hits with 25% of rounds at a range of 200 meters, 40% at 135 meters and 60% at 70 meters when firing at a target two meters high and thirty meters wide[34]. The performance of the *fusils* or light flintlock muskets of Napoleonic times was therefore comparable to that of earlier muskets, but they required four times less ammunition to produce the same effect[35]. However, the technical innovations of the 19th century would shift this balance and initiate a new phase of trial and error until the First World War, in which the requirement for protection took precedence at the expense of mobility.

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[30] See Trevor N. Dupuy, *op. cit*., p. 170.
[31] *Ibid*.
[32] For logistical aspects, see: Martin Van Creveld, *Supplying war: Logistics from Wallenstein to Patton*, Cambridge, Cambridge University Press, 1977, pp. 40-74.
[33] Jacques Garnier and Jean Tulard, *Austerlitz. 2 décembre 1805*, Paris, Fayard, 2005.
[34] Gunther E. Rothenberg, *The Art of Warfare in the Age of Napoleon*, Bloomington, Indiana University Press, 1981, p. 65.
[35] Peter Paret, Yorck *and the Era of the Prussian Reform, 1807-1815*, Princeton, Princeton University Press, 1966, p. 271 and appendix, quoted by John A. English and Bruce I. Gudmundsson, *op. cit.*, p. 13.

The Industrial Revolution

In the first half of the 19th century, a series of technological innovations considerably increased firepower, the range and rate of fire of infantry weapons. After developing a soft, conical bullet in 1847, in 1849 Captains Minié et Delvigne developed a musket with a rifled barrel. This combination had three advantages: much faster muzzle loading, improved accuracy and range thanks to the rotation of the round, and a reduction in powder residue with a corresponding reduction in the risk of the weapon jamming. Range was increased by a factor of six, extending the lethal zone to be crossed by an attacking infantryman to 300 meters[36]. The technological developments initiated by Minié first made themselves felt on the battlefields of the American Civil War and the Crimean War where, because infantry still fought in close order with linear tactics, the new weapons increased the rates of losses to those of the bloodiest Napoleonic battles[37].

Technical innovation speeded up with the development of breech loading: the German Dreyse rifle, followed in 1866 by the French Chassepot, which had a maximum range of 1,200 meters. In 1879 a Scottish watchmaker invented the repeating rifle with a magazine under the breech. This became the Lee Enfield, which was quickly copied by Mauser. The century saw the disappearance of black powder ammunition, which clogged up weapons, gave away firing positions, and whose smoke obscured troops after only a few hours of combat. In 1884 Chief Engineer Paul Vieille, working at the Laboratoire Central des Poudres et Salpêtres (Central Powders and Saltpeter Laboratory) in Paris, invented a nitrocellulose-based powder known as “Powder B.” Although three times more powerful, it generated practically no smoke and left less residue. It allowed fully jacketed ammunition to be developed. The Lebel of 1886 brought together all his innovations. It carried 10 cartridges and had a maximum range of 4,400 meters[38]. At the same time the collective weapon appeared. The machine gun, which was invented by Gatling in 1861, was made self-loading by Sir Hiram Maxim in 1884. Its rate of fire reached 600 rounds per minute, the equivalent of some 30 breech-loading rifles of the time.

This leap forward in the lethality of weapons unbalanced the firepower-mobility-protection triad in favor of the first of these elements. The first months of 1914 showed the consequences of these innovations. From then on the infantry was pinned down by fire from the enemy infantry, and of course by artillery fire. The consequences were psychological, too[39]. The requirement for protection eventually took precedence. Red trousers were abandoned in favor of the less visible horizon blue[40], and the steel helmet was introduced. Towards the end of the war the first bullet-proof vests

[36] See Colonel Michel Goya, *op. cit.*, p. 77.
[37] See Trevor N. Dupuy, *op. cit.*, p. 171.
[38] A. E. Hartink, *Encyclopédie des Fusils et Carabines*, Rebo Publishers, 2009 and the website http://armesfrancaises.free.fr/.
[39] See Antulio J. II Echevarria, *After Clausewitz: German Military Thinkers Before the Great War*, Lawrence, University Press of Kansas, 2001, p. 79.
[40] The idea of camouflaging uniforms appeared. Nowadays, this camouflage also has to be able to reduce the heat signature.

appeared, but were still not very effective. Close order was abandoned in favor of a "revolution in open order"[41] adopted first by the Germans, then by all the infantries. Skirmishing order became obligatory to escape the density of the wall of enemy fire. The cursor had moved to the detriment of mobility. The invention of the tank, then mechanized combat, was an attempt to resolve the dilemma, and obliged the infantry to acquire a new capability, first with anti-tank rifles and later with rocket launchers, the famous *Panzerfaust*, and missiles. This anti-tank capability was the main development in infantry weapons in the 20th century, apart from modern sighting aids.

Where structures were concerned, innovations were introduced to regain mobility, and this led to the invention of infantry infiltration techniques – the *Sturmtruppen* of the Rohr Battalion, then the French free corps, who in a way introduced commando combat – and the squad[42]. This squad is an integrated structure, similar to an artillery piece, which replaces the alignment of identical men. The specialization of each soldier within this structure strengthens the ties between them and their motivation, and this in turn enhances "tactical productivity."[43] Thus the modern infantry appeared, the structures of which have remained broadly unchanged since 1916[44]. In the first post-1918 edition of its infantry manual, Germany expressly rejected the idea of linear tactics, thus marking the final victory of open order[45]. Since then, the infantryman has fought in skirmishing order, the smallest tactical unit being a section of about ten men, the smallest "maneuver unit" being a platoon made up of three or four sections. Modern infantry tactics are now based on a *combination of fire and movement* at the level of elementary sections.

Thus it may be seen that, historically speaking, tactical "optima" are only reached after varyingly long periods of adaptation. Each optimum may be called into question by a technical innovation which in turn makes a new adaptation necessary, and the process continues in cycles. Since the Industrial Revolution it seems that the pace of changes in cycle has increasingly been set by technology. With the "information age" it is actually civilian technology that is directing the process. However, the technological dimension alone cannot explain all the changes. We also need to take the sociopolitical context into account. Thus the hoplite model was consistent with the political organization of the Greek city[46], and the end of chivalry was linked to the socioeconomic context of the Renaissance, which combined the development of the urban world, the gradual decline of the aristocracy and the development of a mercenary market gathering soldiers

[41] See John A. English and Bruce I. Gudmundsson, *op. cit*., pp. 1-13.
[42] Timothy Lupfer, "The Dynamics of Doctrine: The Changes in German Tactical Doctrine during the First World War", *Leavenworth Papers*, no. 4, July 1981, and Bruce I. Gudmundsson, *Stormtroop Tactics: Innovation in the German Army 1914-1918*, New York, Praeger, 1995 and Bruce I. Gudmundsson, *On Artillery*, Westport, Preager, 1993, p. 59. A squad (or section in the British Army) corresponds to the German *Gruppe.*
[43] See Michel Goya, *op. cit.*
[44] *Ibid*.
[45] John A. English and Bruce I. Gudmundsson, *op. cit*., p. 40.
[46] See Pierre Vidal-Naquet, *op. cit.*

from the poor and mountainous regions of Europe – Switzerland, Scotland and the fringes of the Holy Roman Empire.

It therefore remains to be seen whether the current technological revolution marks the end of a tactical optimum initiated by the infantryman of 1916. Unlike all the other operational roles, which have benefited from mechanization, dismounted combat cannot be freely positioned within the mobility-firepower-protection triad, subject as it is to the intangible limits set by human physiology. These inevitably set a limit to the weight that can be carried. However, the current trend is towards substantial increases in weight as a result of the reappearance of armor in the infantry.

The End of the Light Infantry

If you ask an infantryman what his worst enemy is, he is almost certain to reply "weight." Fighting on foot inevitably involves carrying weapons, ammunition and equipment on the man, and this is particularly difficult when one is constantly having to "take up position, move and use one's weapons."[47] This weight is intimately connected with our problem, because the two main factors in the weight of the equipment are protection – armor – and firepower – weapons and ammunition. Increasing weight reduces mobility, which also contributes to protection. Now, in spite of the many innovations that have been examined here, weight has historically stayed relatively constant. On the one hand the physiological limitations of the man naturally set an upper limit, and on the other the fact that the weight of some items of equipment cannot be reduced, and the need to have ever more resources available, prevents the load from being reduced significantly. The return of armor to the infantry and the growth of technology have caused a sharp increase since the end of the 20th century. Furthermore, the latest technological advances have given rise to the concept of "cognitive load," which now also has to be taken into consideration.

The Mules of the Battlefield

Any discussion of the weight of equipment must start with the definition of three types of load. "Weight in combat order" describes the whole of the burden the infantryman must carry in order to fight: uniform, weapons, protection, ammunition, communications, optics. This is what he must carry on his person at all times. "Weight in marching order" describes what the infantryman carries if he has to be autonomous in the field. In this case toilet articles, changes of clothing, as well as rations and camping equipment are added, all of which makes it necessary to carry a backpack. It becomes clear that, the greater the autonomy required, the greater the weight. In contemporary operations we can see an intermediate stage, which generally corresponds to 24 to 48 hours of autonomy[48]. In this case the infantryman carries a patrol pack with protection against bad weather, one or two rations and extra ammunition. The problem is ancient, and the constancy of the weight carried is remarkable, as history has often demonstrated.

For a hoplite, the weight in combat order reached about 25 to 35 kg, equivalent to between 33 and 47% of body weight for a Greek weighing 70

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[47] Ministry of Defense, *Manuel d'emploi de la section d'infanterie*, INF 202.
[48] See illustrations in the appendices.

kg[49]. This was already penalizing, as shown by the four tendencies highlighted by the work of Victor Hanson[50]:

- "a tendency, which continued for 250 years, to change then abandon certain elements of the breastplate;
- the use of personal servants to carry the hoplite's equipment;
- the habit of putting off arming oneself until literally the very last minutes before the clash of spears;
- the hoplite's natural habit of taking off his expensive armor at any moment."[51]

According to estimates, the legionaries of Marius carried 25 to 35 kg in combat order and up to 45 kg in marching order. Logistical independence comes at a price, and the legionaries quickly earned the nickname *Marius Mules*. According to studies conducted in Pompeii and Herculaneum, the average weight of an individual of the time was 66 kg, so this load was equivalent to 55% of body weight[52]. The physical demands of the profession of dismounted soldier were stressed by the Roman military historian Vegetius: "Carrying a weight of sixty pounds (30 kg) at marching pace should be the frequent exercise of the conscript."[53] The Middle Ages were characterized by the development of armor and its gradual increase in weight. In the High Middle Ages the coat of mail, which was made up of 30 to 40,000 metal rings[54], weighed at least 10 kg. In the 11th-13th centuries, fully equipping a man at arms required 25 kg of iron, which was rare at the time, and this partly explains the social status of the knights[55]. Towards the end of the 12th century, the proliferation of crossbows led to increased protection for men and mounts. Metal plates came into general use on hauberks, helmets, gloves and mail leggings. The "man at arms" and his horse "all covered with iron"[56] made their appearance. On its own, the armor of the 15th century weighted 25 to 30 kg, and when the knight had to fight on foot, which was frequently the case, especially after the experience of Crecy, he was particularly vulnerable because he had very little mobility[57]. Once he had fallen to the ground, he could easily be run through by a mere light infantryman armed with a knife, slipping his weapon through a defect in the breastplate.

The appearance of firearms led to the gradual abandonment of plate armor around the 16th century. Spanish pikemen still wore protection

[49] Victor Davis Hanson, *Le modèle occidental de la guerre, op. cit.,* p. 89.
[50] *Ibid*.
[51] And to "drop" his shield, especially when fleeing - hence the Spartan saying: "with it or on it". Spartan mothers and wives handed the warriors their shields with these words: "Return (victorious) with your shield or (dead) on it".
[52] Rob Orr, "The History of the Soldier's Load", Australian Army Journal, vol. 7, no. 2, Winter 2010, p. 71.
[53] Vegetius, *Traité de l'art militaire,* Paris, J. Corréard, 1859, p. 29. (available in the Gallica digital library).
[54] P. Contamine, *op. cit.*, p. 14.
[55] *Ibid*., p. 71.
[56] *Ibid*, p. 85.
[57] J.F.C Fuller, *Armament and History: The Influence of Armament on History from the Dawn of Classical Warfare to the End of the Second World War*, New York, Da Capo Press, 1998, p. 73.

weighing 14 kg, to which the rest of their equipment must be added, including the 10 kg pike. The English pikeman in the Civil War of 1638 carried between 22.5 and 27.5 kg of weapons and equipment[58]. In the end, the proliferation of muskets and the abandonment of armor in the infantry reduced the load to more reasonable figures, and moved the barycenter towards greater mobility. During the Napoleonic Wars, infantrymen carried between 23 and 35 kg, but still complained about the excess weight they had to carry[59]. However, like their Roman predecessors, they could leave much of it in their bivouac, and fought on the battlefield with some 20 kg on their backs.

During the First World War, weight increased with the requirement for protection: heavy helmets, gas masks and entrenching tools. The famous “barda” (kit) alone weighed nearly 30 kg, but in an assault the French soldier took “the essentials” with him in his rolled-up tent canvas, which he carried around his neck. “For the Douaumont attack [October 21, 1916], in addition to their equipment and cartridge belts the soldiers of the 321st RI (Infantry Regiment) carried: two gas masks, one haversack of biscuits, another containing beef and chocolate, a third holding grenades, a two-liter can of wine, another filled with water, a blanket rolled up in the tent, a digging shovel, and two empty sandbags.”[60] During the wars of decolonization, protection was less vital. Mobility was of prime importance because of the need to run after the “Fellagha”, who were capable of covering 30 to 40 km at night in the mountains. Lieutenant Colonel de Vismes noted in a report on the operations conducted by his regiment in Algeria from June 11 to July 11, 1956 that “a lead grenadier-voltigeur carried 15 kg: his PM [submachine gun] weighing 3.5 kg, a basic load of eight magazines weighing 5.39 kg, and his equipment: a helmet, belt and dagger weighing 2.3 kg, and a day's rations: 2.7 kg. Added to this was a daily requirement for 15 liters of water, often found in the field.”[61]

Weight in combat order essentially remained fairly constant at about 30 kg until the Vietnam War (see appendices). Where operations called for considerable autonomy, 10 to 20 kg of equipment were added. On June 6, 1944, the paratroops jumped into Normandy with 40 kg of equipment. When they had barely landed, they immediately buried the non-essentials[62]. In the Falklands, in the course of a now famous exploit, 45 Commando trekked 129 km in three days carrying a load of 54.5 to 66 kg per man[63].

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[58] See Rob Orr, *op. cit*, p. 72.
[59] Jean Tulard, *Dictionnaire Napoléon*, Paris, Fayard, 1999 and Gunther E. Rothenberg, *op. cit*., pp. 83-84.
[60] Georges Blond, *Verdun*, Paris, Livre de poche, 1974.
[61] Service historique de la Défense, Rapport de mission du chef de corps du 2e REP, carton d'archives n°1H3595, Vincennes. Références fournies par Florent de Saint Victor, http://mars-attaque.blogspot.com/, whom we would like to thank.
[62] Samuel L.A. Marshall, *The Soldier's Load and the Mobility of a Nation*, Quantico, Marine Corp Assn Bookstore, 1980, p. 16.
[63] See Rob Orr, *op. cit*, p. 76.

Physiological Limits That Are Constantly Neglected

The reason why this weight has stayed remarkably constant is human physiology. The experience of veterans, which has since been validated by scientific studies, shows that the maximum weight that an individual can carry without too much toil corresponds to roughly one third of his body weight. In April 1894, medical students at the Friedrich Wilhelm Institute in Prussia commenced a series of experiments on the physical limits of the individual. The procedure consisted of a series of marches of between 24 and 75 kilometers carrying a load of 22 to 31 kg.

They reached the following conclusions:

- With a load of up to 22 kg, at medium temperatures, a march of 25 to 28 km maintained physical fitness. In intense heat, problems appeared: heavy perspiration, fast pulse, breathing too rapidly. These symptoms were not serious, and disappeared after a few hours' rest.
- When carrying 27 kg, the soldier still found marching fairly easy to bear. On very hot days, the problems had a harmful influence which could still be felt the following day. This weight of 27 kg must therefore be regarded as the maximum load to be carried by a soldier during marches of 25 to 28 kilometers (i.e. 5 to 6 hours of effort).
- From 31 kg upwards, the effort required had a negative effect on the body, even on medium marches and at cool temperatures. The effects lasted for several days[64].

These conclusions also contradict the generally accepted idea that well-trained soldiers can carry heavy loads without harm. From 31 kg upwards, and whatever their training, physical exhaustion is inevitable, with the corollary of diminished effectiveness in combat. In response to the increase in weight observed in the Great War, the British carried out a study in 1922[65]. They found that, historically, the infantryman had carried between 25 and 30 kg on average, whereas the optimum weight should not exceed 18 to 20 kg. In conclusion, the study recommended that the load should be limited to one third of the individual's body weight which, ironically, corresponded to the accepted limit for the pack animals used in the armed forces: “We were careful not to load the mule with more than a third of his own weight.”[66]

These data have been confirmed by more recent research. One American physiological study showed, for example, that physical abilities measured during jumps, races, obstacle courses and grenade throwing diminished by roughly 1% per kilo carried, and in the long term carrying too heavy a load caused medical problems[67]. The limits recommended by the

[64] Major William L. Ezell, *Battlefield Mobility And The Soldier's Load*, Quantico, USMC, CSC, 1992, pp. 7-10.
[65] Norman V. Lothian, “The load carried by the soldier”, *Journal of the Royal Army Medical Corps*, no. 38, pp. 9-24, 1922.
[66] Samuel L. A. Marshall, *op. cit.,* p. 19.
[67] Joseph Knapik, "Physiological, Biomechanical and Medical Aspects of Soldier Load Carriage, Paper presented at the RTO HFM Specialists’ Meeting on “Soldier Mobility: Innovations in Load Carriage System Design and Evaluation"", RTO

US Army are therefore 45% of body weight for an approach march and 30% (22 kg) for the weight in combat order. In conclusion, the study recommended a range of measures aimed at reducing and better distributing the load on the infantryman's equipment. However, modern combat conditions result in an overload that systematically exceeds the recommendations of the Department of Defense Design. Related to the average weight of an individual of 77 kg, measurements made in Iraq and Afghanistan in three different tactical situations gave the following results:

Figure 1: Comparison between recommended weight and actual weight[68]

	Load carried			
	Recommended		Actual	
	Weight for a subject weighing 77 kg	Recommended % of body weight	Actual weight	% for a subject weighing 77 kg
Combat	22.7 kg	30%	44 kg	57%
Movement on foot (32 km/8 h)	34.5 kg	45%	55.8 kg	73%
Non-tactical movement (from a means of transport to a post)	57.6 kg	75%	75.8 kg	99%

This has significant consequences for the health of the soldiers[69]. The study showed that if two similar units were compared, one deployed in Iraq and conducting highly mechanized operations, and the other deployed in Afghanistan and primarily conducting foot patrols, traumatisms of the ankles, knees, hips and back were 2.2 times more significant among the soldiers in Afghanistan. Some French soldiers deployed in this theatre have admitted that it takes them a year to recover physically, and that in particular they had pains in their knees and backs that took months to disappear.

This health problem leads to a personnel management problem. It is for a reason that the most resilient infantrymen often used to come from an agricultural background where they were accustomed to manual labor. Nowadays, this “strenuousness of the profession of infantryman” is becoming less and less compatible with “service-based” societies where the individual is subject to fewer and fewer physical demands. Indeed, “the

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Meeting Proceedings 56, proceedings of a conference held in Kingston, Canada on 27 to 29 June 2000.

[68] Criteria standard – Human Engineering MIL-STD-1472F, Lieutenant-colonel CHABOT, “Fiche interne de l’Etat-major de l’armée de Terre relative à l’allègement du combattant débarqué”, Fort Benning, January 2010 and fiche STAT N°50067 dated February 12, 2010. The recommendations of the Department of Defense Design can be accessed at http://www.public.navy.mil/navsafecen/Documents/acquisition/MILSTD1472F.pdf.

[69] See Hal Bernton, "Weight of War: Gear that protects troops also injures them", *The Seattle Times*, 13 February 2011, which can be accessed at: http://seattletimes.nwsource.com/html/nationworld/2014209155_weightofwar06.html.

general impact of the machine on all industrial populations is to lower the stamina of the individual and make it less likely that he will develop his legs by walking and harden his back and shoulder muscles by manual toil."[70]. This calls for greater attention to selection criteria, and requires greater progressiveness in training soldiers if a drop in the retention rate is to be avoided[71]. Today's soldiers may no longer be peasants, but they are bigger, much better fed and much better physically trained: a hoplite or a "*grognard"* was 1.55 meters tall on average. However, the risk is a real one for professional armies, who now have to be attractive on the job market and keep an adequate number of infantrymen "on line."

In spite of these physiological changes, today's infantryman is no better off than "Marius' mules." The 55% of body weight carried by a Roman legionary are remarkably similar to the 57% carried by soldiers of the 82nd Airborne during operations in Afghanistan in 2003. There has thus been an increase in the absolute value, but the relative load carried by an infantryman has remained broadly the same for over two millennia[72]. In spite of technology, changes in logistics and means of transport, and changes in the way war itself is conducted, the situation of the Western infantryman on the battlefield is not improving. Another systematic study carried out in Afghanistan in 2003 by the Center for Army Lessons Learned[73] shows that an infantryman in combat order carries at least 28 kg (35% of his body weight) at all times. The average load when he takes part in an operation calling for 24 to 48 hours of autonomy is 45 kg (56.74% of his body weight). His body armor alone represents 25% of the total weight. Often caught in unexpected contacts during foot patrols, he then has to fight with this load on his back. During longer operations without vehicles, he carries 60 kg on average (i.e. 77% of his body weight). The load carried by British infantrymen in Afghanistan varies between 50 and 70 kg[74]. The weights in the French infantry are comparable now, and an infantryman never leaves his Afghan base with less than 40 kg of equipment[75]. This is a constant, because Russian soldiers also carried 40 kg of equipment in the first war in Afghanistan (1979-1989)[76].

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[70] Samuel L. A. Marshall, *op. cit*., pp. 3-4.

[71] In order to maintain the balance of the pyramid of age and rank, the Armed Forces must maintain an average length of service of 8 years (retention rate). Below this figure the need for renewal increases, resulting in a drop in selectiveness or the aging of the armed forces.

[72] Rob Orr, *op. cit.*, p. 77.

[73] U.S. Army Center for Army Lessons Learned, *The Modern Warrior's Combat Load: Dismounted Operations in Afghanistan*, April-May 2003.

[74] Brigadier C.L. Wilks, "The UK Approach to the Integrated Soldier System", Individual Capability Group, *Defence Equipment & Support*, which can be accessed at: http://www.wbresearch.com/uploadedFiles/Events/UK/2010/10983_004/Info_for_Attendees/presentations/BrigadierWilks.pdf, consulted on February 22, 2011.

[75] Interview with X, operating in Afghanistan, November 2010.

[76] Including body armor, whose weight decreased from 18 to 12 kg in the course of the conflict. Rodric Braithwaite, *Afgantsy: The Russians in Afghanistan 1979-89*, London, Profile Books, 2011, p. 199.

As an individual soldier is meaningless from a tactical point of view, it is worth bearing in mind the total weight to be shared within a section. The figure below shows the distribution of loads for a group of 13 US Marines:

Figure 2: Distribution of loads within a squad of 13 Marines[77]

The requirements for protection and firepower each have fair shares of the weight carried, with protection accounting for more than a third of the total weight. For reasons of absorption of kinetic energy, however, it is very difficult to make effective ballistic protection with less than a certain weight. Furthermore, this requirement is legitimate and difficult to call into question in the current sociological and political climate. In the US Army, 10% of soldiers were equipped with last-generation body armor in 2003. Currently, 90% of soldiers have the latest model[78]. After the Uzbin Valley ambush, France used a specific procurement procedure known as urgent operational requirement to bring the American MSA Paraclete body armor into general use. Quite apart from the fact that they save lives, these forms of protection also give confidence, thus contributing to combat effectiveness: “armor, by halving the material action to be suffered, halves the moral action (fear) to be overcome.”[79] This being the case, having an optimum level of protection represents an essential requirement while obviously resulting in a loss of mobility.

The weighting of firepower is due not only to the diversity of the armaments employed – pistols, assault rifles, machine guns, sniper rifles,

[77] Lieutenant-colonel Chabot, *op. cit,* p. 9. For a French section, the distribution is roughly the same, but the weights are smaller because the section has fewer men.
[78] Lance Bacon & Kate Brannen, "US Intel Chiefs Outline Priorities", *DefenseNews*, October 18, 2010, p. 26.
[79] Charles Ardant du Picq, *Etudes sur le combat*, Paris, Champ Libre, 1978, p. 78.

anti-tank weapons – and the widespread use of sighting aids, but also to the exponential increase in ammunition consumption. It took 350 kg of French bullets to kill a Viet-Minh fighter in Indochina, 920 kg of American bullets to achieve the same result in Vietnam, and 2 to 3 tons, or 200,000 to 300,000 rounds fired, to hit an insurgent in Iraq[80]. This increase is paradoxical, given the progress made in the accuracy of fire thanks to modern sighting aids. It is no doubt attributable to the combined effect of increases in the rates of fire of weapons, the “shoot'em up” video game culture among young soldiers, and also the effectiveness of the supply chains of Western armies. Soldiers receive unlimited ammunition, so they see no reason to restrict its use. Finally, the loss of the maneuver culture in favor of a firepower culture imported from the United States has probably also played a part in this[81].

Constraints Imposed by the New Technologies

The trend is therefore towards a general increase in weight. However, this increase in weight is ultimately less related to the new technologies than it is to the two previous factors. It is true that an ordinary American or French infantryman carries about 3 kg of equipment just for observation, aiming and communication[82]. This is comparatively little compared with body armor, especially as the weight of such equipment is falling rapidly. The Land Warrior System issued to the 5th Stryker Brigade Combat Team in 2008 weighs 3.3 kg (for the C4I[83] and optronic portions only), whereas the original version in 2006 weighed 7.7 kg.

The problem posed by the new technologies is more one of autonomy than weight, and batteries are now the principal brake on systems. Current lithium technology is not entirely satisfactory in terms of the ratio between weight and autonomy. The batteries of the *FELIN* system, for example, weigh 700 grams.

Progress is expected in this field. The autonomy of batteries increases by about 3% each year. Fuel cell technology should eventually provide solutions with even better performance, which will also be useful for PDAs, smartphones and laptops. Systems will become progressively lighter while consuming less power. The latest sighting system from the company Aimpoint has an autonomy of 80,000 hours, in other words 8 years of continuous use, and weighs 265 grams[84].

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[80] Lieutenant-colonel Chabot, *op. cit.,* p. 8.
[81] On the subject of the American firepower culture, see Michel Goya, *Res Militaris. De l’emploi des forces armées au XXIe siècle*, Paris, Economica, 2010, pp. 184-189.
[82] Weapon optics, night vision goggles, laser aiming device, flashlight and communication equipment.
[83] Acronym describing the capabilities Command, Control, Computers, Communications and Intelligence.
[84] Paolo Valpolini, "Compendium Modern Soldier programmes 2010", *Armada*, vol. 34, no. 2, April-May 2010, p. 1.

Ultimately, the real challenge lies in the appearance of a new burden on the infantryman, the "cognitive load."[85] The increase in the stream of data and the difficulty of managing this excess information in real time is now an issue. This problem has already been clearly identified for fighter pilots, for example. It is known that information overload in the cerebral system prevents individuals from concentrating effectively on a single task, and that certain limits relating to the capabilities of the brain appear for example when a vertical representation of data – as used in graphics tablets or electronic bird tables – has to be correlated with a horizontal representation of the field of view. Ongoing developments in infantry equipment will make this problem even more significant. What impact will it have on individuals, even those from the iPad and Facebook generations, who will have neither the cognitive abilities nor, above all, the level of training of airplane pilots? Managing and presenting data to provide useful information under the extreme conditions of dismounted combat without hampering the soldier in his reflex actions will be a major challenge.

The Western infantryman, heir to the French soldier of 1916, but undergoing a technological transformation, has managed to arrive at a good compromise between firepower and protection, but at the expense of mobility. He is currently in an unbalanced situation, having to bear not only an excessive physical load, but also an increasing cognitive load. It therefore remains to be seen whether future infantryman systems such as the French *FELIN* will aggravate this imbalance or initiate a development cycle that will lead to a new optimum.

[85] Thom Shanker and Matt Richtel, "In New Military, Data Overload Can Be Deadly", *New York Times*, January 16, 2011, which can be accessed at: http://www.nytimes.com/2011/01/17/technology/17brain.html.

The Infantryman of the Future

2011 is destined to mark a turning point for the French Army, which is initiating the first integrated general overhaul of its infantrymen's equipment since the First World War. As the first operational "integrated soldier system," the case of *FELIN*, which is to enter service shortly in Afghanistan, is symbolic. Beyond this, the dynamics of these systems, which have been launched in about thirty countries, should be analyzed. The advantages of integrated technology at the level of the dismounted soldier are undeniable. Conversely, and even though "we are still in the prehistory of soldier systems,"[86] we must give up any false hopes which this revolution might raise. The logic of making the soldier heavier, at least in the medium term, is not inverted, because there are many sociopolitical conditions that require it, and ultimately these are always the deciding factor.

The Advantages of Technology for the Infantryman

From the end of the 1980s onwards, the incorporation of information and communication technologies has allowed Western – especially American – armed forces to enhance their capabilities in terms of C4I, target acquisition and remote precision strikes considerably, to such an extent that many experts have spoken of a "Revolution in Military Affairs" (RMA) or, more recently, of Transformation[87]. For ground forces, this intelligence superiority and the cover provided by precision strikes was intended to allow the "footprint" and duration of engagements to be reduced. The collapse of the enemy system, brought about abruptly and at little human cost, would then make it possible to resolve the crisis quickly, with a corresponding reduction in the political cost of intervention[88]. These theories are now showing their limitations because they are poorly suited to the needs of stabilization operations, which require political success on the ground, built up over time and amongst the people[89].

However, we now need to get beyond simplistic oppositions between "transformation" and "war amongst the people," between heavy

[86] Interview with Valery Rousset, Director of System Marketing, Thales, January 14, 2011.
[87] On RMA, see Etienne de Durand, "RMA : La résistance au changement est-elle raisonnable?", in Pascal Vennesson (dir.), *Innovations et conduite du changement dans les armées*, Paris, Les forums du C2SD, 2002, pp. 135-160.
[88] Philippe Coquet, "Technologie et guerre – Fin de la RMA et adaptation aux conflits asymétriques", in Thierry de Montbrial et Philippe Moreau Defarges (dir.), *Ramses 2009*, Paris, Ifri-Dunod, September 2008, pp. 88-91.
[89] See Vincent Desportes, *La guerre probable*, Paris, Economica, 2007.

forces and light forces. The lessons of current operations highlight the need to give priority to a flexible, pragmatic approach offering the best possible combination of mobility, protection and firepower[90]. It is essential to integrate the advantages of technology while remaining in phase with the requirements of current conflicts and while controlling costs. It is this delicate marriage that "integrated soldier systems" are intended to address, at a time when operational requirements and the technology available are outlining the following trends:

- thermal imaging, light intensification and laser designation for all combatants;
- integration of the individual combatant into C4I networks, global positioning and a common operating picture;
- the capability of generating "infra-lethal" effects, in other words of categorizing targets and applying suppressive fire while maximizing the probability of direct hits and minimizing the risk of collateral damage;
- in the longer term, the robotization of the operational function[91].

NATO has thus defined five segments for the modernization of the infantryman's equipment: C4I, lethality, mobility, survivability and sustainability. The objective of the programs is to: "[...] allow the infantry to be integrated down to the lowest level into the digitization of the battlespace, [...] speed up the tempo of maneuver considerably, and give combatants unrivaled attack and observation capabilities while ensuring that they have effective protection."[92] Equipment is finally being regarded as a whole, with a permanent objective of ergonomics, weight optimization and power management.

Just as in society, it is first and foremost in the communications function that a revolution is taking place. With *FELIN*, each man is equipped with a Man-Machine Interface (MMI), a kind of Personal Data Assistant (PDA) with a color display, and a software-defined radio[93] with built-in GPS and an osteophonic communications headband[94]. Platoon and squad leaders have the SitComDé, a sort of tactical iPad, which displays maps, graphical orders and messages, and is integrated with the other

[90] Anne-Henry de Russé, "Transformation et contre-insurrection. Implications capacitaires pour les forces terrestres occidentales", *Focus stratégique*, no. 16, May 2009.
[91] In other words the widespread introduction of ground-based robots for reconnaissance, transport or combat to accompany the action of the infantry.
[92] Equipment policy for the dismounted combat function, EMAT (French Army Staff).
[93] Radios that process the signal with the aid of software instead of electronic circuits. Smaller and lighter, these radios automate relays and may allow, for example, signals to be transmitted (and received) simultaneously on several channels (HV, VHF, UHF).
[94] Instead of transmission using sound waves, the system transmits vibrations into the cranium as far as the inner ear.

information systems of digitized units[95]. The Infantryman Information Network RIF (Réseau d'Information du Fantassin), which manages two radio networks simultaneously, allows everyone to exchange audio information (including in conference mode), warning messages, data, images and video. The system permits Blue Force Tracking (BFT)[96] and automatically manages the relay between posts to maintain the link. A central processing unit serves as the system's computer and optimizes power as well as possible. It digitizes the management of personal and medical data, together with logistical functions[97]. As far as ergonomics are concerned, the osteophonic system is admired by anybody who has ever dismounted from the turret of a personnel armored vehicle VAB (Véhicule de l'Avant Blindé) with a TRPP 11 around his neck[98].

The observation and aiming aid function has also been considerably improved. For example, each *FELIN* soldier has a day/night optic with light intensification in a device weighing 370 g[99]. This sight allows system information to be displayed in video and even remote sighting for the weapon. A new version already exists which incorporates thermal technology. Each platoon is equipped with 17 portable thermal observation devices, and this represents a 1,700% increase in capability compared with the current situation, quite apart from the technical improvement of the systems. As orders for the program currently stand, the weapon of one man in three will be equipped with infrared vision, one man in two with a light intensification sight, and all will have night vision goggles. The infrared sight for marksmen has an integral laser rangefinder. The multifunction binoculars used by commanders allow them not only to see in infrared, but also to send images, designate a target and measure its range. A pedestrian can thus be detected over 5 km away and identified at 950 meters. According to evaluations on the ground, engagement ranges are increased by 60% by day and 100% by night[100].

Essentially, these systems are aimed at integrating existing technology and bringing it into synergy, now that it has been sufficiently miniaturized. The main advantage of digitization is obviously to reduce friction on the battlefield by achieving a very marked improvement in the management of friendly forces[101]. The whole of the SUDS[102] cycle is

[95] A unit commander can thus send a tactical situation from his Regimental Information System console to his platoon leader that can be accessed on the SitComDé.
[96] Constant plotting of the positions of friendly units on maps.
[97] This may eventually permit real-time monitoring and automatic management of logistics or MEDEVAC.
[98] An old-generation portable radio, which has since been replaced by the PR4G series.
[99] Mini-D optic from Thales Angénieux SA, integrated into Sagem's FELIN program and Spain's COMbatiente FUTuro program.
[100] Interview with Laurent Barraco, FELIN project manager at the DGA, in "Le FELIN rugit en France", *Safran magazine*, no. 8, June 2010, pp. 32-34.
[101] For the advantages of digitization and the risks if it is not perfectly controlled, see Michel Goya, "Des électrons et des hommes", *Cahier de la recherche doctrinale*, CDEF, June 2005.
[102] Send, Understand, Disseminate Intents, Synchronize.

speeded up down to the lowest tactical level. The results are undeniably a better understanding of the tactical situation and movements, easier friend/foe identification, and faster, more fluid transmission of information and orders. Units will also benefit from an improvement in the acquisition of targets and the accuracy of fires, enhanced ability to act autonomously at the lowest tactical levels, and greater continuity in mounted/dismounted combat through the integration of all networks.

Modern armies have understood this, and 32 future infantryman programs are currently under way around the world[103]. Some countries intend to equip their elite troops only. Others have broader ambitions. India has embarked on a policy aimed at equipping 465 battalions. Manufacturers estimate that the market will be worth 14.7 billion dollars by 2019, with a mean annual growth rate of 18%. In 2019, India and China should represent 15% and 10% of the market respectively. The infantryman's equipment has become a major industrial challenge, and the trend towards developing integrated soldier systems will continue for several decades. Apart from the United States, France is well ahead in the race, because no other systems are due to go into production until 2014-2015.

A Modular Tool, Not A Cure-All

As with the start of any innovation, the entry into service of integrated soldier systems is giving rise to a number of received ideas, myths or false hopes. The criticisms directed at the RMA are not sparing the *FELIN* system, and there are those who say that it was conceived in a Cold War logic, and is out of step with the current paradigm. The same accusation was levied at the Tiger helicopter, and yet it is demonstrating in Afghanistan that it is a remarkable combat tool[104]. Obviously, there is always a certain lag between the definition of a requirement and the entry into service of a weapon system. In fact the military spend their lives conducting today's war by adapting the resources prepared for yesterday's war. It is legitimate to wonder about the contradiction that exists between the desired objectives of maximum protection, enhanced firing and detection capabilities and the speeding up of the decision-making process on the one hand, and the characteristics of today's irregular adversary, who is light, unidentifiable within the population, and has time on his side. Indeed, counter-insurgency “puts the concept of info-centric warfare into context and places the human back in the heart of the battle. Digitization here is reduced to a tool for

[103] See map in the appendices and the Artem-Is report "Panorama "Future Soldier Systems/Panorama des Fantassins du Futur", which can be accessed at: https://www.artem-defense.com/docs/FUTURE_SOLDIER_SYSTEMS_WORLDWIDE_PANORAMA.pdf.

[104] Centre de Doctrine et d’Emploi des Forces, "Fiches d’exploitation du Retex", 2010.

situational intelligence, and indirect fires seem more to be complementing close-quarters combat than replacing it."[105]

FELIN nevertheless seems to fit into the desired logic of median systems combining ruggedness and technology. Even though its "Robocop" appearance may act as a barrier to communication with the local population – which is already true of current equipment – *FELIN* has been designed to be modular and scalable. It is modular, because the tactical commander (and after all it is his responsibility) may adapt the outfit of his troops to suit the mission. From beret/body armor/weapons to full kit, the choice is enormous. It is scalable, because it is possible to change certain technological building blocks, protection, C4I system, software upgrades and the optronic portion in order to adapt to the needs of the moment and to technological advances.

The other side of the technology coin is obviously the increased cost of equipment. The personal equipment of an American soldier cost $2,533 in the Second World War. It now costs $19,454[106]. On average, a future infantryman system costs between $30,000 and $40,000. Some systems may cost as much as $60,000[107]. France's order for 22,588 outfits[108] is worth a billion euros, including 600 million for development. This budget includes the integration of systems, for example by means of vehicle adapter kits for the VAB and VBCI personnel armored vehicles. A single system costs about 27,000 euros, making it more expensive than the equipment of the current American soldier, although this comparison is difficult to make because of the size of the American market and the resulting economies of scale. However, at a time when infantry units are in constant use, especially in France, where it is worth repeating that the infantryman's equipment has not been the subject of a coherent program for nearly a century, a billion-euro program representing a real technological breakthrough does not look like a waste of money. In the current financial context, when the staggering of deliveries has already been decided following the Budget Planning Law for 2009-2015, the real risk in terms of capability would be to try to make savings by reducing the number of infantry units on the pretext that "ten *FELIN* infantrymen can do the work of a hundred." The famous "Augustine's Law" is particularly true of the infantry, where numbers remain a determining factor[109].

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[105] Michel Goya, "Le pouvoir au bout du fusil. Irak ou la redécouverte des 300 derniers mètres", *Doctrine*, no. 07, CDEF, December 2005, p. 79.
[106] In constant dollars, Lance Bacon and Kate Brannen, *op. cit.* p. 26.
[107] VisionGain study, Soldier Modernisation Market 2009-2019, 2009, p. 18, which can be accessed at: http://www.visiongain.com/Report/368/The-Soldier-Modernisation-Market-2009-2019.
[108] In other words 2,500 fewer than the target set in the French White Paper of 2008.
[109] In the 1970s Norman Augustine, a former Lockheed Martin executive, predicted that if "the Pentagon's methods and the trend in costs did not change, around 2050 the budget would only allow a single tactical aircraft to be purchased". See "Les doutes de Norman Augustine", *De Defensa*, vol. 13, no. 5, October 10, 1997, which can be accessed at: http://www.dedefensa.org.

Finally, this new equipment is raising a number of questions regarding weight. The idea that these systems make the infantryman heavier is mistaken, although it is clear that in their current versions they are not going to improve the situation for the "mules of the battlefield." Where cognitive load is concerned, it is not really known how future generations will adopt these tools, which will no doubt seem natural to them. Augmented reality, which provides information as an overlay on the landscape, and dual-spectrum fusion, which allows a heat source visible in the infrared to be overlaid on a normal image, are among the technological avenues being explored to improve the presentation of data. Where physical weight is concerned, the complete *FELIN* outfit, with ballistic protection and 36 hours of autonomy, weights 27 kg, including 14 kg for light to heavy ballistic protection (NIJ 3 or 4)[110], in other words comparable to the current American body armor purchased off-the-shelf. The electronic assembly weighs 4 kg excluding batteries. Measurements made during operational preparations for Afghanistan show that the weight in combat order for autonomy of 48 to 72 hours is 45 to 50 kg[111]. All the same, this is a few kilos more than the current weight. In this "maximum" configuration, in addition to additional supplies, water and the usual minor equipment items, the infantryman carries extra batteries allowing him to operate without his vehicles, for example in a helicopter-borne operation[112]. In the standard configuration, in which the systems can be recharged in the vehicles during certain phases of an operation, the weight is comparable to the current situation, but with considerably better ergonomics and capabilities.

The weight will decrease with future generations of equipment thanks to miniaturization. In two years the new ballistic protection from SAGEM has saved 300g while going up one NIJ protection level[113]. It should also be possible to save 30 to 40% on the C4I equipment by 2020, thanks to increases in capabilities and the miniaturization of computers. Tomorrow a single processor should allow an individual soldier to be given the computing capacity currently found in a vehicle. Where optronics are concerned, the sights currently on the market are approximately twice as light with twice the autonomy of the previous generation, which dates from four or five years ago. Within the next five to seven years the weight of connectors will also be reduced, because the wiring of the equipment will be integrated directly into the fabric of the outfit. A reduction of the total weight by 15 to 20% can therefore be envisaged, although this would involve some development costs or a reduction in capability requirements. The Size, Weight and Power (SWAP)[114] requirement is already making

[110] The standards of the American National Institute of Justice are used as references.
[111] Trials carried out with the 1st RI (Infantry Regiment) and interview with an officer from a "FELINized" unit, April 2011.
[112] Two types of battery are available for the FELIN system, one weighing 700 g, the other 270 g. A recharging kit is installed in the unit's vehicles.
[113] Interview with Philippe Riofreyt, Land Combat Program Manager, Sagem, February 8, 2011.
[114] This acronym describes a requirement to increase the miniaturization and autonomy of weapon systems while making them lighter.

itself felt in invitations to tender for exports, and this is forcing manufacturers to make improvements in this area[115].

In view not only of the expectations but also the doubts raised by these new technologies for the infantryman, one needs to ask whether these developments prefigure a new optimum – in other words, is infantry combat about to be revolutionized? It will be difficult to make an assessment until the systems have entered service, the first feedback on operational experience has been received and the adaptations that will no doubt be necessary have been made. However, a few ideas can already be put forward. Firstly, open order will remain the rule. It has been known since 1914 that any concentration of infantry is doomed to be destroyed. Precise, continuous knowledge of the positions and status of a unit should allow the commander to give his subordinates greater autonomy, thus encouraging dispersal on the ground. This is the basis for the idea of the "digital line," in which the electronic link replaces the physical link for modern phalanxes in combat. However, even if technology makes this possible, it is hard to imagine a subdivision that is smaller than a squad, and there are two reasons for this. Firstly, current sections, especially the seven dismounted soldiers in a French section, already lack firepower. Secondly, the chief limiting factor is psychological, because the herding instinct plays a crucial part here. Technology does not reduce fear, and the infantryman of the future, like his predecessors, will not want to find himself stationed alone in the middle of the battlefield, even if he is linked to his comrades by a flow of electrons.

The dismounted soldier of the future will be able to acquire and identify his target further away, call in combined arms – and even joint – support faster and at the lowest level, and lay down accurate fire. The current tendency to reject maneuver into contact in favor of massive fire superiority is therefore likely to continue. In the event of a symmetrical war between two governments who possess this technology, there is bound to be some equalization of comparative advantages – a constant in military history. This being the case, and all other things being equal, victory is likely to depend on the number of infantrymen. The prospect of 465 "FELINized" Indian infantry battalions is food for thought. In the case of more "likely" wars[116], in the short term asymmetry between the infantryman of the future and his potential adversary will increase, whether in terms of individual protection, cost, technological differential or firepower. However, we should not raise any false hopes: in spite of all this technology, a soldier will not patrol any faster, or meet more *Maliks* (village headmen) in a day, nor will he spend any more time standing at his checkpoint. Numbers will remain a determining factor in dismounted combat and control of the environment. Hardiness, physical fitness, the cohesion of the unit, and firing discipline will still be the infantry's cardinal virtues, because "the best

[115] P. Rioufreyt, *op. cit.*
[116] Vincent Desportes, *op. cit*.

computer in the Marine rifle squad is 13 thinking, educated, trained Marines capable of rapid decision making in any geographical area."[117]

Finally, "*information superiority,*" the central logic of the RMA, is gaining ground as a new criterion alongside the traditional ones of *mobility, firepower* and *protection*[118]. *FELIN* is opening up a new era in this field. It is also reinforcing the French infantryman by enabling greater firepower – more accurate engagement of targets at longer ranges – and better protection. However, it does not resolve the mobility problem because the system as a whole is still too heavy. This problem is no longer one of technology, and the reasons for it must no doubt be sought elsewhere. In the sociopolitical context of contemporary engagements it would seem that force protection is a categorical imperative.

Protection, a Political Imperative

Changes in society, the nature of current wars and their political aims are making the requirement for protection ever more important, with the corollary of a kind of "return of armor" for the infantryman. Contemporary wars are limited, and conducted with professional armies that have been reduced in size[119]. The pressure to reduce both casualties and political cost is strong. In a way, contemporary Western societies have grown unaccustomed to war and the casualties it causes. "Nowadays the loss of a platoon has become an event of strategic importance,"[120] and this is certainly something new in history. As a result, ballistic protection and armor are coming into ever wider use, with a resulting problem of weight and hence mobility – which is a paradox, given that mobility itself provides a measure of protection on the battlefield.

As long as operations are static and combat rare, weight is not a fundamental problem. Conversely, operations in Afghanistan, which involve fighting a tough, tactically skilled enemy on foot in difficult terrain, have given this problem strategic resonance. The shortcomings of the French body armor, which was too heavy and unergonomic, hit the headlines after the Uzbin Valley ambush[121]. In the United States, the Army Chief of Staff has set the objective of restricting weight to 50 pounds (22 kg) for 2010. There is indeed a tactical problem, since it is virtually impossible to leap from one firing position to another, run across open ground and outflank an enemy position with 40 kg of equipment on one's back, especially in contacts lasting several hours. Infantry tactics have become frozen as a result: "operations are conducted in a manner which uses the superiority of night vision equipment to move at night and occupy defensive positions at

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[117] In Mark Richter, "Moving Forward", *SoldierMod*, 2008, available at : http://www.soldiermod.com/summer-08/prog-mer.html.

[118] See diagram in the appendices.

[119] For the consequences of this paradigm see Pierre Chareyron, "Ces guerres qu'on ne sait plus gagner", *Etudes*, November 2010, pp. 439-448.

[120] Interview with Michel Goya, January 2011.

[121] "Embuscade d'Uzbeen. Deux familles déposent plainte contre X", *LePoint.fr,* November 12, 2009, can be accessed at: http://www.lepoint.fr/actualites-societe/2009-11-12/justice-embuscade-d-uzbeen-deux-familles-deposent-plainte-contre-x/920/0/394162.

key points on the ground before sunrise. Once the sun has risen, it is the insurgent who has the advantage of mobility."[122] The aggressive maneuvering recommended in the French infantry manual[123] and the fix, outflank, subdue triad, which is the key to tactical superiority in infantry combat, seem out of reach[124], short of taking the risk of shedding weight by doing without body armor, a decision that has been made for some special forces units, but which is currently impossible to implement universally.

This has many consequences. Western armies are themselves increasing the asymmetry with respect to their light, tactically skilled adversaries. The two cardinal virtues upon which victory in infantry combat depends are firepower and mobility. It is as if the Westerners, having a massive superiority in one, had abandoned the other. "In order to destroy the enemy, modern Western armies no longer need to maneuver, because delivering effects and support are enough to get by in combat. This is why there is no more maneuvering to contact."[125] This is how risks are reduced. This reluctance to engage in hand-to-hand combat comes from "a preference for victories with a score of 1-0 rather than 3-1."[126] This has the corollary of an increase in the volume of fire, and hence the risk of civilian casualties. By contrast, combat in contact is much more "efficient." Taking this argument to its limit, you can never be as sure of properly identifying the enemy and avoiding collateral damage as when you stick your bayonet in his stomach.

Accordingly, there appears to be a major contradiction with the requirements of operations "amongst the people." In an indirect approach maneuver must be conditioned, not by military effect, but by the "political" effect desired. It will not necessarily involve the use of fire or a systematic attempt to engage the enemy. Current operations show that preference should actually be given to movement rather than fire, so as to dissuade the enemy, saturate the area and prevent him from maneuvering, but without resorting to massive use of force. In an analysis of his experience in Kapisa-Surobi, Colonel Bellot des Minières states: "The battalion must force itself to exercise tactical restraint and control fire. However, it is still essential to face fire just like the insurgents [...] to maintain a rhythm which drives the enemy from the field by occupying tactical positions before him and hunting him down on his own ground.[...] Assault infantry combat in immediate contact with the enemy is inevitable. Partitioning the area has an equalizing effect, and limits the value of support provided by the most sophisticated weapons [...]. It is by maneuvering under enemy fire [...] that a brave combatant outclasses his adversary. Above all, this is probably the

[122] Interview with Y, wounded in Afghanistan, Percy Hospital, October 2010.
[123] Ministère de la Défense, *Manuel d'emploi de la section d'infanterie*, INF 202, p. 213.
[124] John A. English and Bruce I. Gudmundsson, *op. cit.*, p. 40.
[125] Colonel Z, interview conducted at the EMAT (French Army Staff) on January 4, 2011.
[126] Interview with Colonel Michel Goya, *op. cit.*

only way to be sure of properly identifying the enemy while avoiding collateral damage by making measured use of support."[127]

This brings us to the heart of the problem. The speeding up of technological innovation has had the effect of multiplying the capabilities of the Western dismounted combatant to an extraordinary degree. For the first time in history he knows exactly where he is on the battlefield, and knows the tactical situation around him perfectly. Realizing the old dream of the Duke of Wellington, he can even finally see what is at the other side of the hill. He communicates with the whole world in real time. However, fighting on behalf of debellicized societies[128], his engagements have never been subject to so many constraints aimed at limiting casualties, both on his own side and among his adversaries. Weighed down by his armor and his technological paraphernalia, no longer needing to maneuver to crush the enemy, he runs the risk of condemning himself to static combat even though the nature of the enemy and of the war he is conducting call for mobility.

This being the case, "giving mobility back to the dismounted soldier is a real problem of which everyone in the armed forces is aware."[129] It is a tactical problem for the current war, but one which remains valid if we look beyond Afghanistan. Whatever the style of future wars it will be necessary to ensure superiority in close combat. History shows that "an entrenched opponent [does] not simply break and surrender in the face of overwhelming power, he [often] continues to resist until he [is] forcefully expelled from his position"[130] What was true at Verdun, or during the assault on Tarawa, or in the Lebanon War in 2006 is being borne out in the valleys of Afghanistan, and recently in Libya.

Solutions do exist. First of all, and at constant technology, the operational or tactical commander will have to reclaim his role by making the decision on what needs to be carried for an operation, and hence on the level of risk he is prepared to accept[131]. Future soldier systems such as *FELIN* will remain modular, and this is essential. However, this is not enough: a real policy of reducing the weight of the dismounted soldier must be implemented. In the United Kingdom an initiative of this kind, the Integrated Soldier System Executive (ISSE) has the ambition of reducing the current weight by 30 kg by 2020 by improving the integration of systems[132]. The US Marines' Marine Expeditionary Rifle Squad (MERS)

[127] CRFM du bataillon ALTOR, armé par le 2e REP, 2010, CDEF, a classified document quoted with the author's permission.
[128] André Thiéblemont, "Incidences d'une culture de paix sur les cultures de combat de l'Armée française", *Revue de l'Observatoire Européen de Sécurité*, no. 25, 4e trimestre 2008.
[129] Interview with EMAT BSA, January 4, 2011.
[130] In Antulio J. II Echevarria, *op. cit*., p. 222.
[131] However, for reasons of command ethics, a subordinate cannot be left to bear this responsibility alone, as the consequences will then have to be accepted, what is more in a context of judiciarization of operations.
[132] Based on the 50 to 70 kg currently observed in the British infantry, see Brigadier C. L. Wilks, *op. cit.*

program is also setting an example of a proactive policy on reducing weight without investing in new technologies[133]. In this context, for six months the Design Light Project involved several dozen military personnel, scientists, experts and manufacturers conducting a detailed analysis of the equipment carried by a section. This study produced over two hundred proposals aimed at reducing weight and volume, in some cases by up to 35%[134]. The systems also need to be further developed. Between the current version and *FELIN* V2, scheduled for 2018, there is an opportunity to give priority to an incremental approach, adopting any technological developments regarded as essential while bearing in mind the crucial issue of weight, even at the price of reducing technological capability to "just enough." In the longer term it is likely that some armies may introduce "mule drones" or exoskeletons. However, these systems are still heavy and expensive, and this does not improve the situation from the point of view of strategic mobility and defense budgets[135].

[133] Paolo Valpolini, *op. cit.*, p. 30.
[134] Mark Richter, "MERS Asks its Questions", *SoldierMod*, vol. 5, Summer-Autumn 2010, available at: http://www.soldiermod.com/volume-5/mers.html.
[135] 23 kg and €40,000 for a HAL-type exoskeleton.

Conclusion

The way infantry is used and the way a given society regards war go hand in hand. In a time of total war, it is normal to prefer a direct approach, with little concern for saving men who are in any case mobilized in droves. By contrast, we live in a time of limited wars conducted on behalf of debellicized societies by professional armies that are reduced in size. The infantryman is a scarce resource whose loss is politically costly. It is therefore logical that the fruits of technological progress should be incorporated into all weapon systems, including the infantryman's equipment, because they enhance tactical effectiveness and above all reduce casualties. Political cost always trumps financial cost.

The information revolution is benefiting dismounted combat. Maneuver is more fluid, engagement ranges are greater, and fires are more accurate. Even more importantly, integration into the complex environment of modern combat is made considerably easier. Integrated soldier systems make the most of new technologies while at last having a consistent approach designed with the individual in mind. With the *FELIN* program and the *VBCI* infantry combat vehicle, the first integrated versions of which will enter service in the summer of 2012, and more generally as a result of the coherence sought in the SCORPION[136] program, the French Army is entering a phase of major, indispensable modernization of its equipment. It is the first to enter the new, inevitable era of “soldier systems.” FELIN V2, which is scheduled for 2018, should continue the process of integration within SCORPION and develop interoperability with UAS and future battlefield robots.

However, the sociopolitical context has made the return of armor in the infantry mandatory. This, combined with the increasing numbers of technological components in his equipment, is generating a greater physical and cognitive overload for the soldier. Should we therefore conceive the equipment as a new balance between mobility, protection, firepower and *information superiority*? The “future infantryman” would then reach a new optimum, provided he regains greater mobility. If not, we will be striving to fight like skirmishers with a carapace twice as heavy as that of a hoplite.

These systems are still in their infancy. The challenge of the next few years will therefore be to manage all the technical developments at a level of “just enough,” while reducing overall weight and controlling cost.

[136] Scorpion is a digitization and coherence program for the Combined Arms Battlegroup (GTIA), see: http://www.defense.gouv.fr/dga/equipement/terrestre/le-programme-scorpion.

The main problem for the French armed forces will in fact be to fund these developments in a context of increasingly tight budgets, failing which *FELIN* might gradually become outdated, one disadvantage of being the first of its kind.

For the foreseeable future, the “augmented” man will remain the stuff of science fiction. The more credible technological avenues, such as exoskeletons, also generate problems of cost, weight and power supply. Bringing down the weight of equipment to regain mobility will therefore remain an imperative. The robotization of the battlefield, the need to add extra functions and the requirement for protection, which will persist, point to a continuing tendency for weight to increase. Without determined, sustained action, the “mule” will continue to be weighed down by a mass of equipment for a long time to come, with all the problems this generates in terms not only of tactical effectiveness, but also of retention and health. The “FELINized” infantryman must take advantage of technology, but without depriving himself of the qualities of the “wiry” soldier, a French tradition that is essential for combat in contact in general, and asymmetric conflicts in particular.

Appendices

The Weight of an Infantryman's Equipment throughout History [137]

Era	Marching equipment	Combat equipment	% body's weight calculated on the basis of the average weight of an individual. (The lowest number refers to combat equipment, the highest to marching equipment)
Greek hoplite	25 to 35 kg		33 to 47%
Roman legionary	45 kg	25 kg	55 %
Byzantine *Skutatoi*	36,5 kg		
English Pikeman in the Civil War (1638-51)	27,5 kg	22,5 kg	
Napoleon's infantrymen	*fusilier* : 23,92 kg. *grenadier* : 27,1 kg *voltigeur* : 24,13 kg *sapeur* : 33,2 kg		
British infantryman 1800	34 to 36,4 kg	22,7 kg	
British infantryman at Waterloo	27,5 to 32 kg		
British infantryman 1850, Crimea	30,9 kg		
Union Army of the Potomac	20,5 to 22,5 kg		33 to 44%
Confederate army	36,5 kg	13,5 kg	22 to 59%
French infantryman WWI		24,7 kg in 1914	
British infantryman WWI		26,8 kg in 1914 30 kg in 1916 33 à 36 kg in 1918	50 to 57,5 %
German infantryman WWI	25 kg	32 kg on average and up to 45 kg	
Australian soldier at Gallipoli	33,5 kg		
US infantryman 1918	27 to 32 kg	22 kg	34 to 50 %
US infantryman 1944		26,3 kg	
Omaha Beach infantryman	41 kg	27,5 kg	41,6 to 62,5%
Paratrooper 6th June1944	40 kg		
Russian infantryman, Eastern front	28 to 35,5 kg		
Japanese War of the Pacific	28 kg 56 kg for a machine gunner		52 to 105%

[137] The boxes have been merged when the distinction between marching and combat equipment is not clear or when the numbers are unavailable. The sources for this table are the following: Emile Lavisse (1902), *Sac au dos : études comparées de la tenue de campagne des fantassins des armées française et étrangères*, Paris, Hachette; Ian Kuring, "The infantryman's load", April 2002; Lieutenant Rob Orr, "The History of the Soldier's Load", *Australian Army Journal*, vol. 7, no. 2, winter 2010, pp. 67-88 ; fiche STAT N°50067 12th February 2010, abovementioned publications and interviews carried out during the study.

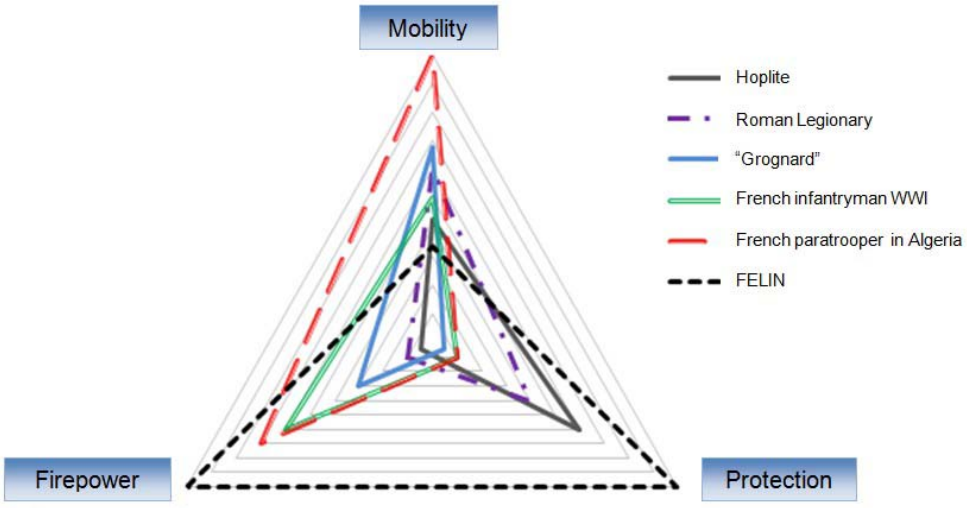
Canadian infantryman, Korean War	22,5 kg		31%
Marine in Toktong Ridge, December 1950	54,5 kg		
NKPA and Chinese volunteer	18,5 kg		
French paratrooper Algeria		15 kg	
US Infantryman 1968	27,5 to 32 kg		
Marine in Vietnam	36,5 to 45,5 kg		
Australian infantryman, Vietnam		36,35 for a Platoon leader 47,7 kg for a machine gunner	
Viet Cong		12 kg	
British infantryman, Falklands 1982	45,5 to 54,5 kg	31,8 to 36,35 kg	
American Rangers, Grenada 1983	54,55 kg		
Russian infantryman, Afghanistan 1989		40 kg*	
US Infantryman, Afghanistan 2003	57,5 kg	45 kg*	56 to 77%
US Machine gunner 2003	60 kg	51 kg*	
Mortar operator 2003	64 kg	48 kg*	
US Squad leader		61kg*	
French infantryman, Afghanistan 2010		40 to 45 kg*	
French MILAN missile operator, Afghanistan 2011		60 to 65 kg*	
FELIN basic pack		27 kg	
FELIN Afghanistan pack		45 kg to 50 kg[1]	58%[2]

[1] with a haversack, for an autonomy of 48 to 72 hours.

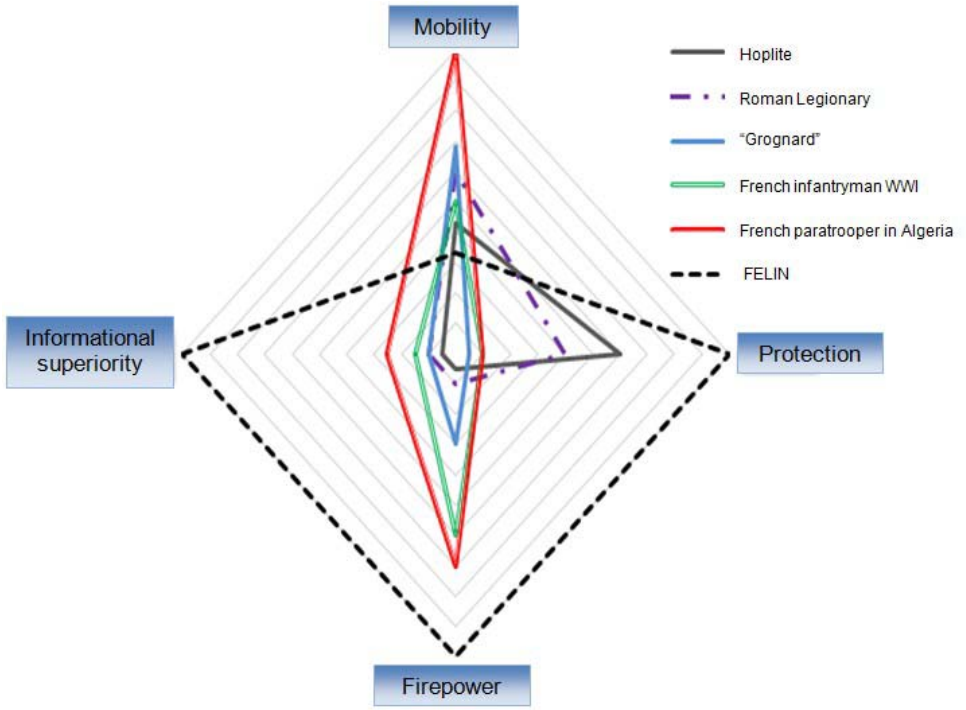
[2] based on the average weight of a French man: 77kg.

Countries Identified as Having a Future Soldier Program

Balance between Protection, Mobility and Firepower

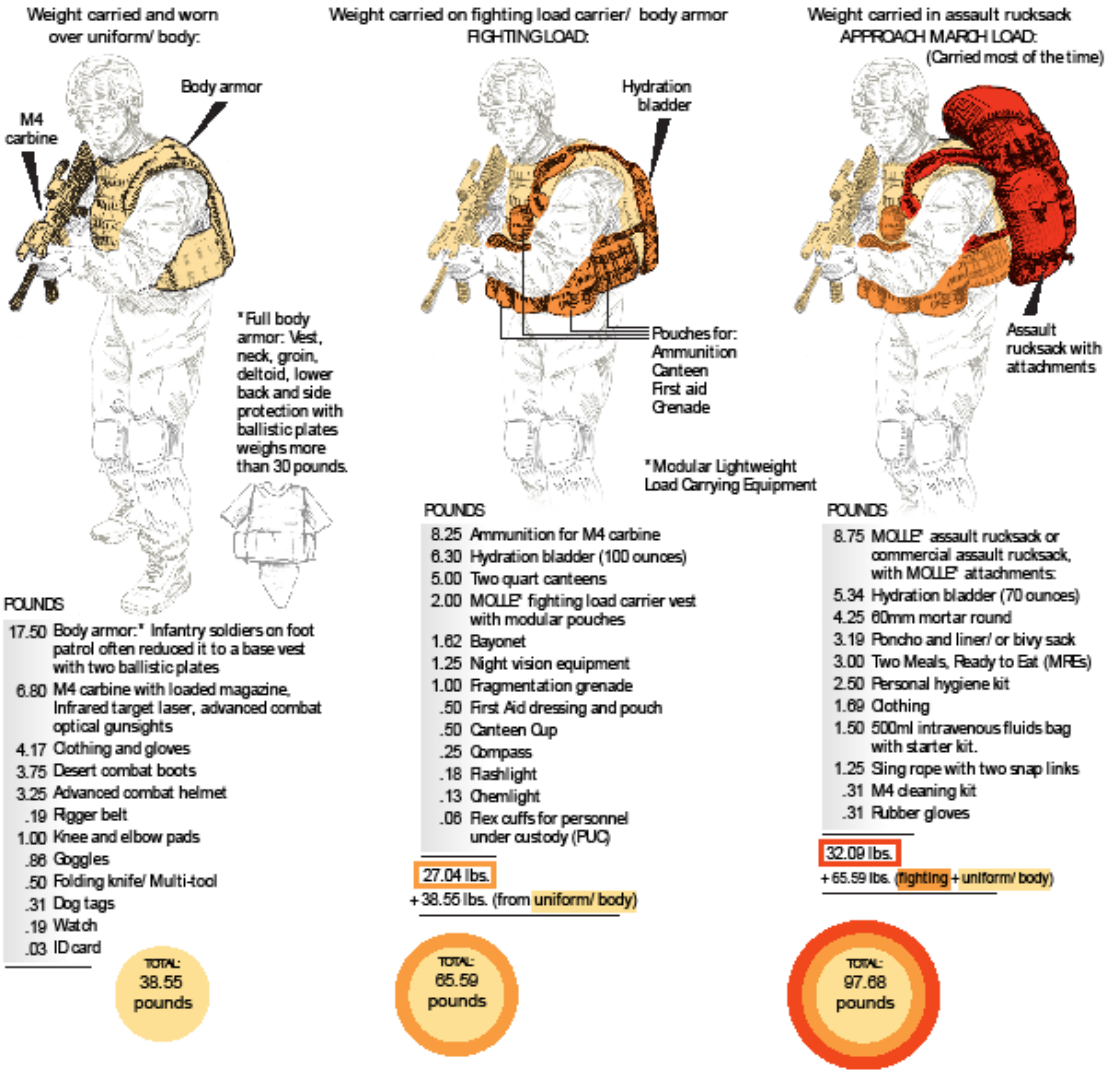


A New Dimension: the Informational Superiority



These diagrams have only an illustrative and not a demonstrative value. As far as mobility is concerned, the indices are calculated according to the above weight table and do not take into account motorization, as only the analysis of dismounted combat is considered. With regard to firepower, the indices are more subjective, as this term can only make sense after the invention of the firearm and as it is difficult to compare quantitatively the hoplite's firepower with that of today's soldier. However, when it comes to individual armament, the legionary who has at his disposal a ranged weapon is affected by a much larger coefficient than the hoplite and so on until the FELIN, affected by the highest criterion. The reasoning is similar for the informational superiority.

Equipment of a Soldier Today



Sources: "The Modern Warrior's Combat Load, Dismounted Operations in Afghanistan, April - May 2003" by U.S. Center for Army Lessons Learned; BAE systems; www.peosoldier.army.mil; "Lightening the Load," Naval Research Advisory Committee, Sept. 2007

Reporting by HAL BERNTON Graphic by MARK NOWLIN / THE SEATTLE TIMES

List of Acronyms

BFT	Blue Force Tracking
C4I	Command, Control, Computers, Communications and Intelligence
FELIN	Fantassin à Equipements et Liaisons Intégrés
ISSE	Integrated Soldier System Executive
MMI	Man- Machine Interface
MERS	Marine Expeditionary Rifle Squad
PDA	Personal Data Assistant
RIF	Réseau d'Information du Fantassin
SUDS	Send, Understand, Disseminate Intents, Synchronize
SWAP	Size, Weight And Power
VAB	Véhicule de l'Avant Blindé
VBCI	Véhicule Blindé de Combat d'Infanterie

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