

Original Study

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One hundred thirty years of armed conflict: Challenges and opportunities in technology adoption

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Abstract: This article aims to comprehend the processes of forecasting and adopting new technologies by the armies of modern states. In this regard, we studied the relevant literature regarding a series of wars where new technologies were widely implemented, ranging from the American Civil War to the Gulf War. The identification of successful and failed examples of forecasting and adoption has led us to identify certain timeless trends that persist despite the passing of years, technological evolutions and manners of conducting combat. These trends, which include the fact that individuals who make the most accurate forecasts often differ from those who influence the implementation of novel technologies, the importance of a high educational level within both military and social ecosystems for the emergence, recognition and effective implementation of technological innovations and the influence of political systems and military administrative structures, are presented in the conclusion of the article.

Keywords: history, war, forecasting, military technology, military innovation

1 Introduction

One of the greatest features that man has exhibited during his age-old quest to master his environment and thrive is his ability to adapt. For man's adaptive capacity to be successful, a combination of high perception (understanding the problem at hand), innovative imagination (envisioning possible solutions),

analytical ability (theoretical solution) and practical application (implementation of the theoretical solution) has always been required and ultimately led to the birth of new techniques and technologies. Thanks to them, man has managed to overcome many of the natural obstacles hindering most other species, while also bequeathing a unique cultural imprint on the planet.

The phenomenon of war, a problem that with today's technology could even prove to be existential, is one that humanity has yet to solve—and therefore still needs the ability to address. According to Carl Von Clausewitz's Theory on War, 'war is an act of violence, aiming to coercively impose one's will on their opponent', carried out by state bodies and dependent on the interaction between the government, the military forces and the people.¹ Clausewitz's views were significantly influenced by the form that war had taken during his time; he himself, faithful to the rational climate of the Enlightenment, attempted to identify the general principles that govern nature and the ideal way of conducting war, giving but little value to its history, except for very recent examples.² His work established him as one of the most influential theorists of war in history, yet he was only one of countless people throughout history who attempted to understand the phenomenon of war and identify the model that would lead to victory. Indeed, a plethora of politicians, military men, scientists and theorists of all kinds, as well as an equally large number of governmental and non-governmental organisations, have attempted to adapt to the data of each era in order to forecast new military technologies in a timely manner, integrate them into the armies and,

1 Ploumis, M. (2020). *Art of Warfare: The Art of War in the Course of History* (Πολεμική Τέχνη: Η τέχνη του πολέμου στη διαδρομή της ιστορίας). Eurasia, Athens, pp. 25-26.

2 Crevel, M. V. (2017). What War is All About. In: Bletas, M., (trans. & eds) *"The Transformation of War"* (Η μεταμόρφωση του Πολέμου). Touriki Editions, Athens, pp. 67-68.

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ultimately, find the right way to use them so as to achieve victory on behalf of the Governments of their states.

As part of this ongoing conversation, the RAND Corporation, one of the most distinguished think tanks in the US, focussing on defence, security and policy research, published a report in 1999, forecasting that the integration of the new technologies brought by what was then called the Revolution of Military Affairs (RMA) could lead to a radical transformation in the conduct of military operations.³ However, although the scientific methods of long-term forecasting used to predict the availability of military technologies were remarkably successful (76% of the 1990 forecasts regarding the availability of specific technologies, including those related to the RMA, were realised and had matured by 2018),⁴ the full adoption of these technologies was slow and often unsuccessful.⁵ This appears to be a recurring historical pattern. While technologies are ready and available in a timely manner, there are often challenges with their timely integration into the military forces, which in many cases has proven fatal for those who delayed their adoption and engaged in military conflicts.

The purpose of this research is to take part in this conversation, albeit from a different perspective. This research employs the methodologies of Literature Review and Historical Analysis for the study and organisation of existing historical literature. It also uses Comparative Analysis and Case Study Analysis to compare technological advancements and their adoption between different wars and nations and illustrate broader trends. Additionally, Theoretical Analysis and Content Analysis are applied to examine both theoretical frameworks and real-life decisions made by political and military leaders regarding the prediction and adoption of military technologies. Finally, the methodology of Trend Forecasting Analysis is used, based on these patterns, to conclude the possible future adoption of military technologies. In this way, the study aims to contribute to understanding the lag between the availability and adoption of new military technologies, an understanding based on military history that will be especially useful to future military and political leaders.

³ RAND Corporation. (1999). Strategic appraisal 1999. Available at: https://www.rand.org/pubs/monograph_reports/MR1029.html [accessed 28 August, 2024].

⁴ Kott, A., & Perconti, P. (2018). 'Long term forecasts of military technologies for a 20 – 30 years horizon: An empirical assessment of accuracy'. *Technological Forecasting and Social Change*, 137, pp. 272-279.

⁵ Grivas, K (2019). *The New Military Revolution and Greek Defense Strategy* (Η Νέα Στρατιωτική Επανάσταση και η Ελληνική Αμυντική Στρατηγική). Livanis, Athens, pp. 37-38.

However, if one were to consider the wars over the years that followed Clausewitz's death, one could quite comfortably agree with his view that only recent history is of essential importance for the study of war; so intense were the changes in conducting war, as brought about by the new technologies of the First and Second Industrial Revolutions. For this reason, the research period chosen for this study begins with the case of the American Civil War, the first war in history showcasing the use of their trademark technologies, namely the railway and telegraph, for military purposes. From then onwards, the rhythm of technological advancement sped up exponentially, constantly transforming the landscape in which policy decisions regarding war technology were made. Similarly, the coming of the Third Industrial Revolution marks yet another spike in the increasingly rapid rate of advancement, in the form of digitisation brought by the invention of the transistor and the microprocessors. The Gulf War, the first war in which the technologies of the Third Industrial Revolution were showcased, marks the end of the research period as the last major conflict within the conventional 30-year boundary that typically separates the study of history from contemporary events.

2 American Civil War (1861–1865)

In 1965, Everett Rogers developed the Diffusion of Innovations Theory, which describes the process where a population adopts a new idea or technology. The people involved in it are the Innovators (risk-takers who create and are the first to use the innovation), the Early Adopters (people interested in trying the innovation and establishing its utility in society), the Early Majority (part of the general population that first uses the innovation in mainstream society), the Late Majority (part of the general population that follows the Early Majority in using the innovation) and the Laggards (people who only start using the innovation when it becomes impossible to avoid). The process includes five steps, which are Awareness, Interest, Evaluation, Trial and Adoption. According to Rogers, important factors that affect the rate of innovation diffusion are the type of innovation, the proportion of rural to urban dwellers in the general populace, its educational level and the extent of the society's industrialisation.⁶

⁶ Halton, C. (2023). 'Diffusion of innovations theory'. *Investopedia*. Available at: <https://www.investopedia.com/terms/d/diffusion-of-innovations-theory.asp> [accessed 5 June, 2024].

Case in point, the difference in mentality and life-style between the residents of the Union and Confederate States, which played a pivotal role in how technology developed between the North and the South before the American Civil War and, by extension, in the degree to which it was introduced into respective troops. In the Union, the proportion of farmers was about 40% and rural dwellers about 25%; in the Confederation, the respective figures were over 80% and over 90%.⁷ The Union also had at its disposal the vast majority of industrial units, 110,000 compared to the South's 18,000.⁸ Finally, differences between the Union and Confederation also existed in the field of education, with 95% of the inhabitants of the former being able to read and write and this percentage falling to 80% for the Confederation.⁹ The greatest theorists of war in the US, having equally influenced the military officers of both armies,¹⁰ were Dennis Hart Mahan and Henry Halleck, who in turn were influenced by Henry Jomini and the general climate of conservatism and standardisation that he brought to the army.¹¹

Thus, at the beginning of the war, the Union had about 35,400 km of railway track compared to 14,500 of the Confederacy, with the former having proceeded to standardise these railway lines, so that every train could pass through every line, in contrast to the Confederate lines and trains, which were of differing sizes. In addition, the majority of the factories that produced the above materials and means were under the control of the Union. Let it be noted that the first sufficiently safe and fast (28.8 km/h) steam engine appeared in 1829¹² not without having met resistance and scorn by local communities. Just in 1825, it was even considered impossible for it to exceed the speed of

16 km/h.¹³ A similar situation occurred with the telegraph: while the Union used it to its full potential, even creating a special corps in 1861 that employed about 1,200 people and laid some 4,000 miles of cable, the Confederacy simply did not have the necessary know-how and industrial foundations to exploit it.¹⁴ Finally, regarding purely military technologies, such as developments in rifles or ironclad ships, these appeared first, or even exclusively, in the Union army.

However, although the increased industrialisation of the Northern States led to this difference in available military technology, the level of integration of this technology into pre-existing military structures was insufficient, thus mitigating the advantage it could bring. The reduced integration appears to have emanated from a combination of bad political decisions,¹⁵ lack of adequate organisation and the military doctrine's failure to adapt to new technologies.¹⁶ Although in the 1860s the West was already at the dawn of the Second Industrial Revolution, the mind-sets of political and military leaders and the population of modern states had not yet adapted to this pace. At the same time, states did not yet have the practical ability to influence their fledgling industries to respond to the needs quickly enough arising during a war. Consequently, their armies could only use the technologies that resulted from the actions of individual inventors and other pioneers before each war started.

7 Keegan, J. (2010). *The American Civil War*. Vintage, London, p. 5.

8 Grimsley, M. (2001). 'Survival through military revolution: The American Civil War' (Επιβίωση Διά της Στρατιωτικής Επανάστασης: Ο Αμερικάνικος Εμφύλιος Πόλεμος). In: MacGregor, K., & Williamson, M. (eds.), *Revolution in Military Affairs: An Anatomy of its Dynamic, 1300-2050 (Η Επανάσταση στις Στρατιωτικές Υποθέσεις: Ανατομία της Δυναμικής της, 1300 – 2050)*. Touriki Editions, Athens, p. 127.

9 Keegan, J. (2010). *The American Civil War*. Vintage, London, p. 11.

10 Hagerman, E. (1988). *The American Civil War and the Origins of Modern Warfare: Ideas, Organization and Field Command*. Indiana University Press, Indiana, pp. 7-8, 14.

11 Hagerman, E. (1988). *The American Civil War and the Origins of Modern Warfare: Ideas, Organization and Field Command*. Indiana University Press, Indiana, pp. 4-5.

12 Lindemann, A. S. (2014). The Engines of Change. In: Christidis, G. (trans.) & Michailidis, I. D., (ed.) *A History of Modern Europe: From 1815 to the Present* ('Ιστορία της Νεότερης Ευρώπης: Από το 1815 μέχρι σήμερα'). Critic, Athens, p. 98.

13 Kott, A. (2019). 'The future of war technology whispers to us from the past, and we must listen better'. *warontherocks.com*. Available at: <https://warontherocks.com/2019/12/the-future-of-war-technology-whispers-to-us-from-the-past-and-we-must-listen-better/> [accessed 25 June, 2021].

14 History.Com Editors. (2018). 'Civil war technology'. *History.com*. Available at: <https://www.history.com/topics/american-civil-war/civil-war-technology> [accessed 18 February, 2022].

15 Grimsley, M. (2001). 'Survival through military revolution: The American Civil War' (Επιβίωση Διά της Στρατιωτικής Επανάστασης: Ο Αμερικάνικος Εμφύλιος Πόλεμος). In: MacGregor, K., & Williamson, M. (eds.), *Revolution in Military Affairs: An Anatomy of its Dynamic, 1300-2050 (Η Επανάσταση στις Στρατιωτικές Υποθέσεις: Ανατομία της Δυναμικής της, 1300 – 2050)*. Touriki Editions, Athens, pp. 121-125.

16 Grimsley, M. (2001). 'Survival through military revolution: The American Civil War' (Επιβίωση Διά της Στρατιωτικής Επανάστασης: Ο Αμερικάνικος Εμφύλιος Πόλεμος). In: MacGregor, K., & Williamson, M. (eds.), *Revolution in Military Affairs: An Anatomy of its Dynamic, 1300-2050 (Η Επανάσταση στις Στρατιωτικές Υποθέσεις: Ανατομία της Δυναμικής της, 1300 – 2050)*. Touriki Editions, Athens, pp. 115-116.

3 The Franco-Prussian War (1870–1871)

The significance of the Union's inadequate integration of new technologies during the American Civil War becomes even more apparent in the study of the example of the Franco-Prussian War. More specifically, the advantage of the longest and most standardised railway network belonged to France,¹⁷ which had managed to expand its railway network from 3,200 km in 1851 to 17,000 km in 1870. On the contrary, Prussia had only 8,000 km¹⁸ of non-standard railway lines but had a long tradition of military exercises, as well as the opportunity to use the railway in actual war conditions, notably during the Seven Weeks War.¹⁹ Generally speaking, Prussia was more industrialised than its adversary, dominating various fields such as iron and lignite production. Moreover, its population in 1866 had reached 19,000,000, with its economic power extending to the 20,000,000 inhabitants of the German States, with which Prussia had entered into a sort of customs union. The corresponding population of France was of course significantly larger, reaching 35,000,000.²⁰

Upon the outbreak of the war, the differences in the integration of the various technologies became evident: France was unable to take advantage of the size of its population and the superiority of its railways, thus managing to amass a total force of 400,000 men against the 1,200,000 which the Prussians were able to raise thanks to their superior conscription system.²¹ This system was based on a combination of state measures and familiarisation with the new technologies of the telegraph (which reduced the time of notification for conscription from 5 days to 1 day) and the railway (which reduced the time for mustering troops from 30 days to 20 days) which the

latter possessed.²² Adaptation to these technologies was more decisive for the war's outcome than adaptation to the weapons systems themselves, of course, without diminishing the latter's importance.

The French, alarmed by the apparent superiority of the breech-loading Dreyse rifle used by the Prussians over the front-loading Austrian rifles in the Seven Weeks War, had converted all their guns to breech-loading, while equipping their Infantry (INF) with the French Chassepot as early as 1866, a weapon far superior to its Prussian counterpart.²³ The Prussians had taken care to apply the most modern technical improvements in the field of Artillery (AR) and managed to use it in a way that exploited the shortcomings of the French counterpart.²⁴ Finally, during the siege of Paris, which ended the war, the city's scientific communities attempted to break it or extend it through the use of technology, whether in the field of electrical power²⁵ or in the fields of explosives, communications and finding food.²⁶ As in the American Civil War, however, these developments were not implemented broadly, nor in a timely manner. So who were the people who actually did contribute to winning the war with their forecasts?

The most decisive role was played by the Prussian Prime Minister and later the Chancellor of the North German Confederation Otto Von Bismarck (1815–1898), who was the architect of Prussian policy in the years leading up to the said war. Bismarck strengthened financially the army despite the reactions of parliamentarians, respecting the principles of Realpolitik, which advocated the strengthening of military state power and the rejection of the application of moral rules between states,^{27,28}

17 Creveld, M. V. (2001a). When demigods rode rails. In: Tsimogianni, M., (trans.) & Bletas, M., (ed.) *'Supplying War: Logistics from Wallenstein to Patton'* (Επιμελητεία και Πόλεμος). Touriki Editions, Athens, p. 114.

18 Wawro, G. (2003). *The Franco-Prussian War: The German Conquest of France in 1870 – 1871*. Cambridge University Press, Cambridge, pp. 1-3.

19 Showalter, D. E. (2001). 'The Prussian-German Revolution in military affairs, 1840-1871' (Η Πρωσο-Γερμανική Επανάσταση στις Στρατιωτικές Υποθέσεις, 1840 – 1871). In: Knox, μ., & Williamson, M. (eds.), *Revolution in Military Affairs: An Anatomy of its Dynamic, 1300–2050* (Η Επανάσταση στις Στρατιωτικές Υποθέσεις: Ανατομία της Δυναμικής της, 1300–2050). Touriki Editions, Athens, pp. 150-153.

20 Cf. 18.

21 Wawro, G. (2003). *The Franco-Prussian War: The German Conquest of France in 1870 – 1871*. Cambridge University Press, Cambridge, pp. 41-43.

22 Showalter, D. E. (2001). 'The Prussian-German Revolution in military affairs, 1840-1871' (Η Πρωσο-Γερμανική Επανάσταση στις Στρατιωτικές Υποθέσεις, 1840 – 1871). In: Knox, μ., & Williamson, M. (eds.), *Revolution in Military Affairs: An Anatomy of its Dynamic, 1300–2050* (Η Επανάσταση στις Στρατιωτικές Υποθέσεις: Ανατομία της Δυναμικής της, 1300–2050). Touriki Editions, Athens, pp. 153-154.

23 Parathyras, K. N. (2017). *'Machine Guns: Historical Evolution and Function'* (Τα Πυροβόλα Όπλα: Ιστορική Εξέλιξη και Λειτουργία). Editions ΑΩ, Kalyvia, pp. 63-64.

24 Gudmundsson, B. I. (1993). *'On Artillery'*. Praeger Publishers, Westport, pp. 1-2.

25 Gorman, M. (1977). 'Electric illumination in the Franco-Prussian War'. *Social Studies of Science*, 7(4), pp. 525-527.

26 Crossland, M. (1976) 'Science and the Franco-Prussian War'. *Social Studies of Science*, 6(2), pp. 198-205.

27 Wawro, G. (2003). *The Franco-Prussian War: The German Conquest of France in 1870 – 1871*. Cambridge University Press, Cambridge, p. 14.

28 Lindemann, A. S. (2014). Nationalism and National Unification. In: Christidis, G. (trans.) & Michailidis, I. D., (ed.) *'A History of Modern Europe: From 1815 to the Present'* (Ιστορία της Νεότερης Ευρώπης: Από το 1815 μέχρι σήμερα). Critic, Athens, p. 163.

and paved the way for like-minded people to bring about important changes in the same direction. Among them were Minister of War Albrecht Von Roon (1803–1879), who was largely responsible for increasing the quantity and quality of men in the Prussian Army through the new system of conscription and training that he devised,²⁹ and General Helmuth Von Moltke the Elder (1800–1891). Following in the footsteps of earlier railway champions such as the German industrialist Friedrich Harkort (1793–1880) and the Prussian banker and subsequently Prime Minister (1848) Ludolf Camphausen (1803–1890), he successfully integrated it into Prussian military doctrine through drills and real combat encounters, while he also claimed the innovation of finding an essential role for the institution of the General Staff.³⁰ The difference with the system of France which could not make use of the size of its people, let alone bring them into the field and properly utilise them,³¹ became evident on the battlefield technologies.³²

4 The Russian–Japanese War (1904–1905)

The Prussian Land Army (LA) provided the model for the first non-European army that managed to impose itself on a European one, specifically that of Japan. Accordingly, its War Navy (WN) was modelled after the British one, as during previous years the Japanese had sent military observers to those two countries, as well as to France.³³ In general, the Empire of Japan was technologically underdeveloped compared to the states of Europe and the USA, as, due to its extreme isolation, it had had little contact

with them for a number of centuries.³⁴ In addition, it maintained several outdated institutions, such as the feudal system of administration and the institution of the Samurai. It took a series of defeats by Russia for a special bureau to be established in 1811, in order to study Russian culture,³⁵ and a corresponding series of defeats against the US Navy from 1853 onwards, in order for these institutions to be disassembled.³⁶

As for the Russian Empire on the other hand, the Russian Empire belonged to the Great Powers of Europe and at the beginning of the 19th century it was considered one of the most ambitious and dangerous, but it found itself lagging behind the rest at the beginning of the 20th century. Its vastness and population heterogeneity, combined with the low standard of living of its citizens and the lack of basic rights enjoyed by citizens of the other Great Powers, led to a persistent climate of political instability.³⁷ From 1871 onwards, Russia followed the European trend towards industrialisation, with the monetary value of industrial production increasing during the period 1871–1914 by 330%. Its army, respectively, reached 3,900,000 men,³⁸ while it is estimated that it could have reached 4,500,000 men in 1904, had the conscription system not been so inefficient.³⁹ But it was insufficient, and so the Russians fielded an approximately equal army of 1,300,000 men against the 1,200,000 Japanese troops.⁴⁰ Also, their supply lines, long and reliant on the railway, were much more difficult to use than those of their opponents.⁴¹

29 Showalter, D. E. (2001). 'The Prussian-German Revolution in military affairs, 1840-1871' (Η Πρωσο-Γερμανική Επανάσταση στις Στρατιωτικές Υποθέσεις, 1840 – 1871). In: Knox, μ, & Williamson, M. (eds.), *Revolution in Military Affairs: An Anatomy of its Dynamic, 1300–2050* (Η Επανάσταση στις Στρατιωτικές Υποθέσεις: Ανατομία της Δυναμικής της, 1300–2050). Touriki Editions, Athens, pp. 158-160.

30 Cf. 19.

31 Showalter, D. E. (2001). 'The Prussian-German Revolution in military affairs, 1840-1871' (Η Πρωσο-Γερμανική Επανάσταση στις Στρατιωτικές Υποθέσεις, 1840 – 1871). In: Knox, μ, & Williamson, M. (eds.), *Revolution in Military Affairs: An Anatomy of its Dynamic, 1300–2050* (Η Επανάσταση στις Στρατιωτικές Υποθέσεις: Ανατομία της Δυναμικής της, 1300–2050). Touriki Editions, Athens, p. 141.

32 Fordred, L. L. (1997). 'Wireless in the second anglo-boer war 1899–1902'. *Transactions of the South African Institute of Electrical Engineers*, 88(3), p. 62.

33 Kirk, G. W. (1999). 'An Analysis of the Russo-Japanese War: Implications for Modern Warfighters'. U. S. Army War College, Pennsylvania, pp. 3-4.

34 Auslin, M.R., (2005). Japanese Strategy, Geopolitics and The Origins of The War, 1792–1895. In: Steinberg, J.W., Menning, B.W., Van Der Oye, D.S., Wolff, D., and Yokote, S. 'The Russo-Japanese War in Global Perspective: World War Zero'. Brill, Leiden, pp. 4-5

35 Auslin, M.R., (2005). Japanese Strategy, Geopolitics and The Origins of The War, 1792–1895. In: Steinberg, J.W., Menning, B.W., Van Der Oye, D.S., Wolff, D., and Yokote, S. 'The Russo-Japanese War in Global Perspective: World War Zero'. Brill, Leiden, pp. 8-9.

36 Cf. 33.

37 Lindemann, A. S. (2014). Mid-century Consolidation, Modernization: Austria, Russia, France. In: Christidis, G. (trans.) & Michailidis, I. D., (ed.) 'A History of Modern Europe: From 1815 to the Present' (Ιστορία της Νεότερης Ευρώπης: Από το 1815 μέχρι σήμερα). Critic, Athens, p. 174-175.

38 Creveld, M. V. (2001b). The Timetable War. In: Tsimogianni, M. (trans.) & Bletas, M. (ed.) 'Command in War' (Η διοίκηση στον πόλεμο). Touriki Editions, Athens, p. 176.

39 Kirk, G. W. (1999). 'An Analysis of the Russo-Japanese War: Implications for Modern Warfighters'. U. S. Army War College, Pennsylvania, p. 11.

40 Margaritis, G. (2014). 'Flow and Ebb, The European 20th century, First Part: From colonization to Nazi New Europe (1873-1942)'. (Πλημμυρίδα και Αμπωτη, Ο Ευρωπαϊκός 20ός αιώνας, Μέρος Πρώτο: Από τον αποικισμό στη ναζιστική Νέα Ευρώπη (1873-1942)). Athens: Vivliorama, p. 96.

41 Cf. 39.

Not delving into the war outcome, we can draw some conclusions about the forecasting and integration of military technologies into the two armies based on how the war was fought. Firstly, the Russian Empire, albeit at a lower level than the rest of the European Great Powers, was an industrialised country. Taking into account its size difference from Japan, the Russian empire could replace losses in personnel and materiel to a much greater extent than its rival – a reality which played a decisive role in naval operations. Indeed, although the Japanese had incorporated the latest technological developments into their vessels, they lacked the capacity to replace them, attempting to solve the difficult problem of reducing losses without surrendering maritime supremacy.⁴² In the same field, the forecasts of both adversaries were proved wrong regarding developments in torpedoes, which were far less effective than the much older technology of sea mines; the latter causing far more casualties while being more cost-effective.⁴³

On land, it seemed that the Russians had the advantage: both their cannons and rifles were more numerous and technologically superior, and their position as defenders was excellently combined with the now extensive machine gun technology. However, the Japanese AR had a superior understanding of its role in general, as well as the ideal way to use its equipment.⁴⁴ At the same time, the Japanese INF's personal equipment was technologically inferior to that of the Russians, who at that time had at their disposal the Mosin-Nagant 1891 rifle, the best in Europe,⁴⁵ and they did not seem to know how to deal with the Russian machine guns even though they themselves had this equipment (and in fact more modern versions); this resulted in massive casualties from their bullets.⁴⁶ Finally, this war saw, from the Russian side, the restoration of the older technology in an improved form: it was the grenade, which was even improved during the war

by Russian scientists based on the defects that appeared during its use in various battles.⁴⁷

5 World War I (WWI, 1914–1918)

The aforementioned phenomenon of technological advancement during the war constituted the norm in WWI and in every major war that ensued. Corrections of this kind came mainly from the more industrialised nations. Indeed, in many cases, the belligerents not only adapted technological developments to their troops but also directed technological developments themselves in order to solve battlefield problems. The most typical example is the attempts to break up the Western Front, which led, among other things, to the development of the armoured tank,^{48,49} the widespread use of aircraft and parachutes to carry out raids⁵⁰ and the development and use of chemical weapons.^{51,52} Another example is represented by the Germans' attempts to cut off England's supply by using submarines.

Many times, in fact, the weapons systems themselves were improved during the war. At the end of the war, planes carried machine guns and radios, which they initially lacked, while they had doubled their speed,⁵³ and the use of parachutes led to an increase in the survivability of the pilots.⁵⁴ Numbers and performance

⁴² Kirk, G. W. (1999). 'An Analysis of the Russo-Japanese War: Implications for Modern Warfighters'. U. S. Army War College, Pennsylvania, pp. 12, 16.

⁴³ Dunley, R. (2018). 'Britain and the Mine, 1900–1915: Culture, Strategy and International Law'. Springer International Publishing, London, p. 45.

⁴⁴ Gudmundsson, B. I. (1993). 'On Artillery'. Praeger Publishers, Westport, pp. 17–20.

⁴⁵ Parathyras, K. N. (2017). 'Machine Guns: Historical Evolution and Function' (Τα Πυροβόλα Όπλα: Ιστορική Εξέλιξη και Λειτουργία). Editions ΑΩ, Kalyvia, pp. 102–103, 105.

⁴⁶ Kirk, G. W. (1999). 'An Analysis of the Russo-Japanese War: Implications for Modern Warfighters'. U. S. Army War College, Pennsylvania, pp. 25–30.

⁴⁷ Bortnovski, A. (2009). 'Hand grenades in the Russo-Japanese War'. *Royal United Service Institution*, 54(389), pp. 918–919.

⁴⁸ Stratigikes Ekdoseis. (2005). *Concise World Military Naval Aviation Encyclopedia – Under the Auspices of the Ministry of National Defence* (Επίτομη Παγκόσμια Στρατιωτική Ναυτική Αεροπορική Εγκυκλοπαίδεια–Υπό την Αιγίδα του Υπουργείου Εθνικής Αμύνης). Stratigikes Ekdoseis, Athens, pp. 882–883.

⁴⁹ Foley, M. (2014). *Rise of the Tank: Armoured Vehicles and Their Use in the First World War*. Pen & Sword Military, Barnsley, p. 74.

⁵⁰ Ripley, T. (2005). Wars in the Industrial Age. In: Tsoukalas, D. (trans.) & Giannopoulos, T. H. (ed.) 'Development of Science and Technology: Guns' (Εξέλιξη των επιστημών και της τεχνολογίας: Όπλα). Savvalas, Athens, p. 35.

⁵¹ Wilson, T., & Prior, R. (2001). Conflict, technology and the impact of industrialization: The Great War 1914 – 1918. *The Journal of Strategic Studies*, 24(3), p. 151.

⁵² Lekkas, A. (2022). 'The use of chemical gases in the WWI which led to their prohibition' (Η Χρήση Χημικών Αερίων στον Α' ΠΠ που Επέφερε την Απαγόρευσή τους), *slpress.gr*. Available at: <https://www.ptisidiastima.com/use-of-gas-in-ww1/> [accessed 31 May, 2022].

⁵³ Hacker, C. B., (2005). 'The Machines of War: Western Military Technology 1850–2000'. *History and Technology*, 21(3), p. 259.

⁵⁴ Theotokis, N. (2020). 'Airborne Landing to Air Assault: A History of Military Parachuting'. Pen & Sword Military, South Yorkshire, pp. 1–4.

also increased in the case of submarines,^{55,56} trucks and tanks,^{57,58,59} while this was also the case with the quantity and lethality of chemical gases.⁶⁰ All of the new improvements and inventions took place in the context of a wider industrial war, aided by the recent invention of electricity and the discovery and use of oil, with production units coming under the direct control of governments, each of which focussed on the areas it deemed most essential.⁶¹ A series of radical inventions, such as electric generators, the telephone, the electric light bulb, internal combustion engines, cement (which changed building processes worldwide) and steel (which offered seemingly limitless applications,⁶² including the production of more advanced military equipment), accelerated the entire process.

As in the wars already studied, WWI was conducted on the basis of the ideas of the high-ranking military, with the General Staff and the Ministers of Defence considered to be the ultimate authorities on matters of war and able to influence a multitude of critical political and military decisions.⁶³ At the same time, existing academic institutions and private bodies had virtually no influence in the field of warfare; even when their

members could indeed forecast the outcome of the battles of WWI, these forecasts were ignored in the same way that the lessons of the Russian-Japanese War had been ignored, when these lessons disagreed with existing ideologies.

These ideologies viewed the Franco-Prussian War model as the only modern and reliable one, even though technology had evolved dramatically since then. Due to the semantic and inherent coupling between the concepts of disaster and security, which creates a dichotomy between a safe situation and a dangerous situation and undermines the ability to create a continuous line between the two⁶⁴ the successes of the Prussian army in that war hindered the advent of change, even when clearly needed. Characteristically, the vulnerability of the Cavalry weapon to the new rifles and machine guns and the impossibility of taking a fortified position – especially if it had machine guns – from an INF raid were completely ignored even though they were established realities, while forecasts about the increased duration of the war or recommendations for the importance of operational strategy in the Navy branch suffered the same fate.⁶⁵

At the same time, certain aspects of the war could not be forecast; instead, they appeared as done facts. Some of the most important examples are the degeneration of the Western Front into a static ‘trench war’ (because of low-cost and low-tech technologies),⁶⁶ the difficulty of exploiting tactical successes in attack and defence due to the interaction of the means of communication with the difficult conditions at the front^{67,68} and the preservation of the physiognomy of naval battles in the form they had a century ago, despite improvements in communications, speed, fuel, armour, range of guns and in general other

55 Wilson, T., & Prior, R. (2001). Conflict, technology and the impact of industrialization: The Great War 1914 – 1918. *The Journal of Strategic Studies*, 24(3), pp. 132-134.

56 Sumida, J. T (2006). The royal navy and technological change, 1815–1945. In: Haycock, R., & Neilson, K. (eds.), *Men, Machines, and War*. Wilfrid Laurier University Press, Waterloo, p. 87.

57 Foley, M., (2014). “*Rise of the Tank: Armoured Vehicles and Their Use in the First World War*”. Barnsley: Pen & Sword Military, p. 70.

58 Margaritis, G. (2014). ‘*Flow and Ebb, The European 20th Century, First Part: From colonization to Nazi New Europe ((1873-1942))*’. (Πλημμυρίδα και Αμπωτη, Ο Ευρωπαϊκός 20ός αιώνας, μέρος Πρώτο: Από τον αποικισμό στη ναζιστική Νέα Ευρώπη (1873-1942). Vivliorama, Athens, p. 171.

59 Creveld, M. V. (2010). Prelude, 1900-14. In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) ‘*The Changing Face of War: Combat from the Marne to Iraq*’ (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ). Govostis Editions S.A, Athens, p. 2-30.

60 Cf. 51.

61 Wilson, T., & Prior, R. (2001). Conflict, technology and the impact of industrialization: The Great War 1914 – 1918. *The Journal of Strategic Studies*, 24(3), pp. 153-154.

62 Margaritis, G. (2014). ‘*Flow and Ebb, The European 20th Century, First Part: From colonization to Nazi New Europe ((1873-1942))*’. (Πλημμυρίδα και Αμπωτη, Ο Ευρωπαϊκός 20ός αιώνας, μέρος Πρώτο: Από τον αποικισμό στη ναζιστική Νέα Ευρώπη (1873-1942). Vivliorama, Athens, p. 55.

63 Margaritis, G. (2014). ‘*Flow and Ebb, The European 20th Century, First Part: From colonization to Nazi New Europe ((1873-1942))*’. (Πλημμυρίδα και Αμπωτη, Ο Ευρωπαϊκός 20ός αιώνας, μέρος Πρώτο: Από τον αποικισμό στη ναζιστική Νέα Ευρώπη (1873-1942). Vivliorama, Athens, p. 156.

64 Rabinow, P. (2003). ‘*Anthropos Today: Reflections on Modern Equipment*’, Princeton University Press, Princeton, p. 45.

65 Creveld, M. V. (2010). Prelude, 1900-14. In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) ‘*The Changing Face of War: Combat from the Marne to Iraq*’ (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ). Govostis Editions S.A, Athens, pp. 25-30.

66 Wilson, T., & Prior, R. (2001). Conflict, technology and the impact of industrialization: The Great War 1914–1918. *The Journal of Strategic Studies*, 24(3), pp. 150-151.

67 Wilson, T., & Prior, R. (2001). Conflict, technology and the impact of industrialization: The Great War 1914–1918. *The Journal of Strategic Studies*, 24(3), p. 148.

68 Creveld, M. V. (2010). Prelude, 1900-14. In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) ‘*The Changing Face of War: Combat from the Marne to Iraq*’ (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ). Govostis Editions S.A, Athens, p. 22.

naval weapons and systems.^{69,70,71} A noteworthy point is the fact that many of these conditions were created because of the aforementioned narrow-mindedness in the perception of military hierarchy. This is also demonstrated by the fact that their resolution came about after changes in the doctrines of war and not because of some new, revolutionary technology, even though the solution was primarily sought in that field.⁷² Who, then, were the people who exercised this influence, and to what extent had the belligerents adapted their doctrines to the new technologies?

As regards Germany, the military men Alfred Schlieffen (1833–1913), Paul von Hindenburg (1847–1934) and Erich Ludendorff (1865–1937) are among the most typical cases. Schlieffen and Hindenburg were veterans of the Seven Weeks War and the Franco-Prussian War. The former was the architect of the German plan of operations for the war and the latter was the associate of both Schlieffen himself and Moltke the Elder on the General Staff. Ludendorff, finally, was a younger officer, but one well-trained in the use of ‘command by mission’, a pioneering method of command that emphasised initiative down to the soldier level. In collaboration with Hindenburg, he had participated in the victories on the Eastern Front and the most successful operations on the West.⁷³ Generally speaking, Germany had been particularly successful in implementing technologies at the tactical level, while often outperforming its rivals in implementing them at the operational level as well. However, errors such as the emphasis of industrial activity on the territorial control of the Eastern Front and the construction of new factories instead of the effort on the Western Front brought to light anachronistic trends and gaps in the leadership’s understanding of the war.⁷⁴

Germany’s main rival on the Western Front, France, was also traditional in its methods. Of course, Ferdinand Foch (1851–1923) and Philippe Petain (1856–1951), both professors at the Supreme Military Academy, each established their success during WWI, while often using the new technologies with relative effectiveness. Still, their rigid adherence to the strict observance of orders and plans cost them losses in personnel and material, and if had their replenishment capacity not been so strong, it would likely have cost them the war.⁷⁵

Finally, England’s war mentality was influenced by Admiral John Fisher (1841–1920), who, as First Lord of the British Admiralty from the beginning of the century, succeeded in modernising Economic Warfare, combining the traditional British practice of naval blockade with targeting the German economy and industry through the control of world trade, banning credit from banking institutions and other economic methods – he even cooperated with political bodies, which was a rare event at that time.⁷⁶ This approach was fitting for a country that until recently was considered to be the planet’s only superpower, with a robust, industrialised economy and a military that controlled about a quarter of the world’s global population and land area and was indeed way more sophisticated than the one it had taken during the Second Boer War (1899–1902), during which it had suffered the loss of 20,000 men out of the 400,000 it sent in total,⁷⁷ due to a combination of overconfidence after triumphing over a number of non-European armies with characteristic ease⁷⁸ and obsolete operational and tactical strategies (the pattern of the combats was the same as the two distinct phase model that had been followed during the Franco-Prussian War,⁷⁹ while the INF itself used dense order formations, as if there had been no developments in military technology⁸⁰).

69 Creveld, M. V. (2010). Prelude, 1900–14. In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) *‘The Changing Face of War: Combat from the Marne to Iraq’* (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ). Govostis Editions S.A, Athens, pp. 22–24.

70 Lautenschläger, K. (1986). ‘The submarine in naval warfare, 1901–2001’. *International Security*, 11(3), p. 103, 112, 114.

71 Sumida, J. T. (2006). The royal navy and technological change, 1815–1945. In: Haycock, R., & Neilson, K. (eds.), *Men, Machines, and War*. Wilfrid Laurier University Press, Waterloo, p. 87.

72 Shimshoni, J. (1990). ‘Technology, military advantage, and World War I: A case for military entrepreneurship’. *International Security*, 15(3), pp. 195–196, 203–204.

73 (2005). *Concise World Military Naval Aviation Encyclopedia – Under the Auspices of the Ministry of National Defence* (Επίτομη Παγκόσμια Στρατιωτική Ναυτική Αεροπορική Εγκυκλοπαίδεια–Υπό την Αιγίδα του Υπουργείου Εθνικής Αμύνης). Stratigikes Ekdoseis, Athens, pp. 1208, 1659, 1894–1895.

74 Cf. 61.

75 (2005). *Concise World Military Naval Aviation Encyclopedia – Under the Auspices of the Ministry of National Defence* (Επίτομη Παγκόσμια Στρατιωτική Ναυτική Αεροπορική Εγκυκλοπαίδεια–Υπό την Αιγίδα του Υπουργείου Εθνικής Αμύνης). Stratigikes Ekdoseis, Athens, pp. 1515, 1872–1873.

76 Staboulis, P. (2021). Hybrid conflicts in the past to 2006’ (Υβριδικές Συγκρούσεις στο Παρελθόν ως το 2006). In: Hellenic Institute for Strategic Studies (eds) *‘Hybrid Wars’* (Υβριδικοί Πόλεμοι). Infognomon Editions, Athens, pp. 100–101.

77 Lindemann, A. S. (2014). France and Britain in the Belle Epoque: 1890–1914. In: Christidis, G. (trans.) & Michailidis, I. D., (ed.) *‘A History of Modern Europe: From 1815 to the Present’* (Ιστορία της Νεότερης Ευρώπης: Από το 1815 μέχρι σήμερα). Critic, Athens, p. 257.

78 Manning, S. (2020). *‘Bayonet to Barrage: Weaponry on the Victorian Battlefield’*. Pen & Sword Military, Yorkshire, England, pp. 1,4–5.

79 Gudmundsson, B. I. (1993). *On Artillery*. Praeger Publishers, Westport, pp. 3, 5.

80 Cf. 32.

6 World War II (WWII, 1939–1945)

By the end of the Great War, of course, cooperation between the military and civilian actors had become the norm, as nations began for the first time to search themselves for the next innovative military technology that could give them the edge in future wars. The experience of the previous war had demonstrated that it was possible for research and production at the state level to create those weapons systems that could grant a significant advantage to the forces that possessed them.^{81,82} Thus, money and resources were invested in their research and development, not in the hands of individual inventors but in organisations, often state-controlled and dedicated exclusively to the specific purpose.⁸³ The technology, however, that captivated a multitude of visionaries (mainly military but, by that time, also a significant portion of scientists) was that of the internal combustion engine and its capabilities, both on land as well as in the air and at sea, with the first two areas becoming testing grounds for new war doctrines.

The reaction of the various states towards these two technologies was typical of their general attitude before WWII. France, for instance, which had taken the lead along with England, in the field of armoured vehicles, and because of the deterring foreign policy it exercised towards Germany, created tanks technologically equal to those of the Germans, while the country possessed a decent number of aircraft, even if they were obsolete. However, demographic and economic difficulties, combined with an antiquated military doctrine, had effectively rendered the French air force useless and had deprived its tank force of its greatest asset, namely speed.^{84,85}

England, for her part, had completely lost her advantage in the field of armoured vehicles, because of her aversion to war doctrines that involved sending troops to continental Europe – an outgrowth of their policy of appeasement towards Germany. On the contrary, the majority of their defence expenditure up to 1938 was directed towards the Navy to protect their overseas installations,

and in addition to the creation of a modern bomber force, as both in England and in the US, the perception prevailed that the real role of the newly formed branch of the Air Force was to bomb enemy cities to destroy their industrial production and demoralise their citizens.^{86,87}

The USA on the other hand, despite having similar perceptions to those of England, had the economic and technological ability not only to completely discredit the LA without fearing that they would be unable to catch up with developments (one, in fact, of the reasons they did not create armoured vehicles after WWI was the excessive number of new tanks proposed by various inventors), but also to lead the way in the fields that had awakened their interest, namely bomber aircraft and the Navy. However, their turn to isolationism after the end of WWI was also reflected in their doctrine; there was no common naval or air doctrine with England in the event of a new war in Europe, which made cooperation between them difficult at the onset of the war.⁸⁸

In any case, all the developed countries that were to be involved in the war aimed to avoid a long-term war of attrition and it was precisely with this rationale in mind that they directed their research and formulated war doctrines. Particularly influential in shaping the notion that such a thing was possible was the Italian General Giulio Douhet (1869–1930), who argued that defence would continue to be favoured over offence and therefore, the solution to the problem lay in aerial bombardment, initially of airforce installations and then in the enemy's population and industrial base with a combination of explosive and chemical bombs.⁸⁹ Against the view that defence would still prevail were John Fuller (1878–1976) (former Chief of Staff of the British Army Corps) and Basil Liddell Hart (1895–1970) (historian and WWI officer), who saw the armoured battle tank as the vehicle that, thanks to its speed, armour and firepower, could lead to decisive victories that would soon end the war.⁹⁰ The same opinion was

⁸¹ Cf. 53.

⁸² Richardson, J. (2002). *War, Science and Terrorism: From Laboratory to Open Conflict*. Routledge, London, p. 78.

⁸³ Creveld, M. V. (2010). World War II, 1939–1945. In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) *'The Changing Face of War: Combat from the Marne to Iraq'* (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ). Govostis Editions S.A, Athens, pp. 185–186, 24.

⁸⁴ Creveld, M. V. (2010). The Twenty Years' Truce. In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) *'The Changing Face of War: Combat from the Marne to Iraq'* (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ). Govostis Editions S.A, Athens, pp. 123–125, 137–138, 152.

⁸⁵ Searle, A. (2017). *Armoured Warfare: A Military, Political and Global History*. Bloomsbury Academic, London, p. 46.

⁸⁶ Johnston-White, I. E. (2019). The Dominions and British Maritime Power in the Second World War. In: Faulkner, M., & Patalano, A. (eds.), *The Sea and the Second World War: Maritime Aspects of a Global Conflict*. Andarta Books, Lexington, Kentucky, p. 83.

⁸⁷ Gray, P. (2016). *'Air Warfare: History, Theory and Practice'*. Bloomsbury Academic, London, pp. 62–63.

⁸⁸ Cf. 82.

⁸⁹ Creveld, M. V. (2010). The Twenty Years' Truce. In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) *'The Changing Face of War: Combat from the Marne to Iraq'* (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ). Govostis Editions S.A, Athens, pp. 113–115.

⁹⁰ Creveld, M. V. (2010). The Twenty Years' Truce. In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) *'The Changing Face of War: Combat from the Marne to Iraq'* (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ). Govostis Editions S.A, Athens, pp. 116–119, 174.

also represented by Georgy Samoilovich Iserson (1898–1976) for Russia and Ludwig Ritter von Eimansberger (1878–1945) for Germany.⁹¹

The different approach taken by the above countries to the same two technologies showcase the fact that technological change, including military technology, does not arise from an autonomous logic or simply from scientific discoveries but is significantly influenced by social, political and economic factors.⁹² Thus, understanding this mutually shaping relationship between technology and society can help in adapting and directing future developments.⁹³ In this context, the study of the narratives that accompany new technologies can help each era forecast which technologies will dominate in the future,⁹⁴ as the rhetorical construction of future worlds, either directly or indirectly, serves as a tool for securing funding, mobilising public support and shaping policies, influencing which technologies will be realised.⁹⁵

And indeed, trench warfare was not repeated. The Germans, emphasising armoured technology, were the only army to have fully motorised units in sufficient numbers,^{96,97,98} which even received close air support from the Air Force in order to facilitate their actions.⁹⁹ And yet, WWII was still a war of attrition, even though the front was not stable; it even outlasted the previous one by two years. The forecast that a modern industrial state could not be completely subjugated except by a long war effort, although unheeded, came from a man perhaps more prominent than all of the above, the aforementioned Erich

Ludendorff. According to him, the effort should include the full utilisation of all military, industrial, economic and other resources of a state. This could only happen with the suspension of democratic freedoms by an authoritarian type of regime, established before the war.¹⁰⁰

This aspect aside, the battlefields constituted the venue of application for new technologies, in an effort to cause maximum casualties, while in the urban centres a ‘scientific race’ was taking place, aspiring that friendly forces would be the ones inflicting these losses. In the field of tanks, the German army had implemented the most successful integration. One could note a difference from the next one, the Russian army which, however, during the war, namely in 1943, began to produce tanks of similar capabilities in large quantities, with the additional advantage that they were better adapted to the terrain and climate of the country.¹⁰¹ For AR, whose missiles caused the largest share of casualties in the war compared to any other category,¹⁰² Germany lost the lead for the first time, with the US possessing a greater number of guns and missiles, of equal or superior technology.^{103,104} Finally, in the field of INF and while the rifle’s importance as a weapon system seemed to have passed, new weapons systems allowed it to remain relevant,¹⁰⁵ as well as to expand into new types of operations, such as urban combat¹⁰⁶ and aviation transport.¹⁰⁷ In fields such as radio wave and tracking technologies,^{108,109} analogue

91 Searle, A. (2017). *Armoured Warfare: A Military, Political and Global History*. Bloomsbury Academic, London, p. 38.

92 MacKenzie, D., & Wajcman, J. (1999). ‘Introductory Essay: The Social Shaping of Technology.’, 2nd edn. Open University Press, Buckingham, p. 5.

93 MacKenzie, D., & Wajcman, J. (1999). ‘Introductory Essay: The Social Shaping of Technology.’, 2nd edn. Open University Press, Buckingham, p. 4.

94 Selin, C. (2008). ‘The sociology of the future: Tracing stories of technology and time.’. *Sociology Compass*, 2(6), p. 1884.

95 Selin, C. (2008). ‘The sociology of the future: Tracing stories of technology and time.’. *Sociology Compass*, 2(6), p. 1879.

96 Searle, A. (2017). *Armoured Warfare: A Military, Political and Global History*. Bloomsbury Academic, London, p. 35.

97 Sheehan, S. (2004). ‘Victories and Defeats.’ In: Tsoukala, E. (trans.) & Giannopoulos, T. H. (ed.) ‘*The Technology of World War II*’ (‘Τα όπλα στο Β’ Παγκόσμιο Πόλεμο’). Savvalas, Athens, pp. 4–5.

98 Margaritis, G. (2014). ‘Flow and Ebb, The European 20th Century, First Part: From colonization to Nazi New Europe ((1873–1942)’. (Πλημμυρίδα και Άμωπη, Ο Ευρωπαϊκός 20ός αιώνας, μέρος Πρώτο: Από τον αποικισμό στη ναζιστική Νέα Ευρώπη (1873–1942). Vivliorama, Athens, p. 418.

99 Gray, P. (2016). ‘Air Warfare: History, Theory and Practice’. Bloomsbury Academic, London, p. 60.

100 Creveld, M. V. (2010). ‘The Twenty Years’ Truce.’ In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) ‘*The Changing Face of War: Combat from the Marne to Iraq*’ (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ). Govostis Editions S.A, Athens, pp. 120–122, 174, 184.

101 Stratigikis Ekdoseis. (2005). *Concise World Military Naval Aviation Encyclopedia – Under the Auspices of the Ministry of National Defence* (Επίτομη Παγκόσμια Στρατιωτική Ναυτική Αεροπορική Εγκυκλοπαίδεια–Υπό την Αιγίδα του Υπουργείου Εθνικής Αμύνης). Stratigikis Ekdoseis, Athens, p. 1758.

102 Blank, S. J., & Weitz, R. (2020). ‘*Artillery Warfare, 1939–1945*’. Pen & Sword Military, Barnsley, p. 26, 183.

103 Dennis, W. G. (2017). ‘U.S. and German Field Artillery in World War II: A comparison’. *On Point*, 22(3), pp. 6–7.

104 Blank, S. J., and Weitz, R., (2020). ‘*Artillery Warfare, 1939–1945*’. Barnsley: Pen & Sword Military, p. 111.

105 Blank, S. J., and Weitz, R., (2020). ‘*Artillery Warfare, 1939–1945*’. Barnsley: Pen & Sword Military, p. 84.

106 Wahlman, A. (2015). ‘*Storming the City: U.S. Military Performance in Urban Warfare from World War II to Vietnam*’. University of North Texas Press, Denton, Texas, pp. 3–4, 20, 40–41.

107 Theotokis, N. (2020). ‘*Airborne Landing to Air Assault: A History of Military Parachuting*’. Pen & Sword Military, South Yorkshire, pp. 5–6, 22–24.

108 Hacker, C. B. (2005). ‘The machines of war: Western military technology 1850–2000’. *History and Technology*, 21(3), pp. 261–262.

109 Richardson, J. (2002). ‘*War, Science and Terrorism: From Laboratory to Open Conflict*’. Routledge, London, pp. 45, 52–53, 216–218.

computers^{110,111} and high-level technology in general, the advantage would often change hands. Still, the superior technological German innovation, namely jet engines used in aircraft and rockets^{112,113,114,115} could not match the corresponding American innovation, represented by nuclear fission.^{116,117} Even if the industrial capabilities of the warring powers were more equal, this difference would have been enough to decide the outcome of this war.

7 The Vietnam War (1955–1975)

In the Vietnam War, however, only one of the two sides – the USA – had direct access to high-end technologies. The establishment of Institutes to finance military-oriented research and development projects, now a systematic practice in many states,^{118,119,120,121}

helped in many ways to develop them, while the state of North Vietnam simply did not have the necessary know-how and infrastructure to do so. Any military use of them took place through equipment supplied to it by China and the USSR, mainly in the form of modern aircraft and air defence systems.^{122,123,124,125} In general, the nature of the struggle waged by the North Vietnamese army, a national liberation guerrilla war, was different from anything the US had ever faced. By contrast, the years preceding its intense military involvement in Vietnam had been dedicated to the research and development of technologies and doctrines that revolved around the nuclear bomb, its delivery systems and its survivability,^{126,127} as the possession and technological improvement of this weapon system was an intrinsic element of the Cold War and largely determined policies and diplomacy in the US and the USSR. Consequently, a plethora of high-tech systems, and especially aircraft, were adapted to very different climates and forms of combat than those they were called upon to face.¹²⁸ Throughout the Cold War, the looming adversary had always been the USSR.

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110 Othman, M. K. & Ameen, ID. (2017). How successful were the Allies in mobilizing technology for war, 1939–45? *Historical Kan Periodical*, 10(38), p. 176.

111 Sheehan, S. (2004). The Secret War. In: Tsoukala, E. (trans.) & Giannopoulos, T. H. (ed.) *'The Technology of World War II' ('Τα όπλα στο Β' Παγκόσμιο Πόλεμο')*. Savvalas, Athens, pp. 30-33.

112 Stratigikes Ekdoseis. (2005). *Concise World Military Naval Aviation Encyclopedia – Under the Auspices of the Ministry of National Defence (Επίτομη Παγκόσμια Στρατιωτική Ναυτική Αεροπορική Εγκυκλοπαίδεια–Υπό την Αιγίδα του Υπουργείου Εθνικής Αμύνης)*. Stratigikes Ekdoseis, Athens, p. 1266.

113 Ripley, T. (2005). Innovations of WWII. In: Tsoukalas, D. (trans.) & Giannopoulos, T. H. (ed.) *'Development of Science and Technology: Guns' (Εξέλιξη των επιστημών και της τεχνολογίας: Όπλα)*. Savvalas, Athens, p. 40, 43.

114 Giffard, H. (2016). *Making Jet Engines in World War II: Britain, Germany, and the United States*. University of Chicago Press, Chicago, p. 15.

115 Sheehan, S. (2004). Inventions and Discoveries. In: Tsoukala, E. (trans.) & Giannopoulos, T. H. (ed.) *'The Technology of World War II' ('Τα όπλα στο Β' Παγκόσμιο Πόλεμο')*. Savvalas, Athens, pp. 48-49, 53.

116 Othman, M. K. & Ameen, ID. (2017). How successful were the Allies in mobilizing technology for war, 1939–45? *Historical Kan Periodical*, 10(38), p. 174.

117 Richardson, J. (2002). *'War, Science and Terrorism: From Laboratory to Open Conflict'*. Routledge, London, pp. 76-82.

118 International Astronautical Federation. (2023). 'Office National d'Etudes et de Recherches Aérospatiales (ONERA)'. *iafastro.org*. Available at: <https://www.iafastro.org/membership/all-members/office-national-detudes-et-de-recherches-aerospatiales-onera.html> [accessed 17 December, 2023].

119 Global Security. (2023). 'Moscow Institute of Thermal Technology (MITT)'. *globalsecurity.org*. Available at: [Moscow Institute of Thermal Technology \(MITT\) \(globalsecurity.org\)](https://www.globalsecurity.org) [accessed 17 December, 2023].

120 Defense Advanced Research Projects Agency. (2023a). 'About DARPA'. *darpa.mil*. Available at: <https://www.darpa.mil/about-us/about-darpa> [accessed 18 December, 2023].

121 Defense Advanced Research Projects Agency. (2023b). 'Innovation timeline'. *darpa.mil*. Available at: <https://www.darpa.mil/about/innovation-timeline> [accessed 13 January, 2025].

122 Mahnken, T. G. (2010). *'Technology and the American Way of War Since 1945'*. Columbia University Press, New York, USA, pp. 90-91.

123 National Museum of the U.S. Air Force. (2023). 'Mikoyan-Gurevich MiG-21PF, Fishbed-D'. *nationalmuseum.af.mil*. Available at: <https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/195970/mikoyan-gurevich-mig-21pf-fishbed-d/> [accessed 30 January, 2023].

124 National Museum of the U.S. Air Force. (2023). 'Mikoyan-Gurevich MiG-21PF, Fishbed-D'. *nationalmuseum.af.mil*. Available at: <https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/195970/mikoyan-gurevich-mig-21pf-fishbed-d/> [accessed 30 January, 2023].

125 Green, M. (2019). *'US Cold War Tanks and Armoured Fighting Vehicles'*. Pen & Sword Military, Barnsley, South Yorkshire, p. 181.

126 Hacker, C. B. (2005). 'The machines of war: Western military technology 1850–2000'. *History and Technology*, 21(3), p. 269.

127 Creveld, M. V. (2010). In the Shadow of the Bomb. In: Karabelas, G. (trans.) & Stergiopoulos, V. (ed.) *'The Changing Face of War: Combat from the Marne to Iraq' (Πόλεμος: Από τη μάχη του Μάρνη έως το Ιράκ)*. Govostis Editions S.A, Athens, pp. 219-221.

128 Mahnken, T. G. (2010). *'Technology and the American Way of War Since 1945'*. Columbia University Press, New York, USA, pp. 15, 18-21.

and its survivability, as the possession and technological improvement of this weapon system was an intrinsic element of the Cold War and largely determined policies and diplomacy in the US and the USSR.

At the same time, their opponents had years of experience dealing with organised troops and understood the organisational structure and military tactics of guerrilla warfare, as well as the importance of popular support, both domestic and international. In fact, technological advances had even made many low-tech weapon systems that favoured this kind of conflict considerably cheaper, thus reducing the power differential to a certain extent.¹²⁹ The results showed that these kinds of low-tech systems and warfare practices raised strong obstacles to higher-tech American systems, as was the case in air operations and the McNamara Line.¹³⁰

More specifically, the US based its planning heavily on aerial bombardment in order to deal with the Ho Chi Minh Trail, a network of paths, roads, parking lots and warehouses used by the Viet Cong to infiltrate South Vietnam through Laos. The simple concealment tactics used by the latter (weaving treetops, transplanting flora) made aerial observation, and thus strike accuracy, particularly problematic.¹³¹ The McNamara Line, consisting mainly of a network of sensors of all types, which sent information for analysis to a computer centre for the purpose of a timely air strike, was unable to interrupt the traffic through it (not only did the guerrilla warfare tactics of the Vietcong play a role, but also the humid climate of the jungle and the technological imperfections of these innovative systems).^{132,133,134,135}

Furthermore, on the ground level, no single technological addition was as effective as the establishment of Combined Action Platoons alone, which, despite comprising only 2–3% of US forces, were responsible for 30% of small unit operations and 17% of North Vietnamese casualties in the years 1966–1970.¹³⁶ These include the also low-tech night vision binoculars, as well as the portable radios, thanks to which the US forces greatly improved their performance.^{137,138} Finally, the coastal and riverine combat, similarly conducted with low-tech means, also significantly disrupted the Vietcong's action.^{139,140}

Of course, the US dabbling in high technology turned out to be anything but a mistake, especially in the long run; most of this technology exists to this day (in improved form) and has indelibly influenced the conduct of warfare. The massive use of attack, reconnaissance and rescue helicopters,^{141,142} the motorised AR of 155 mm with new types of ammunition,^{143,144} missiles with innovative new capabilities^{145,146} as well as completely new technologies, such as detection, recognition and transfer of data from satellites^{147,148,149,150} and the use of Unmanned Aerial

¹²⁹ Margaritis, G. (2014). 'Flow and Ebb, The European 20th Century, First Part: From colonization to Nazi New Europe (1873-1942)'. (Πλημμυρίδα και Αμνηστία, Ο Ευρωπαϊκός 20ός αιώνας, μέρος Πρώτο: Από τον αποικισμό στη ναζιστική Νέα Ευρώπη (1873-1942). Vivliorama, Athens, pp. 241-243, 250-251.

¹³⁰ Hill, A. (1976). Air war over Vietnam. *The RUSI Journal*, 121(4), p. 27, 29.

¹³¹ Rosenau, W. (2001). U.S. air ground operations against the Ho Chi Minh Trail, 1966–1972. In: Rosenau, W. *Special Operations Forces and Elusive Enemy Ground Targets: Lessons from Vietnam and the Persian Gulf War*. RAND Corporation, Santa Monica, pp. 5-8.

¹³² Mahnken, T. G. (2010). 'Technology and the American Way of War Since 1945'. Columbia University Press, New York, USA, pp. 109-111.

¹³³ Rosenau, W. (2001). U.S. air ground operations against the Ho Chi Minh Trail, 1966–1972. In: Rosenau, W. *Special Operations Forces and Elusive Enemy Ground Targets: Lessons from Vietnam and the Persian Gulf War*. RAND Corporation, Santa Monica, pp. 11-12.

¹³⁴ Shaw, G. R. I. (2016). 'Scorched atmospheres: The violent geographies of the Vietnam War and the Rise of Drone Warfare'. *Annals of the American Association of Geographers*, 106(3), pp. 693-694, 699.

¹³⁵ Hacker, C. B. (2005). 'The machines of war: Western military technology 1850–2000'. *History and Technology*, 21(3), pp. 274-275.

¹³⁶ Gortzak, Y. (2014). 'The prospects of combined action: Lessons from Vietnam'. *Small Wars and Insurgencies*, 25(1), pp. 137-141.

¹³⁷ Cf. 132.

¹³⁸ Wahlman, A. (2015). 'Storming the City: U.S. Military Performance in Urban Warfare from World War II to Vietnam'. University of North Texas Press, Denton, Texas, pp. 200-202.

¹³⁹ Mahnken, T. G., (2010). 'Technology and the American Way of War Since 1945'. New York, USA: Columbia University Press, pp. 104-107.

¹⁴⁰ Green, M. (2019). 'US Cold War Tanks and Armoured Fighting Vehicles'. Pen & Sword Military, Barnsley, South Yorkshire, pp. 125-127.

¹⁴¹ Lepore, H. P. (1994). 'The coming of age: The role of the helicopter in the Vietnam War'. *Army History*, 29, pp. 29-33.

¹⁴² Mahnken, T. G. (2010). 'Technology and the American Way of War Since 1945'. Columbia University Press, New York, USA, pp. 102-103.

¹⁴³ Green, M. (2019). 'US Cold War Tanks and Armoured Fighting Vehicles'. Pen & Sword Military, Barnsley, South Yorkshire, pp. 178-180.

¹⁴⁴ Seelinger, M. J. (2011). 'The M107 175mm self-propelled gun'. *On Point*, 16(4), pp. 14-16.

¹⁴⁵ Mahnken, T. G. (2010). 'Technology and the American Way of War Since 1945'. Columbia University Press, New York, USA, pp. 114-116.

¹⁴⁶ Gillespie, G. P. (2006). 'Weapons of Choice: The Development of Precision Guided Munitions'. University Alabama Press, Tuscaloosa, pp. 96-97, 102-105, 112, 114-115.

¹⁴⁷ Stares, P. (1985). 'U.S. and Soviet Military Space Programs: A comparative assessment'. *Daedalus*, 114(2), pp. 127-131.

¹⁴⁸ Catledge, B., Powell, J., Air Command and Staff College, & Space Research Electives Seminars. (2009). 'Space history'. In: Air Command and Staff College & Space Research Electives Seminars (eds.), *AU-18 Space Primer*. Air University Press, Maxwell AFB, pp. 5-6.

¹⁴⁹ Hacker, C. B. (2005). 'The machines of war: Western military technology 1850–2000'. *History and Technology*, 21(3), pp. 277-278.

¹⁵⁰ Mahnken, T. G. (2010). 'Technology and the American Way of War Since 1945'. Columbia University Press, New York, USA, p. 18, 23.

Vehicles^{151,152} were applied during the effort of the US military to prevail against that of North Vietnam, contributing to the latter army suffering greater losses than the former. The main initiator of this specific combination of possibilities and manner of engagement was Robert McNamara, Secretary of State during 1961–1968,^{153,154,155,156,157,158} while the escalation of American involvement and bombings was applauded by the also highly influential politician, diplomat and academic Henry Kissinger.¹⁵⁹ Their predecessors were Hans Morgenthau, father of the Neoclassical Realism movement^{160,161} and George F. Kennan, father of the Doctrine of Deterrence,^{162,163} each of whom was marginalised upon criticising American aggression – which in the case of Vietnam indeed failed to yield results.

From a technological point of view, the barriers raised are clear and to some extent have already been analysed. To these can be added the tendency for centralised administration and excessive proliferation of data created by innovations in the collection, dissemination, storage and analysis of information. This resulted in the transformation

of the ‘scientific’ view of war into one based on organisation and management,¹⁶⁴ with the studies of Max Weber (1864–1920) on formal organisations, small group behaviour and the economy being of paramount importance in the development of the multidisciplinary body of scholarly work that constitutes Organizational Theory. Organizational Theory focusses on many factors, such as the principles of the division of labour, scalar and functional processes, structure and span of control, while also taking into consideration both external elements (economic conditions, cultural values, education systems, legal and political environment, etc.) and interpersonal relationships within organisations.¹⁶⁵

Additionally, the complexity of new weapons systems, which now included digital systems, led to the specialisation of military personnel, divided into more specialisations than ever.¹⁶⁶ This complexity also created challenges in Administrative Support.¹⁶⁷ Also, the new form of ‘environmental warfare’ that had been chosen, which included the use of flamethrowers, chemicals, engineering means and widespread bombing,^{168,169} was viewed particularly brutal by the US citizens, as the media enjoyed increased freedom during the hostilities, allowing them to cover it in a novel way.¹⁷⁰ Most importantly, however, the US failed to understand the differences between the war they were engaged in and the types of war they had known, and it was this, far more than any technological handicap, that ultimately cost them victory.

8 The Gulf War (1990–1991)

Armed with the knowledge of its mistakes in the Vietnam War, the USA pursued a different model of involvement in

151 Mahnken, T. G. (2010). *Technology and the American Way of War Since 1945*. Columbia University Press, New York, USA, pp. 113–114.

152 Shaw, G. R. I. (2016). ‘Scorched atmospheres: The violent geographies of the Vietnam War and the Rise of Drone Warfare’. *Annals of the American Association of Geographers*, 106(3), pp. 699–700.

153 Jones, B. (2018). *Dictionary of World Biography*, 5th edn. ANU Press, Canberra, p. 547.

154 Creveld, M. V. (2001b). The Helicopter and The Computer. In: Tsimogianni, M. (trans.) & Bletas, M. (ed.) *‘Command in War’ (Η διοίκηση στον πόλεμο)*. Touriki Editions, Athens, pp. 271–272, 275–277.

155 Westad, O. A. (2017). *The Cold War: A World History (Ο Ψυχρός Πόλεμος: μια Παγκόσμια Ιστορία)*. Patakis Editions, Athens, p. 293.

156 Cf. 151.

157 Rosenau, W. (2001). U.S. air ground operations against the Ho Chi Minh Trail, 1966–1972. In: Rosenau, W. *Special Operations Forces and Elusive Enemy Ground Targets: Lessons from Vietnam and the Persian Gulf War*. RAND Corporation, Santa Monica, pp. 5–11.

158 Shaw, G. R. I. (2016). ‘Scorched atmospheres: The violent geographies of the Vietnam War and the Rise of Drone Warfare’. *Annals of the American Association of Geographers*, 106(3), p. 694.

159 Kissinger, H. (1999). *The War of Vietnam (1955–1975) A Diplomatic History (Ο Πόλεμος του Βιετνάμ (1955–1975): μια Διπλωματική Ιστορία)*. Govostis Editions, Athens, p. 1,3,88.

160 Jackson, R., & Sorensen, G. (2006). Realism. In: Konstantinidis, C. H. (trans.) & Tsakonas, I. P. (ed.) *‘Theory and Methodology of International Relations: The Modern Discussion’ (Θεωρία και μεθοδολογία των Διεθνών Σχέσεων: Η Σύγχρονη Συζήτηση)*. Gutenberg, Athens, pp. 126–127.

161 See, J. W. (2001). ‘A prophet without honor: Hans Morgenthau and the war in Vietnam, 1955–1965’. *Pacific Historical Review*, 70(3), pp. 419–448.

162 Westad, O. A. (2017). *The Cold War: A World History (Ο Ψυχρός Πόλεμος: μια Παγκόσμια Ιστορία)*. Patakis Editions, Athens, p. 90.

163 Hixson, W. L. (1988). ‘Containment on the perimeter: George F. Kennan and Vietnam’. *Diplomatic History*, 12(2), pp. 149–150.

164 Creveld, M. V. (2001b). Railroads, Rifles, and Wires. In: Tsimogianni, M. (trans.) & Bletas, M. (ed.) *‘Command in War’ (Η διοίκηση στον πόλεμο)*. Touriki Editions, Athens, pp. 174–175.

165 Brown, D. K. (2018). ‘Max weber and organizational theory’. In: Farazmand, A., (eds.), *‘Global Encyclopedia of Public Administration, Public Policy, and Governance’*. Springer International Publishing, Cham, pp. 3949–3950, 3952–3953.

166 Creveld, M. V. (2001b). The Helicopter and The Computer. In: Tsimogianni, M. (trans.) & Bletas, M. (ed.) *‘Command in War’ (Η διοίκηση στον πόλεμο)*. Touriki Editions, Athens, pp. 272–273.

167 Cf. 164.

168 Shaw, G. R. I. (2016). ‘Scorched atmospheres: The violent geographies of the Vietnam War and the Rise of Drone Warfare’. *Annals of the American Association of Geographers*, 106(3), pp. 693–694.

169 Leitenberg, M. (1972). ‘America in Vietnam: Statistics of a war’. *Survival*, 14(6), pp. 268–269.

170 Tannenwald, N. (2006). ‘Nuclear weapons and the Vietnam War’. *Journal of Strategic Studies*, 29(4), pp. 718–719.

the Gulf War, namely the entirety of the operations aiming to liberate Kuwait from Iraqi occupation. Firstly, they did not begin until the consent of the remaining UN nations, including Russia and China, while also curbing both Iraq's propaganda¹⁷¹ and the effectiveness of the international terrorism it practiced.^{172,173}

At the same time, they made sure to intervene in a much more decisive manner than in the case of Vietnam. The international coalition of 35 states against Iraq, reached a total of 737,000 men, 190 ships and 1,700 combat aircraft,¹⁷⁴ while the volume of military material transferred daily to the Theatre of Operations was 6.5 times greater than in the period of escalation in Vietnam.¹⁷⁵ At the same time, Iraq's initial strength of 1,000,000 troops, 5,700 tanks, 1,100 aircraft and other weapons systems,^{176,177} was reduced in capacity by the relentless pounding of the formation's air force, which destroyed 40% of Iraqi tanks, reduced their supply capability by 91% and led to a mass flight of aircraft to Iran,^{178,179,180} as part of a four-phase plan of operations.¹⁸¹ The completion of the ground leg

of these operations left an estimated 50,000 Iraqis dead, compared to less than 150 USA military men who were pronounced dead, wounded or missing.¹⁸²

The technological innovations in this war, as well as most improvements of pre-existing weapons systems, emanated from the coalition camp and mainly the US. The digital revolution affected command, control and communications processes¹⁸³; combined with the new invention of GPS and the use of other satellites,^{184,185,186} it enabled reconnaissance aircraft^{187,188} and unmanned aerial vehicles to improve their surveillance and targeting capabilities,¹⁸⁹ while similar developments occurred with anti-aircraft radars.^{190,191} These technologies also influenced munitions themselves, with the Gulf War seeing the introduction of a plethora of new missiles, with greater range and strike accuracy.^{192,193,194,195,196}

171 Bush, H.W.G. & Scowcroft, B., (1999). Desert Storm. In: Roussos, N. (trans.) & Papaspiliopoulou, D. (ed.) *'A World Transformed' (Η μεταμόρφωση του κόσμου)*. Labyrinthos, Athens, pp. 499, 504, 511–513.

172 Bush, H.W.G. & Scowcroft, B., (1999). Shield and Sword. In: Roussos, N. (trans.) & Papaspiliopoulou, D. (ed.) *'A World Transformed' (Η μεταμόρφωση του κόσμου)*. Labyrinthos, Athens, p. 381.

173 Lambas, N (2018). 'USA and 'Pariah States', Iran, Iraq, North Korea' (ΗΠΑ και «κράτη παρίες», Ιράν, Ιράκ, Βόρεια Κορέα). Poiotita, Athens, pp. 86–88.

174 Cf. 178.

175 Tsakiris, T. H. (2018). *'Energy Security and International Politics – The Geopolitics of "Black Gold" from the Discovery of Oil in the Middle East to the Shale Revolution (1908-2018)' (Ενεργειακή ασφάλεια και διεθνής πολιτική – Η γεωπολιτική του «μαύρου Χρυσού» από την ανακάλυψη πετρελαίου στη μέση Ανατολή έως τη Σχιστολιθική Επανάσταση (1908–2018)*. Papazisi, Athens, p. 595.

176 Bush, H.W.G. & Scowcroft, B., (1999). This Will Not Stand. In: Roussos, N. (trans.) & Papaspiliopoulou, D. (ed.) *'A World Transformed' (Η μεταμόρφωση του κόσμου)*. Labyrinthos, Athens, pp. 335, 355–356, 360.

177 Allison, H. F., (2021). 'The desert war: Marine Corps Aviation in Desert Storm, January–February 1991'. *Expeditions with MCUP*, p. 5, 30–31, 33.

178 RUSI. (2000). 'The role of logistics in modern warfare: Operations desert shield and desert storm'. *Whitehall Papers*, 52(1), p. 52.

179 Press, D. G. (2001). 'The Myth of Air Power in the Persian Gulf War and the future of warfare'. *International Security*, 26(2), p. 39.

180 Ahrari, E. (2010). 'Transformation of America's Military and Asymmetric War'. *Comparative Strategy*, 29(3), p. 227.

181 USA Ministry of National Defence. (2003). Transition to the Offensive. In: Skarvelis, D., (trans. & ed.) *'Conduct of the Persian Gulf War: Final Report to Congress' (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο)*. I. Floros, Athens, p. 74, 78.

182 Bush, H.W.G. & Scowcroft, B., (1999). Desert Storm. In: Roussos, N. (trans.) & Papaspiliopoulou, D. (ed.) *'A World Transformed' (Η μεταμόρφωση του κόσμου)*. Labyrinthos, Athens, p. 529.

183 Mann, E. (1994). 'Desert storm: The first information war?' *Airpower Journal*, 8(4), p. 10.

184 Cf. 189.

185 Perry, J. W. (1991). Desert storm and deterrence. *Foreign Affairs*, 70(4), p. 69, 72.

186 Lambakis, S. (1995). 'Space control in desert storm and beyond'. *Orbis*, 39(3), p. 419.

187 USA Ministry of National Defence. (2003). Transition to the Offensive. In: Skarvelis, D., (trans. & ed.) *'Conduct of the Persian Gulf War: Final Report to Congress' (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο)*. I. Floros, Athens, p. 95.

188 Perry, J. W. (1991). Desert storm and deterrence. *Foreign Affairs*, 70(4), p. 69, 72.

189 Ahrari, E., (2010). 'Transformation of America's Military and Asymmetric War'. *Comparative Strategy*, 29(3), p. 228.

190 Schubert, N. F., & Kraus, L. T. (1995). *The Whirlwind War: The United States Army in Operations*. Center of Military History, Washington, p. 263.

191 Lingamfelter, L. S. (2020). *'Desert Redleg: Artillery Warfare in the First Gulf War'*. The University Press of Kentucky, Lexington, p. 68.

192 USA Ministry of National Defence. (2003). The Air Campaign. In: Skarvelis, D., (trans. & ed.) *'Conduct of the Persian Gulf War: Final Report to Congress' (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο)*. I. Floros, Athens, p. 173, 179.

193 Schubert, N. F., & Kraus, L. T. (1995). *The Whirlwind War: The United States Army in Operations*. Center of Military History, Washington, p. 264.

194 Hellenic Military Aviation. (2023). 'Patriot'. *haf.gr*. Available at: <https://www.haf.gr/arsenal/patriot-pac-iii/> [accessed 29 June, 2023].

195 Hellenic Military Aviation. (2023). 'AGM – 88 High-speed Anti-Radiation Missile (HARM)'. *haf.gr*. Available at: <https://www.haf.gr/arsenal/agm-88-high-speed-anti-radiation-missile-harm/> [accessed 29 June, 2023].

196 Klare, M. T. (1991). 'Behind desert storm'. *Technology Review*, 94(4), p. 34.

In addition, the miniaturisation of electronic sub-systems, combined with the increase in the efficiency of mechanical parts, led to the dramatic improvement in the capabilities of fighter and bomber aircrafts,^{197,198,199,200,201} helicopters,^{202,203} tanks,^{204,205,206,207} land vehicles for troops transport^{208,209} as well as of the various rocket AR^{210,211} and

battle AR.^{212,213,214,215} The same trend was observed in the Navy branch, whose transport capacity,²¹⁶ weapon systems and overall means of the Aircraft Carrier Groups²¹⁷ improved significantly compared to the past.

For its part, Iraqi army had been provided with a robust air defence system,²¹⁸ but this was suppressed by a combination of bombing by stealth planes, guided missiles and helicopters.^{219,220} Accordingly, the relatively weak Iraqi Navy, while possessing a number of dangerous systems, including a variety of old and new types of mines, was ultimately disabled by out-of-range strikes combined with the use of specialised systems.^{221,222}

The US victorious doctrine of that war was pioneered by Caspar Weinberger (1917–2006) and established by his then aide Colin Powell (1937–2021), after whom it was named.²²³ The same man is also responsible for popularising the term ‘pariah states’, which characterised states with specific problematic qualities or dangerous

197 Cf. 205.

198 Perry, J. W. (1991). Desert storm and deterrence. *Foreign Affairs*, 70(4), pp. 74-75.

199 USA Ministry of National Defence. (2003). The Maritime Campaign. In: Skarvelis, D., (trans. & ed.) *‘Conduct of the Persian Gulf War: Final Report to Congress’* (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο). I. Floros, Athens, p. 161, 251.

200 Wright, K. (2017). Desert storm A-10 operations. *Key Aero*. Available at: <https://www.key.aero/article/desert-storm-10-operations> [accessed 13 January, 2025].

201 National Naval Aviation Museum. (2023). ‘A-7E CORSAIR II’. *history.navy.mil*. Available at: <https://www.history.navy.mil/content/history/museums/nnam/explore/collections/aircraft/a/a-7e-corsair-ii0.html> [accessed 25 June, 2021].

202 USA Ministry of National Defence. (2003). The Ground Campaign. In: Skarvelis, D., (trans. & ed.) *‘Conduct of the Persian Gulf War: Final Report to Congress’* (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο). I. Floros, Athens, pp. 245, 321-322, 331.

203 Allison, H. F., (2021). ‘The desert war: Marine Corps Aviation in Desert Storm, January–February 1991’. *Expeditions with MCUP*, pp. 8-9, 30-31, 33.

204 Lingamfelter, L. S. (2020). *‘Desert Redleg: Artillery Warfare in the First Gulf War’*. The University Press of Kentucky, Lexington, p. 49.

205 Searle, A. (2017). *Armoured Warfare: A Military, Political and Global History*. Bloomsbury Academic, London, pp. 178-181.

206 Press, D. G. (2001). ‘The Myth of Air Power in the Persian Gulf War and the future of warfare’. *International Security*, 26(2), p. 13, 40.

207 USA Ministry of National Defence. (2003). The Ground Campaign. In: Skarvelis, D., (trans. & ed.) *‘Conduct of the Persian Gulf War: Final Report to Congress’* (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο). I. Floros, Athens, p. 94, 326.

208 USA Ministry of National Defence. (2003). The Ground Campaign. In: Skarvelis, D., (trans. & ed.) *‘Conduct of the Persian Gulf War: Final Report to Congress’* (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο). I. Floros, Athens, pp. 325, 358-359.

209 Schubert, N. F., & Kraus, L. T. (1995). *The Whirlwind War: The United States Army in Operations*. Center of Military History, Washington, pp. 257, 267-268.

210 USA Ministry of National Defence. (2003). The Ground Campaign. In: Skarvelis, D., (trans. & ed.) *‘Conduct of the Persian Gulf War: Final Report to Congress’* (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο). I. Floros, Athens, p. 380.

211 Lingamfelter, L. S. (2020). *‘Desert Redleg: Artillery Warfare in the First Gulf War’*. The University Press of Kentucky, Lexington, p. 31, 72, 107.

212 Lingamfelter, L. S. (2020). *‘Desert Redleg: Artillery Warfare in the First Gulf War’*. The University Press of Kentucky, Lexington, p. 135.

213 Tank Encyclopedia. (2023). ‘M109 Paladin’. *tanks-encyclopedia.com*. Available at: https://tank-afv.com/coldwar/US/M109_Paladin.php [accessed 29 April, 2023].

214 Academic Accelerator. (2023). ‘M109 Howitzer’. *academic-accelerator.com*. Available at: <https://academic-accelerator.com/encyclopedia/m109-howitzer> [accessed 25 August, 2023].

215 Schubert, N. F., & Kraus, L. T. (1995). *The Whirlwind War: The United States Army in Operations*. Center of Military History, Washington, p. 259.

216 USA Ministry of National Defence. (2003). The Maritime Campaign. In: Skarvelis, D., (trans. & ed.) *‘Conduct of the Persian Gulf War: Final Report to Congress’* (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο). I. Floros, Athens, p. 234.

217 USA Ministry of National Defence. (2003). The Maritime Campaign. In: Skarvelis, D., (trans. & ed.) *‘Conduct of the Persian Gulf War: Final Report to Congress’* (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο). I. Floros, Athens, pp. 233-235, 243-245, 251, 254, 284.

218 Cf. 186.

219 Cf. 207.

220 Shimko, L. K. (2010). *‘The Iraq Wars and America’s Military Revolution’*. Cambridge University Press, New York, pp. 63-64.

221 Tucker, J. A. (2014). *‘The Gulf War: Operation Desert Storm 1990–1991’*. Pen & Sword Military, South Yorkshire, England, pp. 68, 70-71.

222 USA Ministry of National Defence. (2003). The Maritime Campaign. In: Karelis, D., (trans. & ed.) *‘Conduct of the Persian Gulf War: Final Report to Congress’* (Ο Πόλεμος του Κόλπου: Η Τελική Επίσημη Έκθεση του Υπουργείου Εθνικής Αμύνης των ΗΠΑ προς το Κογκρέσσο). I. Floros, Athens, p. 240, 242, 252, 258.

223 La Feber, W. (2009). ‘The rise and fall of Colin Powell and the Powell Doctrine’. *Political Science Quarterly*, 124(1), pp. 72-76.

capabilities that affected American interests. Placing a state in this category usually resulted in a more violent stance on the part of the US.²²⁴ Equally influential at the time was the idea of the emergence of military forces from the Third World, which was first formally expressed by the Commission on Integrated Long-Term Strategy created by the Department of Defence and the US National Security Council in 1988.^{225,226} Finally, the term Revolution in Military Affairs became known to the general public through this war. Although the concept originally emanated from the Soviet camp, it coincided with the American spirit of experimentation and the belief that new technologies also require the adoption of new doctrines,^{227,228,229} which ultimately led to overwhelming success. This included the idea of Network-Centric Warfare, where communication and information technologies would enable forces to operate with greater speed, accuracy and coordination.

9 Conclusions

The anticipation, adoption and use of innovative military technologies by an army are stages in resolving the issue of finding a winning strategy in a war conflict; the present article examines the first two stages.

In contrast to the adoption stage, which is still a matter of political and military leadership, until WWI the idea that the state had the ability to forecast technological advances or direct the development of military technology itself towards favourable directions, simply did not exist. The states did not have at their disposal any state entity that could deal with the forecasting or direction of the development of military technology, with innovations coming 'arbitrarily' in the form of inventions, mainly by private individuals. The only recognised authority able to

judge them as to their utility was the body of the military. Such relevant entities developed alongside the industrialisation of states: during the interwar period, scientists from the fields of science and technology began to participate widely in this process, as well as theorists of organisation and management during the subsequent explosion of the Information Revolution. However, despite the offering of more and more expanded views over time and the existence of more powerful analytical tools, some trends are observed, which stand the test of time.

Firstly, people making the most accurate forecasts tend to differ from those responsible for adopting the technologies. At the adoption level, this aspect contributes to the fact that radical changes in doctrine or technology are historically met with great resistance in the military, even if they are clearly necessary. The fact that the nature of a nation's army is to guarantee its security from external threats, which in many cases have been proven to be existential, accompanied by a sense of self-importance often held by its members, can lead to the rejection of narratives that either are radically different from pre-existing successful ones, or require a restructuring of the army that renders parts of its personnel obsolete. Secondly, states with more industrialised societies and educated populations tend to propose more accurate and innovative forecasts and doctrines. However, changes based on these forecasts seem to occur at a faster pace in states with more authoritarian regimes, where the conservatism of the military can be more easily overridden by leadership. Thirdly, states that have been defeated in the past appear more open to innovative forecasts, and changes in the military are more easily adopted, both based on these and more conservative forecasts on pre-existing technologies and doctrines. Finally, forecasts tend to be biased in favour of technologies that have led to victory or demonstrated outstanding performance during previous wars. This tendency has often led to the phenomenon of preferring the development of pre-existing weapons systems and technologies against the option of inventing innovative ones, especially by the victorious states, indicating that army commanders tend to think more along the axis between safe and dangerous situations rather than the axis between risk and danger.

Of course, the adoption of a new technology does not mean much by itself, even if it is a technology that is ripe for use. Success in adoption seems to predispose historically, firstly the adoption of new war doctrines and, furthermore, a combination of the use of technologies that are not yet fully mature (so as to be fully integrated in the future) and, on the other hand, respect for pre-existing technologies and for the importance of the skill of the

²²⁴ Lambas, N (2018). 'USA and 'Pariah States', Iran, Iraq, North Korea' (ΗΠΑ και «κράτη παρίες», Ιράν, Ιράκ, Βόρεια Κορέα). Poiotita, Athens, pp. 20, 23, 25, 44, 46-47, 52-53.

²²⁵ Klare, M. T. (1991). 'Behind desert storm'. *Technology Review*, 94(4), pp. 30-31.

²²⁶ Collins, J. J. (1992). 'Desert storm and the lessons of learning'. *Parameters: Journal of the US Army War College*, 22(3), p. 87.

²²⁷ Blank, S. J., & Weitz, R. (2010). 'Russian military studies: A call for action'. In: Blank, S. J., & Weitz, R., 'Russian Military Today and Tomorrow: Essays in Memory of Mary Fitzgerald'. Strategic Studies Institute – Army War College, Carlisle, pp. 1-2.

²²⁸ Ahrari, E., (2010). 'Transformation of America's Military and Asymmetric War'. *Comparative Strategy*, 29(3), p. 226.

²²⁹ Grivas, K. (2008). 'The End of Oil and the Beginning of the New American Geostrategy' (Το Τέλος του Πετρελαίου και η Αρχή της Νέας Αμερικανικής Γεωστратηγικής). Livanis, Athens, pp. 155-156, 158-159.

operators of the weapons systems. Also, prior usage of said technologies in military drills can be a major factor of success in its integration. Finally, although pluralism of opinion may slow down the decision-making process, it appears to ultimately lead to better decisions.

The aforementioned findings are not a panacea, nor is the degree of their influence clearly defined, as they are part of a problem composed of multiple factors. Any change in the military involves risk, as the adoption of an inadequate or ineffective array of capabilities puts the entire national security at risk. However, lack of change equals disaster. Fortunately, history is rich with examples from which today's political and military leaders can draw valuable wisdom to ensure the security of their states.

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