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Winning the Industrial War
Comparing Russia, Europe and Ukraine, 2022–24

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Executive Summary

Protracted wars are won by the party able to generate new, competitively trained forces and the armaments with which they are equipped and sustained. The ability to generate a second and third echelon of forces is an important aspect of a state's deterrence posture.

During Russia's full-scale invasion of Ukraine, the Russian defence industry has managed to significantly increase defence production. Ukraine has also done this, although to a lesser extent. European members of NATO, meanwhile, faced substantial problems in expanding defence-industrial output, despite an abundance of funds. This paper examines the processes of military-industrial mobilisation in each of these areas to assess the causes of radically different outcomes.

First, Russia had a well-developed plan for military-industrial mobilisation which it implemented early in the war. Ukraine did not have such a well-developed plan but could draw on its Soviet legacy to regenerate industrial capacity. Europe, meanwhile, lacked both a plan and the data with which to build one; this made investment into defence production inefficient.

Second, Russia and Ukraine maintained a highly centralised level of coordination over their respective defence industries and had an understanding of the supply chains to enable a relatively coherent orchestration of investments. Europe, meanwhile, lacked control, and could only incentivise industry, while governments and industry lacked an understanding of their own supply chains, leading to massive internal competition and uneven expansion.

Third, while Russia did achieve a much more efficient military-industrial mobilisation, it also cost far more than is generally acknowledged. Russia has not only expanded defence spending but also rerouted money from other budgets to expand military-industrial recapitalisation and has advanced credit to defence companies to enable rapid growth. This will pose challenges in the medium term. It is not reasonable to expect Europe, which is not at war, to mobilise investment to a comparable level. However, the fragmentation of the European defence market has meant that money is spent very inefficiently. Greater European coordination of spending could improve the return on investment.

The regulatory environment in Russia and Ukraine should not be held up as a model. In Ukraine, regulation of core defence industries has necessitated a large unregulated non-traditional defence ecosystem to emerge. In Russia, practices are manifestly unsafe and have often led to accidents. In Europe, however, the burden of regulation is often self-defeating in raising the cost and slowing the

production of equipment. Incentives for stockpiling equipment and taking risk, meanwhile, are skewed in such a way as to lead to systemic policy failure. Regulatory reform and harmonisation for the testing, procurement, storage and transportation of defence materiel are essential.

In an environment where Europe must be able to deter Russia with reduced US support, Russia's full-scale invasion of Ukraine should spur significant efforts to address what has been demonstrated to be a manifestly inadequate defence-industrial base.

Introduction

An assessment of the military balance is overwhelmingly concerned with the comparison of adversaries' first echelon of forces, along with the first round of mobilised reserves.[1] The confrontation of opposing first echelons with their original equipment usually produces the most rapid stages of a conflict. These troops are the most professional and best-equipped units, and they tend to be fewer in number than the force following mobilisation, so there is more space for manoeuvre on a front.[2] The clashes of these forces tend to set the terms for follow-on fighting. They may decisively achieve their objectives, as was the case for Azerbaijan's forces in Nagorno–Karabakh in 2020,[3] the US-led coalition in Iraq in 1991,[4] and the German invasion of France in 1940.[5] Or they may fail, with the limits of their advance setting the conditions for a period of slower and more destruction-centric warfare, as during the First World War on the Western Front,[6] the Iran–Iraq War,[7] or Russia's full-scale invasion of Ukraine.[8]

Where wars protract, they become industrial,[9] with the capacity of a force to continue the struggle enabled by its capacity to manufacture a sufficient volume of equipment and to remain competitive in the equipment that it fields. Winning a long war depends on the ability to mobilise the necessary resources to ensure the ability to wage it.[10] This applies, of course, to human resources, but the provision of an adequate volume of weaponry and military equipment is just as

1. This is true of the scope of the International Institute for Strategic Studies' (IISS) *Military Balance*, as well as a significant proportion of net assessments published by RAND, RUSI and others. There are sound methodological reasons for this.
2. This produces an emphasis in planning on short, victorious wars. See Raphael S Cohen and Gian Gentile, 'America's Dangerous Short War Fixation', RAND Commentary, 31 March 2023, <https://www.rand.org/pubs/commentary/2023/03/americas-dangerous-short-war-fixation.html>, accessed 4 December 2024.
3. Phillip Andrews, 'Lessons from the Nagorno-Karabakh 2020 Conflict', Center for Army Lessons Learned, August 2021, <https://api.army.mil/e2/c/downloads/2023/01/31/693ac148/21-655-nagorno-karabakh-2020-conflict-catalog-aug-21-public.pdf>, accessed 4 December 2024.
4. Anthony H Cordesman, 'Lessons of the Gulf War: 1990–1991', Center for Strategic and International Studies (CSIS), revised July 2013, <https://csis-website-prod.s3.amazonaws.com/s3fs-public/160628_Lessons_of_the_Gulf_War_1990-1991_full.pdf>, accessed 4 December 2024.
5. Julian Jackson, *The Fall of France: The Nazi Invasion of 1940* (Oxford: Oxford University Press, 2004).
6. Barbara W Tuchman, *The Guns of August* (New York, NY: Presidio, 2004).
7. Stephen C Pelletiere, *The Iran-Iraq War: Chaos in a Vacuum* (New York, NY: Praeger, 1992).
8. Mykhaylo Zabrodskyi et al., 'Preliminary Lessons in Conventional Warfighting: Russia's Invasion of Ukraine: February–July 2022', RUSI, 30 November 2022, <https://www.rusi.org/explore-our-research/publications/special-resources/preliminary-lessons-conventional-warfighting-russias-invasion-ukraine-february-july-2022>, accessed 5 January 2025.
9. Arthur Herman, *Freedom's Forge: How American Business Produced Victory in World War II* (New York, NY: Random House, 2013); David Edgerton, *Britain's War Machine: Weapons, Resources and Experts in the Second World War* (London: Penguin, 2012).
10. Poor decision-making in this space determines extremely destructive decision-making. See Adam Tooze, *The Wages of Destruction: The Making and Breaking of the Nazi Economy* (New York, NY: Penguin, 2008).

important.[11] Numerical superiority in troops, their training and high morale do not matter if these troops do not have arms and ammunition. War is not only an art, but also a science, and this is especially true of long wars, which are determined ultimately by the second or third echelon – that is, a country's reserves – and subsequent entirely new units of conscripts from the population.

Assessing the military balance of second- and third-echelon forces, and thus the capacity of a state to sustain a long war, is not as simple as measuring wealth and industrial potential. By late March 2022, officials in Russia realised that industrial and military mobilisation would be necessary.[12] There has been a persistent narrative in parts of NATO that Russia is an insignificant threat because the GDP of NATO countries alone is about $46 trillion, which is almost half of world GDP.[13] Russia, by comparison, has a GDP of approximately $2 trillion, representing only 2% of global GDP from an economy smaller than Canada's.[14] The military threat from Russia was often dismissed on the basis that it had an economy the size of Italy.[15] This complacency is evident in the fact that as Russian defence spending expanded by some 227% and China's by 566% from 2000, defence spending across Europe and Canada continued to decline until 2014 and, even then, was stable until 2022.[16]

Despite Russia's comparative economic weakness, Russia still managed to outproduce NATO in military materiel throughout 2022–24,[17] even with significant efforts in some NATO member states to expand defence production. This reflects the challenges of aligning political will, regulatory and legislative enablement, industrial planning and capacity, and understanding and control over supply chains. Russia's continuing advantage in defence production poses a strategic threat to NATO and the credibility of its conventional deterrence. It poses a catastrophic risk for Ukraine, since its international partners have become its strategic depth.

11. Alex Vershinin, 'The Return of Industrial Warfare', *RUSI Commentary*, 17 June 2022, <https://www.rusi.org/explore-our-research/publications/commentary/return-industrial-warfare>, accessed 3 February 2025.
12. Jack Watling and Nick Reynolds, 'Operation Z: The Death Throes of an Imperial Delusion', RUSI, 22 April 2022, <https://rusi.org/explore-our-research/publications/special-resources/operation-z-death-throes-imperial-delusion>, accessed 4 December 2024.
13. IMF, 'GDP, Current Prices', 2025, <https://www.imf.org/external/datamapper/NGDPD@WEO/OEMDC/ADVEC/WEOWORLD>, accessed 23 March 2025.
14. CIA, 'The World Factbook: Russia', <https://www.cia.gov/the-world-factbook/countries/russia/>, accessed 4 December 2024.
15. Lauren Carroll, 'Graham: Russia "Has an Economy the Size of Italy"', *Tampa Bay Times*, 27 July 2014, <https://www.tampabay.com/archive/2014/07/27/graham-russia-has-an-economy-the-size-of-italy/>, accessed 4 December 2024.
16. Nan Tian et al., 'Trends in World Military Expenditure, 2023', SIPRI Fact Sheet, April 2024, <https://www.sipri.org/sites/default/files/2024-04/2404_fs_milex_2023.pdf>, accessed 4 December 2024.
17. Julian E Barnes, Eric Schmitt and Thomas Gibbons-Neff, 'Russia Overcomes Sanctions to Expand Missile Production, Officials Say', *New York Times*, 13 September 2023; Julian Cooper, 'Military Production in Russia Before and After the Start of the War With Ukraine: To What Extent Has It Increased and How Has This Been Achieved?', *RUSI Journal* (Vol. 169, No. 4, 2024), pp. 10–29.

This paper compares the military-industrial measures in Russia, Ukraine and European NATO over the course of Russia's full-scale invasion of Ukraine. It uses such comparisons to identify lessons on how war production among Ukraine's international partners can be made more resilient and efficient to support Ukraine today and deter Russia into the future. The paper also explains how, and at what cost, Russia has achieved its scaling of military production. The paper does not offer a comprehensive breakdown of the defence industry across all these jurisdictions. Rather, its focus is on key policy issues that have shaped production outputs.

The scope of this paper requires some explanation. On the Russian side, Iran, North Korea, Belarus, India, and China are central to the country's ability to industrially sustain the war.[18] Similarly, for Ukraine, the US and several non-European partners are important supporters. However, these countries are excluded from the study. The reason for this is that apart from the US, most of these states have been involved in the war as suppliers or funders, servicing orders or offering support. They have not needed to address major policy questions of industrial mobilisation.

For the US, which has retained a substantial defence industry and has policies in place for industrial mobilisation, Russia's full-scale invasion has prompted investment in the expansion of some kinds of munitions production. However, the mechanisms for doing this were the same as those used during the War on Terror to address shortages of precision-guided munitions.[19] The main policy debate in the US was not one of industrial policy. Rather, it was the balance of investment in equipment relevant to supporting Ukraine and that which is useful in deterring Chinese aggression towards Taiwan.[20]

The paper, therefore, focuses on those states where key policy questions of how to industrially mobilise arose, with significant differences in what has been achieved and how. Focusing on Europe, without the US, is also relevant given that over the next few years, it is likely that more US capacity will be fixed in the Indo-Pacific. It is therefore useful and necessary to assess Europe's military-industrial readiness. It may be asked, quite reasonably, why Europe is treated as a unified entity when it is highly fragmented in defence-industrial policy. The reason is that most European militaries are too small to sustain their domestic defence enterprises. Once scaling activities became necessary, it became clear

18. Russian Ministry of Defence, 'The 21st Meeting of Russian-Indian Inter-Governmental Commission on Military and Military-Technical Cooperation Takes Place in Moscow', 10 December 2024, <https://eng.mil.ru/en/mcis/news/more.htm?id=12541566@egNews>, accessed 5 February 2025.
19. Karen DeYoung and Greg Jaffe, 'NATO Runs Short of Some Munitions in Libya', *Washington Post,* 15 April 2011.
20. Sidharth Kaushal and Juliana Suess, 'The Impact of a Taiwan Strait Crisis on European Defence', *Whitehall Report,* 1-24 (November 2024), <https://rusi.org/explore-our-research/publications/whitehall-reports/impact-taiwan-strait-crisis-european-defence>, accessed 5 February 2025.

that the European defence market must be considered collectively. Indeed, the competitive interactions across this market reveal the frictions and opportunities that have emerged over the course of the war. The discussion, therefore, is focused on Europe.

The evidence for this paper is diverse. The authors have – throughout the war – been actively engaged in policy discussions in Ukraine and across Europe on support for the Ukrainian war effort. The authors have also extensively consulted with the defence industry across Europe and both industrial and policy leaders in Ukraine. The research into Russian defence production combines a range of open and closed sources, some of which are sensitive in nature.

The combination of commercial sensitivity in Europe, operational security in Ukraine and official secrecy in Russia make it difficult to pursue a unified methodology for these three areas of study. Similarly, while the Ukrainian government has assisted in the research for this paper, the Russian government has sought to prevent it. In Europe, meanwhile, there is a diverse range of actors, to which access was also provided under various terms. Together, this makes it difficult to present a comparable data set for each area of study. Instead, therefore, this paper seeks to understand each industrial environment on its own terms through the information available, and subsequently to draw conclusions about policies and their impact on production.

A brief note on numbers. The chapter on Russia includes some specific production figures and costs. In some instances, it has been possible to obtain sensitive industrial information on Russian production, and so these numbers are used. The chapter on Europe does not use many specific numbers, although there are a great many in circulation. This is because while specific numbers are often included in press releases and media reports, the authors' interviews with the parties concerned invariably indicated that actual numbers were markedly different, or that those that were publicly released amalgamated various kinds of data. The specific data was nevertheless shared in confidence and could not be used. In general, therefore, numbers are omitted.

The paper has three chapters, one for each of the three areas of study: Russia, Ukraine and Europe. From a policy perspective, it may have made more sense to divide the chapters thematically, comparing policy and regulation, industrial capacity, and stockpiling and supply chains across the three areas. However, because of the different methodologies necessary for obtaining data, it is hard to compare like with like, and so the paper considers each separately, and then draws conclusions.

I. Russia: Military-Industrial Mobilisation

The initial Russian invasion plan for Ukraine envisaged the destabilisation of the Ukrainian state by Russia's special services, followed by a *coup de main* by the Russian military to rapidly seize and take control of Ukraine's political and economic centres. The main military phase of the campaign was planned to take 10 days, with consolidation of control lasting several months. In this context, Russian planners did not expect to expend significant numbers of munitions or lose large volumes of military equipment. Thus, industrial mobilisation did not accompany the commencement of the Special Military Operation.

When the initial plan failed, Russia found itself expending significantly more munitions and losing more equipment than it was producing. As early as March 2022, this led to advice from a range of Russian ministries to begin mobilisation of both personnel and the defence industries. The Kremlin deferred mobilisation of personnel. Although the Kremlin had decided on achieving its objectives in Ukraine militarily, it initially expected to be able to do this without mobilisation simply because of the limited stocks in Ukrainian arsenals. The expansion of Western military-technical assistance, the culmination of Russian offensive operations in Donbas, and the prospects for a protracted war undermined these assumptions. As a result, the emphasis in Russia shifted towards a partially mobilised war economy. The Russian leadership decided to wage a war of attrition against Ukraine, counting on the unwillingness of Kyiv and its Western partners to maintain the necessary level, pace and duration of funding. Russia's leaders also assumed that Ukraine and its partners would not be able to effectively transform available financial resources into weapons and military equipment, primarily due to the degradation of industrial capabilities in general and defence-industrial capabilities in particular among Russia's adversaries.

The attention of intelligence agencies and think tanks focused on the possible start of the mobilisation of reservists of the Armed Forces of the Russian Federation as an indicator of the Kremlin's readiness to wage a long war. However, the first and more important indicators of Russia's shift to a protracted conflict were those related to the start of its industrial mobilisation. President Vladimir Putin initiated the partial mobilisation of personnel on 21 September 2022 with his decree 'On the announcement of partial mobilisation in the Russian

Federation',[21] in response to a need to increase the density of forces in Ukraine. But industrial mobilisation had already been underway for months. Importantly, Russia had a detailed and established plan for industrial mobilisation as part of its war plans.[22] This included the pre-drafting of legislation to enable military-industrial expansion.

Most professional and academic assessments of Russia's ability to sustain a protracted war have over-emphasised calculations of how long Russia will last with the weapons and military equipment it had in stockpiles when the war began, especially with regard to munitions.[23] Assessments of Russia's military-industrial capacity to produce more equipment, and the significance of stockpiles for the production and maintenance of equipment, were both scarcer and less precise. Nevertheless, it was when Putin pulled these levers that Russia shifted to fighting a protracted war. This chapter outlines how this mobilisation was achieved, examining legislative, financial and industrial changes.

Mobilising Industry

The decision to prepare mobilisation was made during Russia's offensive on Donbas. Officially, it began on 6 July 2022 when the Russian parliament adopted pre-prepared changes to several strategic laws related to Russia's defence, the defence industry and system of public procurement. These created the legal prerequisites for the introduction of some elements of a war economy. [24]

Among other things, changes to the legislation allowed Russia's government to:

- Start using all mobilisation capacities and facilities – primarily industrial facilities that can be involved in the production of goods and materials necessary to wage the war (including mothballed facilities).
- Use material assets of the State Reserve – primarily strategic materials necessary for the production of weapons and military equipment (including reserved ones).

21. Vladimir Putin, « Ukaz Prezidenta ob obyavlenii chastichnoi mobilizatsii » ['Presidential Decree, on the Announcement of Partial Mobilisation'], 21 September 2022, <http://publication.pravo.gov.ru/Document/View/0001202209210001>, accessed 4 December 2024.
22. Julian Cooper, 'If War Comes Tomorrow: How Russia Prepares for Possible Armed Aggression', *Whitehall Report*, 4-16 (August 2016), <https://www.rusi.org/explore-our-research/publications/whitehall-reports/if-war-comes-tomorrow-how-russia-prepares-possible-armed-aggression>, accessed 3 March 2025.
23. Assessments tended to suggest this would be six years, whereas it is now evident that Russian stocks of equipment will begin to deplete after four years of fighting.
24. Vladimir Putin, « Federalniy Zakon, O vnesenii izmeneniy v otdelnye zakonodatelnye akty Rossiyskoy Federatsii » ['Federal Law. On Amending Certain Legislative Acts of the Russian Federation'], 14 June 2022, <http://publication.pravo.gov.ru/Document/View/0001202207140026?rangeSize=1&index=1>, accessed 4 December 2024.

- Restrict labour rights in organisations, institutions and enterprises whose activities are related to the provision of military needs, including the obligation of employees to work 12 hours a day, at night, at weekends and on holidays, as well as the cancellation of annual leave and reducing the mandatory weekend to one day per week.
- Prohibit organisations from refusing to conclude agreements with the government on the supply of goods and services aimed at meeting military needs.
- Refuse tender procedures, and purchase from a single supplier, of the goods and services required for the state defence order, as well as for the formation of stocks of products, raw materials and components necessary to ensure the production of weapons and military equipment.
- Expand state regulation of prices in the sphere of state defence procurements.

These rules could thereafter be applied to any organisation, including private ones, enabling the government to mobilise the economy. These changes built on a robust legislative base, enabling the Russian government to direct its defence industry. In accordance with the Order of the Ministry of Industry and Trade No. 1981 dated 18 May 2022 in the General Register of Enterprises of the Russian Defence Industry, there were about 1,400 enterprises of all forms of ownership.[25] The majority of them were state-owned. More than 977 of these enterprises (including Rostec enterprises) were subordinated to Russia's Ministry of Industry and Trade, 166 to the Ministry of Defence, 80 to Roscosmos and 43 to Rosatom. The state therefore exercised significant management over more than 4,000 enterprises and organisations. More than 4.5 million people worked in Russia at enterprises related to the implementation of state defence orders, as either direct employees or contractors: 25% in scientific organisations and 75% in manufacturing enterprises.[26] Thus, taking into account family members, approximately 10% of Russia's population was connected with the defence industry in 2022, and this figure has since expanded.[27]

These changes affected the portfolio of a range of critical companies. The state corporation Rostec, which includes more than 800 industrial and scientific

25. Ministry of Economic Development of Ulyanovsk Oblast, « Razyasneniya kasatelno protsedury vklyucheniya organizatsiy v svodny reestr organizatsiy oboronno-promyshlennogo kompleksa » ['Clarifications Regarding the Procedure for Including Organisations in the Consolidated Register of Defence Industry Organisations'], 29 September 2022, <https://ekonom73.ru/news/29-09-2022/35566/>, accessed 4 December 2024.
26. G N Chernysheva, T B Ivashinina and Yu A Savich, « Sovremennoe sostoyanie oboronno-promyshlennogo kompleksa Rossii » ['The Current State of the Defense-Industrial Complex of Russia'], 5 March 2024, <https://cyberleninka.ru/article/n/sovremennoe-sostoyanie-oboronno-promyshlennogo-kompleksa-rossii-2/viewer>, accessed 4 December 2024.
27. Assuming 4.5 million people in a population of 140 million produces 3.2%, so that with the conservative estimate of one spouse and one child, or other dependent, per worker, the figure of approximately 10% of the population can be reached.

enterprises,[28] was responsible for the fulfilment of about 40% of the state defence order in 2022.[29] By analysing its financial indicators it is possible to understand the general characteristic of the entire government policy in this area. According to its 2023 results, despite a significant reduction in the export of weapons and military equipment, Rostec's revenues increased to almost 3 trillion roubles (about $34 billion).[30] This was a third more than in 2022, and the main part of these funds was from the state defence order. According to the estimates of Rostec Director General Sergey Chemezov, the structure of these funds mostly reflects the cost of weapons and military equipment, as the profitability of Rostec's production for the Russian military is only 2.28%.[31] Chemezov has stated that up to 80% of equipment employed by Russian forces in Ukraine has included input from Rostec.[32]

Similar processes are taking place with other suppliers of the Russian Ministry of Defence. In 2022, Roscosmos lost a significant part of its export portfolio, which accounted for Western countries and assembled civilian goods and services for use in space. However, in 2023, revenue began to grow again due to an increase in weaponry and military equipment orders. Roscosmos management estimates that in two to three years the loss of Western markets (about $2 billion per year) will be fully compensated.[33]

The significant growth of companies – such as Roscosmos and, as discussed later, Rosatom – is an important part of the impact of Russia's military-industrial mobilisation. These enterprises have taken on significant responsibilities for military-industrial production since 2022. Moreover, because Ukraine's international partners perceive these companies as serving non-military functions, such as nuclear energy, they have often become robust avenues for Russia to obtain specialist equipment and components to enable the continued

28. Rostec, « 'O Goskorporatsiy » ['About the Government Company'], <https://rostec.ru/about/>, accessed 4 December 2024.
29. *RBC News*, « «Rostekh» iz-za gosoboronzakaza zapretil menedzheram ukhodit v otpuska » ['"Rostec" Banned Managers from Going on Leave Because of the State Defence Order'], 10 August 2022, <https://www.rbc.ru/business/10/08/2022/62f26f2c9a79475fc70aea4c>, accessed 4 December 2024.
30. Rostec, « Sergey Chemezov: Rostekh v 2023 godu uvelichil vyruchku na tret » ['Sergey Chemezov: Rostec Increased Revenue by a Third in 2023'], 3 May 2024, <https://rostec.ru/media/news/sergey-chemezov-rostekh-v-2023-godu-uvelichil-vyruchku-na-tret/>, accessed 4 December 2024.
31. *The Insider*, « Politolog: glava «Rostekha» dal ponyat', chto strana ne sokratit finansirovanie pushek radi masla » ['Political Analyst: The Head of Rostec has Made it Clear That the Country Will Not Cut Funding for Guns for the Sake of Butter'], 18 May 2024, <https://theins.ru/news/271656>, accessed 4 December 2024.
32. *RBC News*, « Chemezov zayavil ob «ogromnom kolichestve problem» v ekonomike «oboronki» » ['Chemezov Says "Huge Number of Problems" in Defence Economy'], 17 May 2024, <https://www.rbc.ru/business/17/05/2024/66465d789a79475db1eac775>, accessed 5 February 2025.
33. *TASS*, « Borisov: vyruchka raketno-kosmicheskoy industrii RF za god uvelichilas' na 24 mlrd rubley » ['Borisov: Revenue of the Russian Rocket and Space Industry Increased by 24 Billion Roubles over the Year'], 26 December 2023, <https://tass.ru/ekonomika/19633613>, accessed 4 December 2024.

production of sophisticated weapons. It is not just the scale of their contribution to defence that has increased; it is also their significance.

These dynamics are not entirely new. Roscosmos enterprises were active executors of the state defence order prior to 2022.[34] Their cooperation with Western clients (including governmental ones), in addition to financial income, was also used to obtain access to the most modern Western technologies. Such technologies were necessary, for example, for the development of Russia's own military missile programmes. The West saw Roscosmos as an ordinary space agency and a legitimate partner for NASA and the European Space Agency. However, a large part of the companies that were part of the management of this holding are engaged in the production of weapons and military equipment, including various types of ballistic and cruise missiles for Russia's Strategic Nuclear Forces,[35] missile fuel,[36] missile launchers and artillery systems.[37] This structure is quite natural, because Roscosmos is the legal successor of the Ministry of General Machine Building of the Soviet Union,[38] a body that was responsible for the coordination of a large number of industrial enterprises and scientific institutions that carried out the production of missiles and space technology, including ICBMs.[39]

The important role of Roscosmos in the Russian defence-industrial complex has never been especially hidden. It was directly spelled out in the holding's statutory documents, where it is specifically stated that the Roscosmos corporation was created for the production of missile technology, military and dual-purpose rocket and space technology, the provision of satellite navigation for Russian defence and intelligence agencies, and fulfilment of other tasks of the state armaments programme.[40] The special importance of the defence-industrial function of Roscosmos is indicated by the competencies of the heads of this

34. *RBC News*, « Rogozin otchitalsya Putinu ob uspekakh «Roskosmosa» » ['Rogozin Reports to Putin on Roscosmos Successes'], 20 February 2021, <https://www.rbc.ru/technology_and_media/20/02/2021/6030bd369a794744bffd4cab>, accessed 4 December 2024.
35. *TASS*, « V Rossii startovalo proizvodstvo seriinikh raket «Sarmat» » ['Russia Has Started Serial Production of Sarmat Missiles'], 25 June 2022, <https://tass.ru/kosmos/15031365>, accessed 4 December 2024.
36. *RBC Ufa*, « Salavatskiy khimzavod podal isk na 45 mln k proizvoditelyu raket «Proton» » ['Salavat Chemical Plant Sues Proton Rocket Maker for 45 Million'], 16 July 2021, <https://ufa.rbc.ru/ufa/16/07/2021/60f121e39a7947ee467ed985>, accessed 4 December 2024.
37. *Natsionalna Oborona*, « Sankt-Peterburgskiy «Arsenal»: artilleriyskie ustanovki – v stroyu » ['St Petersburg "Arsenal": Artillery Installations – in Service'], <https://2009-2020.oborona.ru/includes/periodics/defense/2017/0619/122321574/detail.shtml>, accessed 4 December 2024.
38. Space Council, Academy of Sciences of Russia, « Obrazovanie Ministerstva obshchego mashinostroyeniya SSSR » ['Structure of the Ministry of General Machine Building of the Soviet Union'], <http://sovet.cosmos.ru/sites/default/files/history/2_5.pdf>, accessed 4 December 2024.
39. Center 'Z' of Military-Political Research [MGIMO], « «Topol-M»: istoriya sozdaniya i perspektivy » ['"Topol-M": History of Creation and Perspectives'], <http://www.pravo.mgimo.ru/?q=node/23091>, accessed 4 December 2024.
40. Government of the Russian Federation, « Gosudarstvennaya korporatsiya po kosmicheskoy deyatel'nosti «Roskosmos» » ['"Roscosmos", State Corporation for Space Activities'], <http://government.ru/department/363/about/>, accessed 4 December 2024.

corporation in recent years – Dmitriy Rogozin and Yuri Borisov, before leading Roscosmos, had been deputy prime ministers for defence and space industry. Borisov was also the deputy minister of defence responsible for the armament programme of the Russian Armed Forces.

A significant part of the funds in the Russian budget allocated to financing space programmes, even before the full-scale invasion, went to defence tasks – the production of products for the fulfilment of a state defence order, as well as the development of weapons, military and special equipment.[41] In the new space programme for the years 2024–26, more than 1 trillion roubles (about $12 billion) have been laid down. Almost all of these funds will not be directed to the lunar exploration programme, but as state subsidies to companies of the Roscosmos corporation engaged in the development and production of missiles, missile engines and ballistic weapon coordination systems.[42] Among the recipients of subsidies is the Special Design Bureau of the Moscow Energy Institute (OKB MEI), which produces products for the coordination of ballistic, anti-aircraft and cruise missiles, including intercontinental missiles Yars and Bulava. Another form of subsidy is the contribution of funds to the capital of these enterprises. For these needs, Roscosmos will receive $1 billion from the budget in 2024. The Yaroslavl Radio Plant, which produces tactical and satellite military communications for the needs of the Ministry of Defence, will receive part of these funds as part of its charter capital.[43] Special attention in the space programme is paid to the expansion of the satellite group for the performance of military tasks. The militarisation of space technology is, according to the statements of the Russian political leadership, a current priority.

State nuclear energy corporation Rosatom is also an important executor of the Russian state defence order. The structure of Rosatom includes the enterprises of Russia's nuclear weapons complex, which are engaged in the maintenance of operational efficiency, modernisation, development and testing of new models of nuclear weapons. Enterprises are also involved in the development and production of non-nuclear weapons.[44] Like Roscosmos, this function of Rosatom is quite natural. Rosatom is the successor of the Soviet Ministry of Medium

41. *Vedomosti*, « V blizhayshie tri goda Federalnaya kosmicheskaya programma vyrastet bolee chem na 70 mlrd rub » ['In the Next Three Years, the Federal Space Programme Will Grow by More Than 70 Billion Roubles'], 5 October 2022, <https://www.vedomosti.ru/society/articles/2022/10/05/943919-pravitelstvo-uvelichit-finansirovanie-kosmicheskoi-programmi>, accessed 4 December 2024.
42. *Mash News*, « Rossiya vydelyayet trillion na kosmicheskie programmy » ['Russia Allocates 1 Trillion for Space Programmes'], 27 November 2023, <https://mashnews.ru/rossiya-vyidelyaet-trillion-na-kosmicheskie-programmyi.html>, accessed 4 December 2024.
43. *Ibid*.
44. *RIA News*, « Glava «Rosatoma» soobshchil o kratno vyroshey nagruzke po gosoboronzakazu » ['The Head of Rosatom Reported a Large Increase in the Load of State Defence Contracts'], 24 April 2023, <https://ria.ru/20230424/rosatom-1867286132.html>, accessed 4 December 2024.

Machine Building,[45] which, in addition to developing and testing nuclear weapons, dealt with atomic energy. VNIIEF, VNIITF and VNIIA, which carry out the development of nuclear charges and nuclear ammunition,[46] as well as Elektrokhimpribor[47] and Priborostroitelny Zavod,[48] which carry out serial production of nuclear ammunition, are among the enterprises that are part of Rosatom. Rosatom enterprises also participate in the development and production of non-nuclear weapons and military and special equipment,[49] which are actively used by the Russian military against Ukraine.[50] These systems include the Ataka anti-tank guided missile,[51] the Sturm multi-purpose missile complex,[52] the Chrysanthem-S anti-tank missile complex, cluster munitions for the Grad and Smerch multiple launch rocket system (MLRS), the Igla-S MANPADS, complexes for missile control systems, high-precision weapons,[53] and conventional ammunition and their components.[54] Rosatom also develops and produces weapons based on new physical principles, including the Zadyra-16 laser combat complex.

Rosatom's role in the Russian state defence order has predictably increased since the beginning of Russia's full-scale aggression.[55] At the same time, the West continues to hesitate to apply sanctions against Rosatom, citing the high

45. Rosatom, « Otechestvenny lokomotiv ekonomicheskogo progressa » ['Domestic Engine of Economic Progress'], <https://web.archive.org/web/20160304093132/http:/www.delruss.ru/gallery/publication/article/760/article.pdf>, accessed 4 December 2024.
46. I V Blatov, « Kak sozdavalsya yadernyy shchit Rossii » ['How Russia's Nuclear Shield Was Created'], 2009, <https://elib.biblioatom.ru/text/blatov_kak-sozdavalsya-yaderny-schit_2009/p3/>, accessed 3 March 2025.
47. *TASS*, « Eks-sotrudnik proizvodyaschego boepripasy zavoda RF stal figurantom dela o narushenii gostayny » ['Ex-employee of Russian Ammunition Factory Becomes a Defendant in State Secrets Violation Case'], 13 June 2023, <https://tass.ru/proisshestviya/17994311>, accessed 4 December 2024.
48. Rosatom, « Yaderny oruzheynyy kompleks » ['Nuclear Weapons Complex'], <https://rosatom.ru/production/nuclear-weapons-complex/>, accessed 4 December 2024.
49. Russian National Research Institute of Experimental Physics, « Neyadernyye vooruzheniya » ['Non-nuclear Weapons'], <https://www.vniief.ru/researchdirections/notnuclearweapons/>, accessed 4 December 2024.
50. Prime, « Likachev rasskazal o primeneniye tekhniki «Rosatoma» v zone SVO » ['Likhachev Spoke about the Use of "Rosatom's" Equipment in the SMO Zone'], 28 February 2024, <https://1prime.ru/20240228/844659991.html>, accessed 4 December 2024.
51. Russian National Research Institute of Experimental Physics, « Kumulyativnye boevye chasti » ['Cumulative Warheads'], <https://www.vniief.ru/researchdirections/notnuclearweapons/cumulative/>, accessed 4 December 2024.
52. Rosatom, « Ob'yavlen konkurs na zameshcheniye dolzhnosti rukovoditelya FGUP «VNIIA im. N.L. Dukhova» » ['A Competition was Announced to Fill the Position for the Head of "All-Russian Research Institute of Automatics Named after N.L. Dukhov"'], 4 April 2023, <https://web.archive.org/web/20240726015939/https://rosatom.ru/career/competitions-for-substitution/obyavlen-konkurs-na-zameshchenie-dolzhnosti-rukovoditelya-fgup-vniia-im-n-l-dukhova/>, accessed 4 December 2024.
53. Rosatom, « FGUP FNPTS PO «Start» im. M.V. Protsenko » ['FGUP FNPTS PO "Start" Named after M.V. Protsenko'], <https://web.archive.org/web/20241105183626/https://zato.tv/company/fgup-fnpc-po-start-im-mv-procenko>, accessed 4 December 2024.
54. Catherine Belton, 'Russia's Civilian Nuclear Power Conglomerate Aids War Effort, Leading to Calls for Sanctions', *Washington Post*, 20 January 2023.
55. *TASS*, « Gosoboronzakaz Rosatoma uvelichilsya v yadernoy i neyadernoy chasti » ['Rosatom's State Defence Order Increased in Number of Nuclear and Non-Nuclear Parts'], 26 May 2022, <https://tass.ru/ekonomika/14735279>, accessed 4 December 2024.

dependence of Western energy companies on the supply of Russian nuclear fuel and other related technologies.[56] This allows Rosatom to continue to generate substantial income from its international operations.[57] In 2023, it amounted to $16 billion, more than half of all the income of the corporation.[58] In addition, the absence of sanctions removes restrictions on the purchase and import of export-controlled items such as microelectronics, which can also be used by other enterprises of the Russian defence-industrial complex.[59]

In 2022, Rosatom also expanded its production of microelectronics. For this purpose, a new enterprise of the NPO 'KIS' (Scientific and Production Association 'Critical Information Systems') was created within the structure of Rosatom. This entity also started the purchase of specialised assets. In May 2024, it was discovered that Rosatom intends to acquire the Russian company NTC Modul, which produces computing modules, control systems, navigation equipment, high-precision positioning, recognition systems and analysis of video images used in Russian weapons, including in attack UAVs.[60] The purpose of the purchase is to use Rosatom's funds to expand production, as well as eliminate the company's current problems with the supply of Western components. It is important to note that for the development of both nuclear and conventional weapons, Rosatom uses funds that formally have no relation to the Ministry of Defence. For example, the state programme 'Development of the nuclear energy industrial complex', supervised by the Ministry of Energy, includes subprogrammes for financing the development of Russia's defence-industrial complex enterprises.

The activities of the Russian Academy of Sciences (RAN) are also subordinated to the interests of war. Even fundamental scientific research is aimed, in accordance with the position of the Russian government, at 'the creation of scientific and technical development in the interests of the defence and security

56. Anna Roze, « «Skandal'nyy fakt». Pochemu Yevropa prodolzhaet rabotat s «Rosatomom» » ['"Scandalous Fact". Why Europe Continues to Work with Rosatom'], *Radio Svoboda*, 13 November 2023, <https://www.svoboda.org/a/skandalniy-fakt-pochemu-evropa-prodolzhaet-rabotat-s-rosatomom/32682704.html>, accessed 4 December 2024; Darya Dolzikova, 'Power Plays: Developments in Russian Enriched Uranium Trade', RUSI, 14 March 2024, <https://rusi.org/explore-our-research/publications/special-resources/power-plays-developments-russian-enriched-uranium-trade>, accessed 5 February 2025.
57. Darya Dolzikova and Jack Watling, 'Mess Around and Find Out: The Need to Decouple from Rosatom', *RUSI Commentary*, 10 September 2024, <https://www.rusi.org/explore-our-research/publications/commentary/mess-around-and-find-out-need-decouple-rosatom>, accessed 5 February 2025.
58. Atomic Energy, « Rosatom dostig rekordnoy vyruchki v razmere $16 milliardov za rubezhom » ['Rosatom Achieved Record Revenues of $16 Billion Abroad'], 29 February 2024, <https://www.atomic-energy.ru/news/2024/02/29/143591>, accessed 4 December 2024.
59. Belton, 'Russia's Civilian Nuclear Power Conglomerate Aids War Effort, Leading to Calls for Sanctions'.
60. *CNEWS*, « «Rosatom» khochet kupit' razrabotchika mikroelektroniki NTS « Modul» » ['"Rosatom" Wants to Buy Microelectronics Developer NTC "Modul"'], 28 May 2024, <https://www.cnews.ru/news/top/2024-05-28_rosatom_hochet_kupit_razrabotchika>, accessed 4 December 2024; Module, <https://www.module.ru/company#>, accessed 4 December 2024.

of the state, primarily solving the problems of the Armed Forces'.[61] Representatives of the Main Directorate of Innovative Development of Russia's Ministry of Defence, as well as military innovation technopolis 'Era', participate in the determination of scientific research that scientific institutions of the RAN carry out. Direct customers of research are generally designers of defence enterprises. In January 2024, Putin issued a decree on the inclusion of the head of RAN, Academician Gennady Krasnikov, in Russia's Security Council.[62] Russia's budget for 2024 has earmarked about $3 billion solely for fundamental research.[63]

Many other companies have similar recent histories: since 2022, despite clear losses of business in relation to exports, revenue and production have expanded. While space prevents detailed examinations of each case, the point is that the first explanation for Russia's successes in expanding military production was its comprehensive ability to take existing engineering enterprises servicing civilian functions and repurpose them for military production. This was chiefly enabled by tight state control. However, it also reflects Russia's concern with production capacities; this stands in contrast with the West, where dual use is largely a discussion about technologies.

Another important aspect of Russia's legislative changes was the ability to expand the labour available to the defence industry. At the time of writing, Russian defence enterprises are drawing on labour from students in the last year of university[64] and technical schools,[65] as well as those convicted of criminal offences.[66] Drawing on these sources of labour significantly reduces the wage expenses of these categories of employees,[67] who receive a lower wage or are

61. *TASS*, « Kabmin nameren rasshirit' programmu nauchnykh issledovaniy dlya nuzhd SVO » ['The Government Plans to Expand the Scientific Research Programme for the Needs of the Special Military Operation'], 13 June 2024, <https://nauka.tass.ru/nauka/21092895>, accessed 4 December 2024.
62. *RAS*, « Prezident RAN akademik Gennadiy Krasnikov vklyuchyen v sostav Soveta Bezopasnosti Rossiyskoy Federatsii » ['President of the Russian Academy of Sciences, Academician Gennadiy Krasnikov, Included in the Security Council of the Russian Federation'], 15 January 2024, <https://new.ras.ru/activities/news/prezident-ran-akademik-gennadiy-krasnikov-vklyuchyen-v-sostav-soveta-bezopasnosti-rossiyskoy-federats/>, accessed 4 December 2024.
63. Institute for Statistical Research and Knowledge Economy, « Raskhody federal'nogo byudzheta na grazhdanskuyu nauku v 2023 godu » ['Federal Budget Expenditures on Civil Science in 2023'], 3 July 2024, <https://issek.hse.ru/news/938883383.html>, accessed 4 December 2024.
64. *RIA Novosti*, « Mintrud rasskazal, skol'ko studentov rabotayut na predpriyatiyakh OPK » ['Ministry of Labour Reports How Many Students Work at Defence Industry Enterprises'], 16 March 2023, <https://na.ria.ru/20230316/rabota-1858251961.html>, accessed 4 December 2024.
65. *TASS*, « Na predpriyatiya OPK ustroilis' 99% iz tekh, kto proshel na nikh pereobucheniye » ['99% of Those Who Completed Retraining Were Employed at Defence Industry Enterprises'], 28 May 2024, <https://tass.ru/ekonomika/20926245>, accessed 4 December 2024.
66. *Vedomosti*, « Rossiyiskie kompanii nachali aktivnee privlekat' na rabotu osuzhdennykh k prinuditelnomu trudu » ['Russian Companies Have Begun to More Actively Hire Prisoners for Forced Labour'], 1 August 2023, <https://www.vedomosti.ru/management/articles/2023/08/01/987869-rossiiskie-kompanii-nachali-aktivnee-privlekat-na-rabotu-osuzhdennih>, accessed 4 December 2024.
67. *URA News*, « «Rostekh» trudoustroit osuzhdennykh iz sverdlovskikh ispravtsentrov » ['"Rostekh" to Employ Prisoners from Sverdlovsk Correctional Facilities'], 17 October 2023, <https://ura.news/

not paid at all. As of May 2024, there were about 34,000 convicts in Russia who were being used for forced labour, both at defence-industrial enterprises and in logistical and other functions supporting the defence industry. Russia aims to increase this source of labour in 2025 to 80,000.[68] According to information released in May 2024 by British defence intelligence, the Russian government is also planning to introduce forced labour mobilisation, with appropriate changes to labour legislation being prepared for this purpose.[69] Russia is also making immigrants from Africa and elsewhere work in its defence industries,[70] although this is not likely to be an extensive phenomenon.

Another important element of the transition to war is the blending of defence-industrial processes with the units of the Russian Armed Forces. The re-establishment of BTRZ (equipment repair workshops), was a key part of Russia's industrial mobilisation plan and enabled the maintenance of legacy equipment. Specialist enterprises of the Russian Ministry of Defence and the repair units of the Russian Armed Forces are actively involved in restoring and repairing weapons and military equipment, as well as carrying out a full cycle of pre-combat preparations of new equipment, including in the combat zone.[71] Such enterprises and units use mobilised personnel as well as conscripts.

According to Russian military standards, repair work aimed at restoring the operational efficiency and serviceability of weapons or their components is divided into military repair, which is carried out at the bases and locations of military operating units (*voiskovoi remont*), mostly by the Russian Armed Forces independently; and factory repair (*zavodskoi remont*), which involves sending weaponry and military equipment to repair enterprises and manufacturing plants. In accordance with Russian standards, only major repairs are carried out at repair enterprises and manufacturing plants; all current repair work must be carried out by military units that operate the equipment independently or with the involvement of specialist repair units. Thus, only those systems that have suffered significant damage are sent to the factories; the military itself must repair medium and light damage. According to information released by

news/1052695553>, accessed 4 December 2024.

68. *New Prospect*, « Ispravlennomu verit'. Kak biznes ispol'zuet trud osuzhdennykh i chto oni sami ob etom dumayut » ['Trust the Reformed. How Business is Using Prisoner Labour and What They Think About It'], 29 May 2024, <https://newprospect.ru/news/articles/ispravlennomu-verit-kak-biznes-ispolzuet-trud-osuzhdennykh-i-chto-oni-sami-ob-etom-dumayut/>, accessed 4 December 2024.
69. UK Ministry of Defence, 'Latest Defence Intelligence Update on the Situation in Ukraine – 20 May 2024', @DefenceHQ, X Post, 20 May 2024, <https://x.com/DefenceHQ/status/1792473858575937892>, accessed 4 December 2024.
70. Emma Burrows and Lori Hinnant, 'Africans Recruited to Work in Russia Say They were Duped into Building Drones for Use in Ukraine', *AP*, 10 October 2024.
71. Nasha Oborona, « Vosstanovlenie i remont voennoy tekhniki i vooruzheniya v polevykh usloviyakh » ['Recovery and Repair of Military Equipment and Armaments in Field Conditions'], 11 August 2023, <https://nashaoborona.ru/2023/08 />, accessed 4 December 2024.

the Russian Ministry of Defence at the beginning of 2024, of the weapons, military equipment and special equipment damaged during the war, only 7% is sent to specialist enterprises for repair. Most of the systems (66%) in need of repair are restored by military repair units. A further 22% are repaired by field teams of the Ministry of Defence's enterprises.[72]

Financial Mobilisation

The discussion above demonstrates that Russian industry has been reoriented to serve defence. This section turns to its funding. Analysis of Russia's defence industry has chronically under-estimated its defence spending. When evaluating the level of financial support of the Russian Armed Forces, especially in terms of their ability to purchase new weapons, many researchers limit their analysis to the annual budget of Russia's Ministry of Defence, as represented in US dollars. The budget of Russia's Ministry of Defence in 2024 was approximately $52 billion, or approximately 15 times less than that of the US Department of Defense, and comparable to that of the UK or France.[73] Given that Russia has a larger force and a significantly larger arsenal than the UK or France, and further expanded production after 2022, the dollar value of the defence budget clearly does not reflect defence spending. As Richard Connolly has observed, Russia's defence expenditure is considerably higher when compared using purchasing power parity, which produces a level of expenditure commensurate with the results prior to 2022.[74]

Along with a higher baseline of expenditure prior to the war, Russian expenditure on defence has also grown considerably since 2022. Total funding for Russian defence, security and intelligence in 2024 is about $150 billion (non-PPP comparison),[75] with defence amounting to approximately 38.6% of the total budget and about 6.7% of Russia's GDP.[76] Organisations such as the Stockholm

72. Lenta.ru, « V Minoborony rasskazali o remonte voennoy tekhniki v usloviyakh SVO » ['The Ministry of Defence Discusses the Repair of Military Equipment under the Conditions of the Special Military Operation'], 3 January 2024, <https://lenta.ru/news/2024/01/03/v-minoborony-rasskazali-o-remonte-voennoy-tehniki-v-usloviyah-svo/>, accessed 4 December 2024.
73. Duma, « Komitet po oborone utverdil zaklyucheniye na proyekt byudzheta na 2023–2025 gody » ['The Defense Committee Approved the Conclusion on the Draft Budget for 2023–2025'], 11 October 2022, <http://duma.gov.ru/news/55471/>, accessed 23 March 2025.
74. Richard Connolly, 'Russian Military Expenditure in Comparative Perspective: A Purchasing Power Parity Estimate', CNA, October 2019, <https://www.cna.org/reports/2019/10/russian-military-expenditure>, accessed 9 March 2025.
75. *Izvestiya*, « Zashchita i mekhanizm: na oboronu i bezopasnost' potratiat 39% byudzheta-2024 » ['Defence and Security: 39% of the 2024 Budget will be Allocated to Defence'], 13 November 2023, <https://iz.ru/1604090/milana-gadzhieva-mariia-kolobova/zashchita-i-mekhanizm-na-oboronu-i-bezopasnost-potratiat-39-biudzheta-2024>, accessed 4 December 2024.
76. *Current Time*, « Uzhe v 2024 godu pochti 40% rossiyskogo byudzheta uydut na armiyu i silovikov » ['Almost 40% of Russia's Budget in 2024 Will Go to the Army and Law Enforcement: What Will be Saved?'],

International Peace Research Institute exclude security and intelligence funding from calculations of Russian defence expenditure, as this includes a range of non-defence activities. While this was a defensible position prior to 2022, it is difficult to justify since the invasion. There are more than 25,000 troops of the Russian Guard operating in the occupied territories in Ukraine, fielding some 520 armoured fighting vehicles, 140 artillery pieces and 22 helicopters.[77] The FSB (Federal Security Service), meanwhile, has established a large presence in the occupied territories that is critical to Russia's counterintelligence regime there.[78] Russia's special services have also played a major role in financing the recruitment of personnel in Ukraine. Although security spending should not be counted as only related to defence, a significant proportion of it has directly contributed to the war effort since 2022.

Much of the additional expenditure in the defence budget, furthermore, goes to financing the invasion in Ukraine, and the share of these funds intended for defence purchases is significantly higher than in Western countries. Thus, in 2022, the volume of the state defence order amounted to about $27 billion.[79] In 2023, it was increased 1.5 times,[80] and continued to increase in 2024.[81] To cover such high expenditure, a significant part of the funds is raised using bank loans,[82] where the main role is still assigned to Promsvyazbank (PSB). Since 2019, the Russian government has designated PSB as a support bank for servicing the defence industry. At the same time, the government signs long-term contracts

29 November 2023, <https://www.currenttime.tv/a/rossiyskogo-byudzheta-armiyu-silovikov/32703638.html>, accessed 4 December 2024.

77. *Rosgvardiya*, « Uchastiye voysk natsional'noy gvardii v spetsial'noy voyennoy operatsii » ['Participation of the National Guard Troops in the Special Military Operation'], <https://web.archive.org/web/20230131101426/https://rosguard.gov.ru/special/Z/index.html>, accessed 5 February 2025; Kommersant, « Zolotov rasskazal o boytsakh Rosgvardii na SVO i vspomnil popytku myatezha Prigozhina » ['Zolotov Talks about the Rosgvardiya Fighters in the Special Military Operation and Recalls Prigozhin's Mutiny Attempt'], 3 October 2023, <https://www.kommersant.ru/doc/6691905>, accessed 5 February 2025.
78. Jack Watling, Oleksandr V Danylyuk and Nick Reynolds, 'Preliminary Lessons from Russia's Unconventional Operations During the Russo-Ukrainian War, February 2022–February 2023', RUSI, 29 March 2023, <https://rusi.org/explore-our-research/publications/special-resources/preliminary-lessons-russias-unconventional-operations-during-russo-ukrainian-war-february-2022>, accessed 3 February 2025.
79. Pavel Luzin and Alexandra Prokopenko, « Pushki vazhyie vsego. Chto proekt byoudzheta – 2024 govorit o priopitetakh Kremlia » ['Russia's 2024 Budget Shows It's Planning for a Long War in Ukraine'], Carnegie Politika, 11 October 2023, <https://carnegieendowment.org/russia-eurasia/politika/2023/09/russias-2024-budget-shows-its-planning-for-a-long-war-in-ukraine?lang=ru>, accessed 4 December 2024.
80. *Rossiyskaya Gazeta*, « Shoygu: v 2023 godu finansirovanie gosoboronzakaza uvelichitsya v 1,5 raza » ['Shoigu: In 2023, Financing of State Defence Orders Will Increase by 1.5 Times'], 30 November 2022, <https://rg.ru/2022/11/30/shojgu-v-2023-godu-finansirovanie-gosoboronzakaza-uvelichitsia-v-15-raza.html>, accessed 4 December 2024.
81. *Interfax Military News*, « Ob'yemy zakupok i remonta tekhniki dlya nuzhd Vooruzhennykh sil RF uvelichatsya – Shoygu » ['Procurement and Repair Volumes for the Needs of the Russian Armed Forces Will Increase – Shoigu'], 21 November 2023, <https://www.militarynews.ru/story.asp?rid=1&nid=606577&lang=RU>, accessed 4 December 2024.
82. *Vedomosti*, « Gosoboronzakaz budut vypolnyat' v dolg » ['State Defence Order Will Be Fulfilled on Credit'], 13 December 2020, <https://www.vedomosti.ru/politics/articles/2020/12/13/850768-gosoboronzakaz-dolg>, accessed 4 December 2024.

with defence enterprises. Payments must be made after several years and, to fulfil the contract, the enterprises receive a targeted loan from PSB. This makes it possible to order and receive weapons for amounts that are significantly larger than the combined annual procurement budgets of the defence and security agencies. With the sufficiently high discount rate (16%) of Russia's Central Bank and expensive loans provided at 18–19% per annum, defence industry enterprises receive loans in the range of 5–6%.[83] This is ensured by subsidising the difference on the part of the government, as well as providing soft loans by the banks themselves, which then receive compensation from the Central Bank.

Alongside the higher than usually acknowledged baseline of expenditure on defence in Russia, the significant expansion of the defence budget since 2022 and the favourable structures of loans to accelerate the availability of funds for defence enterprises, defence has drawn on budgets outside spending allocated to the Ministry of Defence. When assessing the real level of Russia's cost of waging war in Ukraine, significant expenditure is borne by civil department budgets or is compensated by state and sometimes even private company funds. In addition to the state programmes 'Development of the defence-industrial complex',[84] 'Ensuring the country's defence capability'[85] and others, the military nature of which is understandable, the budgets of formerly civilian programmes are also used to finance the needs of the defence-industrial complex. These include:

- 'Space activities of Russia' and 'Development of the nuclear power industrial complex' (about $1 billion per year).[86]
- 'Development of the electronic and radioelectronic industry' (more than $2 billion per year).[87]
- 'Scientific and technological development of the Russian Federation' (Ministry of Education and Science, about $15 billion per year).[88]

83. *RBC*, « Chemezov — RBK: «Ekonomika dlya voennykh — delo desyatoe» » ['Chemezov – RBC: "The Economy for the Military is a Secondary Issue"'], 17 May 2024, <https://www.rbc.ru/interview/economics/17/05/2024/664215389a7947dc93772782#toc-772782-8>, accessed 4 December 2024.
84. Government of the Russian Federation, « Ob utverzhdenii gosudarstvennoy programmy Rossiyskoy Federatsii «Razvitie oboronno-promyshlennogo kompleksa» » ['On Approval of the State Programme of the Russian Federation "Development of the Defence Industry Complex"'], 16 May 2016, <http://ips.pravo.gov.ru/?doc_itself=&nd=102398541&page=1&rdk=4&link_id=151#I0>, accessed 4 December 2024.
85. Government of the Russian Federation, « Gosudarstvennaya programma «Obespechenie oboronosposobnosti strany» » ['State Programme "Ensuring the Defence Capability of the Country"'], <http://government.ru/rugovclassifier/872/>, accessed 4 December 2024.
86. *TASS*, « Finansirovanie atomnoy otrasli v 2023–2025 godakh predlagaetsya uvelichit' na 17 mlrd rubley » ['Financing of the Nuclear Industry in 2023–2025 is Proposed to Increase by 17 Billion Roubles'], 28 September 2022, <https://tass.ru/ekonomika/15901703>, accessed 4 December 2024.
87. *Interfax*, « Raskhody na programmu razvitiya radioelektroniki mogut sokratit' na 3 mlrd rubley » ['Spending on the Radio Electronics Development Programme May be Reduced by 3 Billion Roubles'], 29 September 2023, <https://www.interfax.ru/business/923434>, accessed 4 December 2024.
88. *TASS*, « Gosprogramma «Nauchno-tekhnologicheskoe razvitie RF» v 2024 godu prevysit 1,33 trln rubley » ['The State Programme "Scientific and Technological Development of the Russian Federation" Will

- 'Economic development and innovative economy' (Ministry of Economic Development, more than $4.2 billion for the period 2022–24).[89]
- 'Development of industry and increasing its competitiveness' (Ministry of Industry and Trade, more than $7 billion in 2024).[90]
- 'Development of the aviation industry' (about $10 billion by 2030 – Rostec will receive most of the funds)[91] and others.

Not all funds in each budget line are diverted to military expenditure. However, the emergence of a centralised planning process for military-industrial coordination within the presidential administration has allowed for investments from these budget lines to significantly contribute to the defence industries, through investment in machine tooling, training, logistics and other expenditures. These would otherwise be borne by the defence budget. The involvement of these programmes in defence-related activities is indicated by the decision of the Russian government not to publish data on their implementation.[92] In addition, Roscosmos took a legislative initiative to classify information about all commercial operations of its companies to 'protect suppliers'.[93] The Russian government also decided not to publish data on several programmes in the field of international cooperation, in particular 'Foreign Policy Activities' and 'Support and Promotion of the Russian Language'. This may indicate that these programmes are used to finance the foreign operations of Russian special services. The Russian Fund for the Support and Protection of the Rights of Compatriots Living Abroad (known as Pravfond), which was officially supposed to provide legal assistance to Russian expatriates, was used to conduct Russian influence operations in 48 countries – the majority in Europe – on which millions of euros were spent.[94]

Exceed 1.33 Trillion Roubles in 2024'], 29 September 2023, <https://tass.ru/ekonomika/18878567>, accessed 4 December 2024.

89. Ministry of Economics of Russian Federation, « Gosudarstvennaya programma «Ekonomicheskoye razvitiye i innovatsionnaya ekonomika» » ['State Programme "Economic Development and Innovative Economy"'], <https://web.archive.org/web/20221008044027/https://www.economy.gov.ru/material/departments/d19/gosudarstvennaya_programma_ekonomicheskoe_razvitie_i_innovacionnaya_ekonomika/>, accessed 04 December 2024.
90. *TASS*, « Finansirovanie gosprogrammy po promyshlennosti RF uvelichat na 267,9 mlrd rubley v 2024 godu » ['Funding for the Russian Industrial Programme Will Increase by 267.9 Billion Roubles in 2024'], 27 September 2023, <https://tass.ru/ekonomika/18857753>, accessed 4 December 2024.
91. *Vedomosti*, « Na razvitiye aviaproma iz FNB vydelyat bolee 280 mlrd rubley » ['More Than 280 Billion Roubles Will Be Allocated from the National Wealth Fund for the Development of the Aviation Industry'], 15 January 2024, <https://www.vedomosti.ru/business/articles/2024/01/15/1015149-aviaproma-fnb-280>, accessed 4 December 2024.
92. *TASS*, « V RF do kontsa 2024 goda ne budut publikovat' dannye o realizatsii nekotorykh gosprogram » ['In Russia, Data on the Implementation of Some State Programmes Will Not Be Published Until the End of 2024'], 22 December 2023, <https://tass.ru/politika/19613955>, accessed 4 December 2024.
93. *RIA Novosti*, « Roskosmos khochet zasekretit' goszakupki, svyazannye s gosoboronzakazom » ['Roscosmos Wants to Classify State Procurement Related to the State Defence Order'], 27 April 2023, <https://ria.ru/20230427/roskosmos-1868162038.html>, accessed 4 December 2024.
94. Andrew Roth, 'Revealed: Russian Legal Foundation Linked to Kremlin Activities in Europe', *The Guardian*, 2 June 2024.

Expanding Production

The output of Russian defence industries has increased due to the effectiveness of the measures outlined above. When it adopted a strategy premised on outlasting Ukraine and its international partners, Russia based many of its industrial targets in 2022 on an assessment of anticipated production in NATO countries. These assessments assumed that industrial mobilisation would be taking place across NATO, albeit unevenly, by 2023, and would reach the planned levels of output in 2024. To overtake the West, Russian enterprises began to work in three shifts, six days a week. At the end of 2022, Russian experts believed that Russia was four months ahead of the West in setting up arms production. This was evaluated as an extremely positive result, since, according to them, 'the one who starts the military assembly line first gets an undeniable advantage'.[95] Importantly, the failure of NATO countries to demonstrate alacrity in military-industrial investment at this time contributed to the Kremlin's optimism over the long-term trajectory of the conflict.

In parallel with the maximum development of existing industrial capacities, the Russian government began to actively invest in the creation of new production facilities. According to analysis of satellite images since February 2022, many Russian defence enterprises were expanded, and some were built 'from scratch'.[96] This applies to enterprises engaged in the production and maintenance of ammunition as well as UAVs, combat helicopters and explosives. According to Putin, during the first year and a half of the invasion, Russia created 520,000 new jobs in the defence industry.[97] The process of building up defence and industrial capacities has continued. In 2024, almost $1 billion was spent on the renewal and expansion of defence-industrial plants in Tatarstan alone. A significant part of these funds went to the development of the Kazan Gunpowder Plant.[98] Notably, these funds are not government expenditures, but Rostec's own investments.

95. *TASS*, « Kakim stal 2022 god dlya oboronno-promyshlennogo kompleksa Rossii » ['How 2022 Was for Russia's Defence Industry'], 28 December 2022, <https://tass.ru/armiya-i-opk/16696305>, accessed 4 December 2024.
96. *Current Time*, « Rossiya stroit novye voennye zavody po vsej strane i rasshiryaet uzhe imeyushchiesya – spouknikovye snimki » ['Russia is Building New Military Factories Across the Country and Expanding Existing Ones – Satellite Images'], 27 October 2023, <https://www.currenttime.tv/a/rossiya-stroit-voennie-zavody/32655505.html>, accessed 4 December 2024.
97. *TASS*, « Putin: bolee 520 tys. novykh rabochikh mest sozdano v oboronke v RF za poslednie 1,5 goda » ['Putin: More Than 520 Thousand New Jobs Created in the Defence Industry in Russia over the Past 1.5 Years'], 2 February 2024, <https://tass.ru/armiya-i-opk/19886153>, accessed 4 December 2024.
98. *URA News*, « Rostekh potratit 70 mlrd na razvitie oboronnykh zavodov v Tatarstane » ['Rostec Will Spend 70 Billion Roubles on the Development of Defence Factories in Tatarstan'], 18 April 2024, <https://ura.news/news/1052757641>, accessed 4 December 2024.

The level of combat readiness of the troops depends not only on the amount of allocated funds, but also on the efficiency of their use. It is important to note that the main military-economic approach to providing the Russian Armed Forces with the necessary weapons and military equipment is to maximise their military-economic efficiency, which is determined by 'the level of damage inflicted on enemy objects at a certain time and at a certain cost of material resources'.[99] This determines the preference for cheaper, mass samples, as well as the restoration and modernisation of existing weapons, including those that are in 'deep conservation' warehouses.[100] This approach is particularly noticeable with Russian armoured vehicles. Of the 2,100 tanks that were delivered to the Russian Armed Forces in 2023,[101] only 210 were new tanks and more than 800 were modernised T-72s. The remaining tanks were restored T-72s and T-80s, as well as some obsolete T-62s. There were also T-55s/54s, which are mostly used as self-propelled artillery to fire from closed positions, as well as to strengthen defence lines as long-term firing points. For comparison, in 2023, Ukraine received 70 Leopard 2s, 31 Abrams M1s and 14 Challenger 2s, none of which were new, as well as about 100 Leopard 1s manufactured in the 1960s and 1970s.[102]

Russia has taken the same approach with guided aerial bombs. These have become one of the primary weapons of the Russian Aerospace Forces in the war.[103] In production and, as a result, use, preference is given to the conversion of conventional unguided aerial bombs (FAB-250, FAB-500, FAB-1500 and FAB-3000), large stocks of which were left over from Soviet times, to guided glide munitions with a range of up to 70 km. Such a transformation is carried out by installing a mounted planning and correction module (UMPK) developed by the Russian enterprise Basalt, which is part of Rostec. The UMPK is a Russian analogue of the American JDAM. The relatively low price of the kit, which was

99. G A Baharev, « Boyevaya effektivnost' i zatraty » ['Combat Effectiveness and Costs'], <https://cyberleninka.ru/article/n/boevaya-effektivnost-i-zatraty-1/viewer>, accessed 4 December 2024.
100. Lenta.ru, « «Armiya vryad li budet ispol'zovat'.» Glava «Rosteha» ob'yasnil otsutstvie novejshego rossijskogo tanka «Armata» na SVO » ['"The Army Is Unlikely to Use It". The Head of "Rostec" Explained the Absence of the Latest Russian Tank "Armata" in the Special Military Operation'], 4 March 2024, <https://lenta.ru/news/2024/03/04/armata-ona-v-obschem-to-dorogovata-glava-rosteha-ob-yasnil-otsutstvie-noveyshego-rossiyskogo-tanka-v-zone-svo/>, accessed 4 December 2024.
101. Karolina Modzelewska, « Ponad sto czołgów miesięcznie? Rosja na poważnie wzięła się za ich produkcję » ['Over a Hundred Tanks a Month? Russia has Taken Their Production Seriously'], *WP Tech*, 14 December 2023, <https://tech.wp.pl/ponad-sto-czolgow-miesiecznie-rosja-na-powaznie-wziela-sie-za-ich-produkcje,6973704637721248a>, accessed 4 December 2024.
102. Volodymyr Datsenko, « Vid blyzko 800 odynyts bronetekhniky u sichni do nulya u zhovtni. Chomu Zakhid perestav aktyvno postachaty Ukraini vazhke ozbroiennya? Doslidzhennya Forbes » ['From Nearly 800 Armoured Vehicles in January to Zero in October. Why Has the West Stopped Actively Supplying Ukraine with Heavy Weaponry? Forbes Investigation'], *Forbes Ukraine*, 9 November 2023, <https://forbes.ua/war-in-ukraine/vid-blizko-800-odinits-bronetekhniki-u-sichni-do-nulya-u-zhovtni-chomu-zakhid-perestav-aktivno-postachati-ukraini-vazhke-ozbroennya-doslidzhuvav-forbes-09112023-17145>, accessed 4 December 2024.
103. David L Stern and Serhii Korolchuk, 'Russia's Glide Bombs Give its Air Force New Power in Ukraine', *Washington Post*, 11 March 2024.

about $20,000, attracted the Russians at that time.[104] The UMPK is much simpler than the JDAM. In addition to the relatively accurate kits equipped with a satellite and inertial guidance system, capable of hitting targets at 40–70 km, the Russians also produce and use even more simplified versions that have only an inertial guidance system, and even uncorrected ones that are equipped only with folding wings.

The use of cheaper but more primitive modifications of the UMPK inevitably decreases accuracy. This is compensated for by the use of heavy high-explosive aerial bombs weighing 1,500 kg and 3,000 kg,[105] as well as cluster and vacuum bombs, which significantly increase the area of effect. Thus, when using the FAB-3000, the radius of complete destruction of buildings is 18 metres, the lethal impact on manpower is 40 metres, and the infliction of severe but non-fatal injuries is 160 metres. Since the Soviet reserves are finite, production of the FAB-3000 has resumed in Russia, and production of the FAB-1500 and FAB-500 is also ramping up.[106] Currently, Russian industry is trying to adapt UMPK kits for its stocks of FAB-5000 and FAB-9000, which will likely be used to destroy large industrial buildings, port and railway infrastructure, and warehouses, causing significant damage to residential areas.[107]

Partial success with the use of UMPK will probably inspire Russia to look for other relatively cheap solutions that can advance the mass production and use of high-precision weapons.[108] Such solutions could include Russian analogues of the precision guidance kit (PGK) M1156, which turns unguided 155-mm projectiles into guided ones (estimated price of the kit is $12,000), as well as the AGR-20 advanced precision kill weapon system ($20,000), which turns unguided Hydra 70 rockets into precision ones. The Russian defence industry is trying to move in this direction. Among the projects that are receiving special support, it is worth highlighting the OU-122 system,[109] which equips unguided 122-mm projectiles

104. Eric Tegler, 'The Boeing Kratos PJDAM is a 300-Mile Smart Bomb', *Forbes*, 25 October 2023, <https://www.forbes.com/sites/erictegler/2023/10/25/the-boeing-kratos-pjdam-is-a-300-mile-smart-bomb/>, accessed 10 March 2025.
105. *TopWar*, « Kogda razmer imeet znachenie: UMPK na FAB povyshennogo moguschestva » ['When Size Matters: UMPK for High-Power FAB'], 13 September 2023, <https://topwar.ru/225777-kogda-razmer-imeet-znachenie-umpk-na-fab-povyshennogo-moguschestva.html>, accessed 4 December 2024.
106. *Rossiyskaya Gazeta*, « V Rossii nachalos massovoe proizvodstvo trekhtonnykh aviabomb FAB-3000 » ['Mass Production of Three-tonne FAB-3000 Aerial Bombs Has Begun in Russia'], 21 March 2024, <https://rg.ru/2024/03/21/v-rossii-nachalos-massovoe-proizvodstvo-trehtonnyh-aviabomb-fab-3000.html>, accessed 4 December 2024.
107. *TopWar*, « Kogda razmer imeet znachenie » ['When Size Matters'].
108. *TopWar*, « Problema vysokoj stoimosti vysokotochnykh boepripasov i puti ee resheniya » ['The Problem of the High Cost of Precision-Guided Munitions and Ways to Solve It'], 18 September 2022, <https://topwar.ru/201871-problema-vysokoj-stoimosti-vysokotochnyh-boepripasov-i-puti-ee-reshenija.html>, accessed 4 December 2024.
109. *TopWar*, « RSZO stanut vysokotochnymi blagodarya novoj sisteme navedeniya » ['MLRS Will Become High-Precision Thanks to a New Guidance System'], 25 June 2019, <https://topwar.ru/159424-rszo-stanut-vysokotochnymi-blagodarja-novoj-sisteme-navedenija.html>, accessed 4 December 2024.

for the Grad and Tornado-G MLRS with a guidance system with an accuracy of up to 10 metres, as well as the Russian complex Ugroza,[110] which turns Russian unguided S-5, S-8 and S-13 rockets into precision munitions. It is also possible to substitute the expensive Krasnopol laser-guided 152-mm projectile and return to the Dynamika module, which was a Russian analogue of the PGK M1156 for projectiles of 152-mm calibre and above, and costs less than $1,000.[111]

The ability to produce means of destruction in the volume that meets the requirements of a full-scale war (primarily artillery shells and missiles, the production of which has increased in Russia since the beginning of 2022 from 14 to 22 times, depending on type) directly depends on the availability of the necessary amount of explosives, rocket fuel and some other chemical substances. In Russia these are called 'special chemistry', following the Soviet tradition.[112] Notably, before 2022 Russia was one of the world leaders in the production of explosives, and yet since the full-scale invasion, billions are still being invested both in the modernisation of existing enterprises and in the construction of new special chemical enterprises.[113] The Ministry of Industry and Trade is responsible for the financing and implementation of these investments in Russia.

One of the main tasks is to achieve complete independence from foreign supplies. Russia successfully circumvents sanctions by purchasing raw materials – even from NATO countries – to produce explosives.[114] However, the Russian leadership does not favour this. To reduce dependence on imports, Russia is searching for and using alternative technologies. For example, Russia is not a producer of cotton, which is necessary to produce nitrocellulose which, in turn, is the main raw material in the production of gunpowder and other explosive substances. To improve its own supply, the Russian government is investing in the development of technology to produce nitrocellulose from wood and flax.[115] According to

110. Missilery.info, « Kompleks aviatsionnogo upravlyaemogo oruzhiya Ugroza (S-5Kor, S-8Kor, S-13Kor) » ['Airborne Guided Weapon System Ugroza (S-5Kor, S-8Kor, S-13Kor)'], <https://missilery.info/missile/ugroza>, accessed 4 December 2024.
111. *TopWar*, « Chto ni vystrel – vse v tsel! » ['Every Shot Hits the Target!'], 22 October 2011, <https://topwar.ru/7853-chto-ni-vystrel-vse-v-cel.html>, accessed 4 December 2024.
112. O N Maslenikova and L M Amirova, « Sostoyanie i perspektivy razvitiya proektnogo dela v oblasti proizvodstv boepripasov i spetskhimii » ['Status and Prospects of Project Development in the Field of Ammunition and Special Chemical Industries'], 2016, <https://cyberleninka.ru/article/n/sostoyanie-i-perspektivy-razvitiya-proektnogo-dela-v-oblasti-proizvodstv-boepripasov-i-spetshimii/viewer>, accessed 4 December 2024.
113. *Izvestia*, « Medvedev zaiavil o milliardnykh investitsiiakh v novye predpriiatiia spetskhimii » ['Medvedev Announced Billion-Dollar Investments in New Special Chemistry Enterprises'], 11 July 2024, <https://iz.ru/1726117/2024-07-11/medvedev-zaiavil-o-milliardnykh-investitciiakh-v-novye-predpriiatiia-spetckhimii>, accessed 4 December 2024.
114. Ian Talley and Brett Forrest, 'Russia Doubled Imports of an Explosives Ingredient – With Western Help', *Wall Street Journal*, 29 March 2024.
115. *TopWar*, « Rossiiskii OPK osvoil proizvodstvo porokha iz drevesiny » ['Russian Defence Industry Has Mastered the Production of Gunpowder from Wood'], 8 April 2024, <https://topwar.ru/239993-rossijskij-opk-osvoil-proizvodstvo-poroha-iz-drevesiny.html>, accessed 4 December 2024.

statements from Rostec representatives, industrial production has already started and there are plans to increase the share of gunpowder produced from such nitrocellulose to 60–70%.[116] While European explosives manufacturers are concerned about the reliability of the supply of cotton from China,[117] the world's largest cotton producer, research is also being carried out in China to produce nitrocellulose from wood. According to researchers, this will not only expand the raw material base, but also reduce the cost of production.[118]

The results of Russian government policies are reflected in the year-on-year production figures so far during the war. Many Western commentators have assumed a high level of corruption and thus inefficiency in Russian defence production. There is corruption, certainly, but this has not prevented Russian industry from meeting its allocated targets. In summer 2023, Russian industry provided the Ministry of Defence with an assessment of what it was likely to deliver in 2024. In 2022, Russian industry had produced 250,000 152-mm artillery shells, which had risen to 1 million in 2023. In 2024, the projected output was 1.325 million 152-mm rounds. In practice, Russia produced just over 1.3 million 152-mm rounds. Russian industry projected that it would produce 800,000 122-mm shells and managed to meet this target in 2024. Growth in 2025 will continue, especially later in the year as new special chemistry factories begin to reduce limitations on available propellent and high explosive to fill shells. Russian industry managed to produce 420 out of a target of 460 Kh-101 missiles in 2023, and, in 2024, this rose to over 500. Production of 9M723 ballistic missiles rose from approximately 250 in 2023 to more than 700 in 2024. UMPK production has also grown precipitously, from only a few thousand units in 2023 to around 40,000 units in 2024, with more than 70,000 ordered for 2025. UAV development is also expanding, with the production rate of Geran-2 one-way-attack UAVs reaching 30 units per day by the end of 2024. Armoured vehicle manufacture, including artillery production, has remained steady at around 2,000 tanks and 3,000 other armoured fighting vehicles per year, although only about 10–15% of these are new-build. However, Russian industry is rapidly acquiring barrel machines and working to expand production lines to increase the output of new-build armoured vehicles. Although output is increasing, it will be lower than current refurbishment rates. The figures speak for themselves in demonstrating that Russia has managed to significantly increase production of its critical weapons systems.

116. *Ibid.*
117. Arjun Neil Alim, Patricia Nilsson and Sylvia Pfeifer, 'European Defence Groups Warn over Reliance on Chinese Cotton Used in Gunpowder', *Financial Times*, 8 April 2024.
118. Google Patents, 'Method for Preparing Cellulose Nitrate for Explosive from Wood Pulp', <https://patents.google.com/patent/CN102219861B/en>, accessed 4 December 2024.

In summary, an examination of the measures that Russia has adopted makes both the scale of its industrial output and the speed of expansion comprehensible. The current Russian defence-industrial policy is characterised by the following factors:

- A high level of coherence due to the extensive preparation and planning of the defence-industrial mobilisation process, which was adhered to and implemented.
- A high degree of centralised control following the establishment of a centralised coordinating mechanism to manage the process of defence-industrial mobilisation.
- The establishment of several elements of a war economy, including: industrial mobilisation; the introduction of the appropriate legal regime, which allows the government to set direct tasks to both state and private companies that produce weaponry and military equipment and their components, or produce or extract the necessary raw materials for their production; and the authority to set prices, and to limit the labour rights of employees.
- A ready availability of funds, due to the growth in budget for the production and development of weapons, which is a result of significant increases in the direct budgets of the Ministry of Defence and other paramilitary bodies that are directly involved in the war, as well as the allocation to the war of budgets of a wide range of civilian departments and organisations (Ministry of Industry and Trade, Rosatom, Roscosmos, Ministry of Education and Science, RAN and others). Taking into account this level of militarisation of officially civilian programmes, the real level of budgetary funding of the Russian military's defence industry programmes is significantly higher than indicated solely by the size of the Russian defence budget, which is about $150 billion.
- A high level of attracting state and private bank credit to produce weapons and military equipment, with reimbursement by the Russian Central Bank of part of the interest on such loans. This allows defence-industrial enterprises to attract loans at 5–6% per annum in roubles. Such lending allowed for an increase in the volume of the state defence order in 2024, rising probably to more than $50 billion per year.
- A high level of investment in the modernisation of defence-related existing enterprises, as well as in the creation of new enterprises. Such investments are made from the enterprises' own funds, the majority of which are state-owned, and from state programmes that are not formally related to the war and are aimed at ensuring Russia's economic development, enabling import substitution.
- Maximising the combat effectiveness of weapons – according to the Russian criteria for this – by giving preference to mass, cheap samples of weapons and military equipment, and to the restoration and modernisation of existing systems.

- A reduction in the cost of services for the production and maintenance of weapons and military equipment due to the introduction of partial de facto labour mobilisation. This allows for the involvement in production and logistics of conscripts undergoing military service in special repair units, as well as the involvement of students who receive minimal payment for their work, and prisoners whose work is close to unpaid.

This level of industrial mobilisation exposes the Russian economy to the risk of growing economic instability over time and will have significant negative long-term consequences for Russian society if it is sustained. In the medium term, however, these policies are enabling Russia to massively increase output of military equipment. Moreover, a large proportion of the funds dedicated to this expansion represent capital investment in industrial capacity such that large-scale production can continue with reduced funds. Thus, unless there is a rise in political instability, it is likely that Russia will be producing large quantities of military equipment for a protracted period, even if there is a forced rebalancing of the economy.

II. Europe: Blasé-Faire Defence Economics

Standing before the Bundestag on 27 February 2024, then Chancellor Olaf Sholtz pronounced that, 'The twenty-fourth of February 2022 marks a watershed in the history of our continent'.[119] The full-scale invasion of Ukraine left Europeans feeling suddenly insecure, and galvanised a wide range of pronouncements pledging support for Ukraine, commitment to NATO and condemnation of Russia. In Germany, a special €100-billion fund was allocated to the Bundeswehr. And yet, despite large amounts of money being made available and near-universal rhetorical commitment to boosting defence, European defence production languished for more than a year. European countries have struggled systematically to convert capital and intent into production output. Understanding why they have failed requires an examination of the policy dilemmas that have hampered the allocation of funds, the regulation that has limited its effective expenditure, and the issues of supply chain resilience and competition that have limited value for money.

Money to Munitions

At the beginning of Russia's full-scale invasion many states pledged lethal aid. The desperate need to push equipment into Ukraine that would make an immediate difference with little training or support meant that man-portable anti-tank and air defence systems were prioritised, along with small arms.[120] Thus, European countries began to send NLAWs, Panzerfaust-3s, Javelins, Karl Gustav recoilless rifles, Stingers, Marlet and Starstreak MANPADS to Ukraine.[121] Although individually effective, the impact of these gifted weapons paled in

119. Bundesregierung, 'Policy Statement by Olaf Scholz, Chancellor of the Federal Republic of Germany and Member of the German Bundestag, 27 February 2022 in Berlin', 27 February 2022, <https://www.bundesregierung.de/breg-en/news/policy-statement-by-olaf-scholz-chancellor-of-the-federal-republic-of-germany-and-member-of-the-german-bundestag-27-february-2022-in-berlin-2008378>, accessed 1 October 2024.
120. *This is Not a Drill*, Series 2, Episode 37, 'War Update: Dr Jack Watling', 21 July 2022, Apple Podcasts, <https://podcasts.apple.com/gb/podcast/war-update-dr-jack-watling/id1593634121?i=1000570572578>, accessed 5 January 2025.
121. Nicky Harley, 'Starstreak: Javelin, NLAW: 200,000 Items of Weaponry Sent to Ukraine from West's War Chest', *National News*, 10 March 2022, <https://www.thenationalnews.com/world/uk-news/2022/03/10/starstreak-javelin-nlaw-2000-pieces-of-weaponry-sent-to-ukraine-from-wests-war-chest/>, accessed 5 January 2025.

comparison with the stocks of weapons Ukraine already possessed.[122] Nevertheless, when Ukraine managed to blunt Russian advances more successfully than the country's international partners anticipated, it also found itself running short of artillery munitions and other core platforms. Ukraine's partners lacked either large stockpiles or latent production capacity for these items.

The initial decisions on allocation of funds were straightforward and went in two directions: funding for replenishment of stocks of gifted weapons, such as NLAW;[123] and funding for new platforms relevant to NATO's conventional deterrence, such as F-35 purchases.[124] For most European countries, however, there were some key policy challenges in how to allocate funds for Ukraine's enduring resistance. The first challenge was simply a question of time. Although national stocks are not publicly disclosed, it is evident that Western European states had just weeks of artillery ammunition in stockpile.[125] The problem was that while they could contract to expand production, their stockpiles were inadequate to bridge the gap until new production could come online.[126] Russian forces prepared to press hard against Ukrainian troops in Donbas in April 2022. In response, European governments mostly prioritised purchasing ammunition from the international market on the basis that this would provide a more immediate benefit to Ukraine and a more predictable supply in the short term for the purposes of planning.[127] The shorter delivery times were also politically attractive and fuelled the rounds of announced support packages. Leaders used these to demonstrate to their domestic audiences that they were making good on their rhetorical commitments to Kyiv.[128]

The first orders to the defence industry were to replace the man-portable weapons that had been donated. Subsequent discussions arose on orders for artillery

122. Zabrodskyi et al., 'Preliminary Lessons in Conventional Warfighting'.
123. HM Government, 'UK Orders Thousands More Anti-Tank Weapons to Bolster Stockpiles', press release, 7 December 2022, <https://www.gov.uk/government/news/uk-orders-thousands-more-anti-tank-weapons-to-bolster-stockpiles>, accessed 5 January 2025.
124. *Reuters*, 'Germany to Buy 35 Lockheed F-35 Fighter Jets from U.S. Amid Ukraine Crisis', 14 March 2022.
125. House of Lords, International Relations and Defence Committee, 'Corrected Oral Evidence: Defence Concepts and Capabilities: From Aspiration to Reality', 13 July 2022, <https://committees.parliament.uk/oralevidence/10646/pdf/>, accessed 5 January 2025.
126. Jack Maidment, 'British Army "Ran Out of Ammunition in Just Eight Days of Fighting" in Simulated 10-Day Online War Exercise, Warns Ex-Commander of the US Army in Europe', *Daily Mail*, 7 July 2021; Stephen Grey, John Shiffman and Allison Martel, 'Years of Miscalculations by U.S., NATO Led to Dire Shell Shortage in Ukraine', *Reuters*, 19 July 2024.
127. Author interviews with staff tasked with making these purchase, various locations, March–July 2022. This even saw significant purchases from Russian partners or allies. See Alec Russell and Marton Dunai, 'Serbia Turns Blind Eye to Its Ammunition Ending Up in Ukraine', *Financial Times*, 22 June 2024; Krishn Kaushik, 'Exclusive: Ammunition from India Enters Ukraine, Raising Russian Ire', *Reuters*, 19 September 2024.
128. For example, HM Government, 'PM Announces Major New Military Support Package for Ukraine: 24 March 2022', press release, 24 March 2022, <https://www.gov.uk/government/news/pm-announces-major-new-military-support-package-for-ukraine-24-march-2022>, accessed 5 January 2025.

ammunition. This discussion became problematic. Most European states were only willing to propose orders to replenish their own stocks, or else wanted to make large one-off orders that could not be met by existing capacity and were also not long term enough to support capacity being increased.[129] Companies therefore started to add orders sequentially to their order books. However, while governments proposed more contracts, the result was simply to extend the delivery timetable. Companies had no assurances from governments that orders would continue over the long term.[130]

For governments, three main factors limited willingness to make long-term investments. First, they were unsure how long the demand would last. Second, the core requirements for the Ukrainian military were not assessed to necessarily be the same as for a NATO military – raising the question of opportunity costs. In some cases, ramping up production was seen as coming at the expense of NATO modernisation. Third, many countries worried about the competitiveness of an industry over the long term. For example, even if the UK ramped up munitions production, it was feared that it would produce fewer rounds – likely at an uncompetitive price point – than Germany. The risk, from the UK's point of view, was that it would spend significant amounts to expand production capacity, and then have to subsidise an uncompetitive production line for a protracted period when there might well be a supply glut and demand slump across NATO. This led many countries to hold off placing orders. Countries such as Finland moved faster, but, initially, this simply placed their orders higher in the order books.[131] In 2022, orders did not expand production capacity.[132]

For countries on NATO's eastern flank, the industrial paralysis that was afflicting Europe in 2022 was a cause of alarm. NATO members were depleting their stockpiles but failing to invest in industrial capacity to sustain Ukraine's or NATO's ability to fight. In this context, the Estonian government began to agitate for an EU commitment to supply Ukraine with 1 million rounds of 155-mm ammunition within a year.[133] The EU as an institution was exceedingly reluctant to take on this task. Article 41.2 of the Treaty of Rome states that 'Operating

129. The authors engaged extensively with both European defence ministries and the European defence industry during this period, including by hosting roundtables on these topics throughout 2022.
130. Industry regularly emphasised the need for long-term planning. See Jessica Parker, 'Europe Needs a Decade to Build Up Arms Stocks, Says Defence Firm Boss', *BBC News*, 13 February 2024.
131. Subsequently, capacity increased as orders expanded. See Joe Saballa, 'Finland Orders More 155mm Artillery Ammunition Parts', *Defense Post*, 30 March 2023, <https://thedefensepost.com/2023/03/30/finland-artillery-ammunition-parts/>, accessed 5 January 2025.
132. Nicolas Barotte, « Munitions : les stocks français jugés «préoccupants» » ['Munitions: French Stocks Deemed "Worrying"'], *Le Figaro*, 15 February 2023; Sam Skove, 'It Takes Europe at Least a Year to Fill a Ukrainian Order for Artillery Shells', Defense One, 13 February 2024, <https://www.defenseone.com/threats/2024/02/newly-ordered-european-155mm-shells-take-year-or-more-reach-ukraine-estonian-official-says/394146/>, accessed 5 January 2025.
133. Jennifer Rankin, 'EU Seals Deal to Supply Ukraine with a Million Rounds of Shells', *The Guardian*, 20 March 2023.

expenditure to which the implementation of this Chapter gives rise shall also be charged to the Union budget, except for such expenditure arising from operations having military or defence implications and cases where the Council acting unanimously decides otherwise'.[134] Although the Article refers to 'operations' rather than industrial activity, the European Commission has interpreted it as preventing the EU institutionally from spending on orders with the defence industry. Nevertheless, the Estonians correctly pointed out that with each European state making its own orders to industry, the orders were small, but, if combined, would potentially be large enough to make it commercially viable for companies to invest in expanded production.

Estonia's diplomacy achieved its objective of galvanising a political realisation of the importance of key war materials. However, it did not resolve the industrial problem. The EU, unable to fund defence procurement under its own interpretation of its mandate, instead set about negotiating framework agreements with defence companies to produce rounds at a fixed price, through which member states could each spend. This was to turn multiple small orders into one large one.[135]

This mechanism, while innovative, ultimately failed, for one simple reason: the companies had no idea how many rounds were going to be ordered. The price set, therefore, reflected the fact that companies might need to have capital to invest in scaling production, or might need to retain small production lines with significant overheads. The result was an agreed price point of €4,000 per round, which many member states viewed as too expensive and therefore continued to try to draw up contracts directly with companies.[136] Member states also did not like the idea of funding an EU project that would place orders outside their own territory. The result was that from an ambition to deliver 1 million rounds in 12 months, the EU managed to contract through its framework agreements 40,000 to be made in the first year, and a further 40,000 the following year.[137] With member states refusing to put money forward, the project was given political protection by member states counting their own purchased rounds as contributing to the 1-million objective, so that the EU claimed to deliver 500,000 rounds within a year.[138] This reflects what was eventually delivered to Ukraine, but a large amount of this was purchased from the international market, and not from new production.

134. European Commission, 'Consolidated Version of the Treaty on European Union', *Official Journal of the European Union* (C326, 2012), Title V, Article 41.
135. European Defence Agency, 'EDA Brings Together EU Countries and Norway for Joint Procurement of Ammunition', 20 March 2023, <https://eda.europa.eu/news-and-events/news/2023/03/20/eda-brings-together-18-countries-for-common-procurement-of-ammunition>, accessed 5 January 2025.
136. Author interviews with officials involved in these negotiations, various locations.
137. Numbers provided by officials involved in the projects.
138. Elsa Court, 'Borrell Confirms EU Delivery of 500,000 Shells to Ukraine by End of March', *Kyiv Independent*, 25 March 2024, <https://kyivindependent.com/borrell-eu-has-delivered-500-000-shells-to-ukraine/>, accessed 5 January 2025.

Sensitivities over spending among Ukraine's international partners were exacerbated by Russia's coercion of Europe by constraining energy supplies. Across the continent, as the cost of energy spiked, governments had to reallocate spending in their budgets to subsidise energy and to build new infrastructure to expand liquefied natural gas capacity. This put pressure on European treasuries during a period of economic stagnation. It also created a political problem. Although European publics were largely supportive of Ukraine, private polling across the continent tended to show that defence was not a top priority other than in states along NATO's eastern flank. Politicians, therefore, largely saw the diversion of major spending from other portfolios to defence as a vote-loser, whereas gifting stores or diverting existing defence expenditure to support Ukraine was a vote-winner.

EU members were politically sensitive to price, and therefore spurned the European Defence Agency's framework agreements. However, confidence in their direct contracting proved limited. Early in the conflict, arms companies suggested that with modest investment, they could significantly boost output of shells. When these proposals were examined, however, it was discovered that the speed at which companies could expand production was far lower than originally anticipated. To understand why, it is necessary to outline what is required to produce a shell. A shell must have its casing forged, be filled with high explosive and have a fuze added. In general, forging and fuze production can be expanded quite easily. Filling is more complicated. A shell is filled with high explosive in a temperature-controlled environment, where the temperature is slowly lowered so that the explosive in a batch of shells is set in an even manner.[139]

Most filling facilities were not working at capacity at the beginning of Russia's full-scale invasion of Ukraine.[140] However, each type of shell uses the same infrastructure. Thus, companies quoted a capacity in response to government enquiries. However, orders made for either 155-mm, 105-mm, 122-mm or 152-mm howitzer shells, or 120-mm or 125-mm tank rounds, or 120-mm, 81-mm or 82-mm mortar bombs, suddenly took up the available filling capacity for other orders. When filling capacity hit a ceiling, the challenge in expanding production became regulatory: more locations needed to be certified to handle high explosives. Despite ministries of defence perceiving the urgency, the need to handle such matters with alacrity was not felt across government departments. These issues, however, were teething problems compared with the supply chain challenges that subsequently emerged.

139. Oleksii Borovikov et al., 'Ore To Ordnance: Disrupting Russia's Artillery Supply Chains', Open Source Centre and RUSI, 2024, <https://static.opensourcecentre.org/assets/osc_ore_to_ordnance.pdf>, accessed 5 January 2025.
140. Author observations of filling facilities in 2022.

Many arms companies, when approached by governments, quoted what was feasible in terms of output from their own production facilities. But this assumed a ready supply of raw materials. With small orders across Europe, manufacturers of high explosive and, more importantly, explosive propellants, had consolidated into a small number of suppliers.

There had been limited demand for highly enriched nitrocellulose, as the precursor for propellent powders, for decades. Suddenly, demand far exceeded supply. This had several consequences. The cost of explosive energetics rose steeply and drove up the price per shell. Prior to the full-scale invasion of Ukraine, 155-mm rounds cost between $800 and $3,000 (the higher cost reflecting framework agreements where companies held cold production lines ready for government). This rose to $6,000–$8,000 per round.[141] At the same time, Russia had fixed the price for 152-mm ammunition from its domestic industries at around $1,000.[142] Furthermore, while a certain amount of nitrocellulose may have been available on the market, and companies could assess how many shells they could produce based on that amount, the fact that governments were contracting domestic manufacturers in isolation saw these companies bidding against each other for these supplies.[143] Beyond inflated costs, this also meant that where a European defence manufacturer succeeded in increasing production, it was often at the expense of another European company, so that while governments across Europe invested in munitions production, output remained far below both the projections of the manufacturers and the requirement from Ukraine.[144]

A major barrier to scaling the whole munitions enterprise was that key parts of it – especially nitrocellulose enrichment – had been offshored to China.[145] In consequence, Western companies lacked not only the facilities and machinery, but also the skilled workforce to begin production. For industries, such as explosives production, where entry into the workforce required recruitment,

141. These figures represent a range of quotes provided by different manufacturers. Exact price per shell varies depending on the structure of a contract and the size of an order. See Gwladys Fouche and Sabine Siebold, 'Rising Ammunition Prices Set Back NATO Efforts to Boost Security, Official Says', *Reuters*, 17 September 2023.
142. *Vedomosti*, « Rossia proizvodit artilleriiskie snariady vtroe bystree SSHA i Evropy » ['Russia Produces Artillery Shells Three Times Faster Than the US and Europe'], 26 May 2024, <https://www.vedomosti.ru/politics/news/2024/05/26/1039550-rossiya-proizvodit>, accessed 5 January 2025.
143. *France 24*, 'Europe Battles Powder Shortage to Supply Shells for Ukraine', 2 March 2024, <https://www.france24.com/en/live-news/20240302-europe-battles-powder-shortage-to-supply-shells-for-ukraine>, accessed 5 January 2025.
144. A trend throughout the interviews for this paper was that while a target had been set and announced publicly, delivery was far smaller than the figures discussed in public forums. See Roel Beetsma et al., 'How to Ensure Defense Capabilities for Europe? Economic and Fiscal Consequences', *EconPol Forum* (Vol. 25, July 2024).
145. Prakash Nanda, 'China's Monopolization of "Gun Powder" Chokes US, British & French Military; Alarmed West Looks for Options', *Eurasian Times*, 9 July 2024, <https://www.eurasiantimes.com/us-alarmed-france-shocked-with-chinas/>, accessed 5 January 2025.

potential vetting and a high level of sign-off from governments, private industry was again faced with the challenge of being asked to make investments in areas where the demand from government might be short lived.

By 2024, European investment in munitions production had started to see results. Germany and the Nordic states, in particular, had increased their levels of output.[146] But production nevertheless continues to be significantly below demand. Ukraine needs approximately 2.4 million 155-mm rounds a year to confidently hold its defence line.[147] Between the US and Europe, Ukraine received approximately 1.6 million rounds in 2023 and 1.5 million in 2024,[148] and the consequences can be measured in lost personnel, equipment and, eventually, terrain. European governments continue to scour the international market to make up the shortfall. And while diplomatic efforts to convince countries with relationships with Russia – including Serbia, Egypt and others – to arm Ukraine have yielded results, it is nevertheless embarrassing that this is proving easier than increasing domestic production.

There are four lessons that can be identified in this sorry story.

First, reflexive secrecy among NATO members – on production capacity for ammunition – has shielded democratic governments from accountability for a hollowing-out of the sector and limited the ability for coordination of production among allies, without significantly improving security.

Second, governments have not questioned the resilience and depth of their supply chains. This has made it hard to anticipate the impact of large injections of capital into arms production in terms of the capacity to scale production.

Third, the chronic tendency to try to protect domestic manufacturing has driven intense competition among allies. This has meant investment was devalued, rather than used to encourage collaboration to maximise the efficiency of production across the continent.

Fourth, a desire to run defence industries to sustain the industrial requirements of a war purely based on free-market economics without price controls – but in a heavily regulated sector – meant that governments maximised risk to investors, while also driving up costs on themselves. The resulting incentive structure was

146. Jan Erola, 'Double or Nothing: Nordics are Ramping Up Ammo Production', *Nordic Defence Review*, <https://nordicdefencereview.com/double-or-nothing-nordics-are-ramping-up-ammo-production/>, accessed 3 March 2025; Rheinmetall, 'Success in Brussels: Rheinmetall Receives over €130 Million in EU-Funds to Increase Production Capacities in the Artillery Sector', 26 March 2024, <https://www.rheinmetall.com/en/media/news-watch/news/2024/03/2024-03-26-130-million-in-eu-funding-for-rheinmetall-to-expand-ammunition-production>, accessed 5 January 2025.

147. Estonia Ministry of Defence, 'Setting Transatlantic Defence Up for Success: A Military Strategy for Ukraine's Victory and Russia's Defeat', Discussion Paper, December 2023, <https://kaitseministeerium.ee/sites/default/files/kaitseministeerium_2023veeb_17.12.pdf>, accessed 5 January 2025.

148. These are the figures of received rounds, held by Ukraine's General Staff and Logistics Command.

one that left private businesses lacking trust and unwilling to commit capital, and governments unable to provide certainty to investors as to whether regulation would be sufficiently flexible to meet the demand.

In short, European governments pursued a form of blasé-faire economics, in which they wanted the private sector to solve the problem without creating any incentives or a regulatory environment that would allow it to do so. The conclusions are that governments need to retain effective data on their supply chains, have robust plans for expanding production, cooperate proactively with allies to efficiently burden-share and be much more interventionist in the business to ensure appropriate outcomes.

Stockpiles, Safety and Obsolescence

Alongside failing to scale production of basic ammunition natures for three years while massively driving up the price of war materiel, European defence-industrial policy also failed to replenish stockpiles of precision weapons. The UK, for example, still has not replaced the man-portable weapons that it gifted to Ukraine in 2022, although it has signed contracts to do so.[149]

The first reason for the failure to replenish precision weapons stocks is a consequence of the order profile within many precision weapons portfolios in Europe. Since the end of the Cold War, the anticipated expenditure rates of precision weapons have been low. Nevertheless, countries have wanted to maintain the competitiveness of their munitions. The approach has been to order a small production run of a given complex weapon, and then to contract the same business to develop a future and more-capable munition to be produced in similarly small quantities – often at smaller quantities owing to increasing costs. Thus, companies such as MBDA have been encouraged to design a weapon such as Stormshadow, build a specified number and then move to the design of future capabilities that keep pace with enemy defences, closing down the previous production line.

The consequence of these iterative improvements is that there is little emphasis given to retaining the capacity to manufacture more of the previous generation of capability. In the case of man-portable complex weapons production in the UK, this became evident when orders were placed to replenish stocks, only for the delivery schedule of new munitions to be set out to 2026. There were several reasons for this.

149. HM Government, ‘UK Orders Thousands More Anti-Tank Weapons to Bolster Stockpiles’.

There was the need to set up the production line and hire staff. But more consequential was the need to manage obsolescence. Because the original production had been concluded, some of the sub-components were no longer being produced, while the small numbers of components needed made re-establishing production of the sub-components uneconomical. This meant that the manufacturer had to redesign how to make the munition before it could set up new production.[150]

Another reason for small order volumes is the carriage life of munitions. Over time, weapons degrade and this can reach a point when they are deemed to be insufficiently reliable to be depended on in combat. For this reason, most countries specify a lifespan for a munition after which it needs to be disposed of. This means that if a certain number of munitions are expected to be used, the purchase of any further munitions will not only be wasted but will also impose further costs in safely disposing of the munitions. Russia does not have this approach and continues to store extremely old munitions. In many cases, this has reduced their reliability. In others, where inspection has determined that the munitions are not in a condition for use, it has provided a base for refurbishment of munitions.

The evidence suggests that the assessed lifespan of most Western munitions is considerably greater than is currently reflected in regulation.[151] Not all countries certify weapons for the same period of time, but there is limited evidence to suggest that the countries that certify weapons for a longer period have correspondingly serious safety issues.[152] Across NATO, there is sufficient evidence to extend the shelf life of a large proportion of munitions in some territories. Furthermore, there are conditions in which a munition is no longer suitable for its originally intended purpose. Weapons carried on aircraft, for example, can become fatigued because aircraft expose them to significant G-forces, temperature and pressure changes and therefore pose a flight safety risk if they are retained on aircraft weapon stations. However, Ukraine has demonstrated that many of these munitions can be usefully stockpiled and used in a ground-launched role.[153] The result is that it should be possible to significantly increase both the size and lifespan of a stockpile in Europe simply by reassessing existing regulations.

Problems of obsolescence and small stockpiles were not confined to munitions. The UK, for example, initially gave Ukraine 14 Challenger 2 main battle tanks

150. Author interviews with industry involved in NLAW production, 2022–23.
151. A significant proportion of munitions provided to Ukraine were beyond their service life and yet performed acceptably.
152. Although there are some outside cases of system failure.
153. HM Government, 'The UK Bolsters Ukraine's Air Defence After Putin's Latest Air Strikes', news story, 29 December 2023, <https://www.gov.uk/government/news/the-uk-bolsters-ukraines-air-defence-after-putins-latest-air-strikes>, accessed 5 January 2025.

(MBT), out of a fleet of 227.[154] This was despite the UK intending to upgrade only 148 Challenger 2 MBTs to the Challenger 3.[155] In part, the reason for the tiny fleet being donated stemmed from shortages of spares packs so that a larger fleet would see availability diminish rapidly for both Ukraine and the UK. Again, many of the components of the spares packs were no longer being manufactured, such that new production had to be established.[156]

As the demand for armoured vehicles grew from across Europe, it became apparent that stockpiles of these vehicles were limited. This partly stemmed from a tendency to sell off old military surplus vehicles to private companies.[157] In the UK, for example, the Treasury charged the military for the assessed depreciation in value of a given system held in storage. This meant that the armed forces were actively disincentivised by penalties from retaining equipment in stores. The tendency was therefore to pay for the removal of sensitive equipment and weapons from vehicles, and then to sell the hulls to private companies. In Belgium, this policy was followed in 2006 with the sale of the country's fleet of Gepard self-propelled anti-aircraft guns for about €15,000–€20,000 each. However, in 2023, when the Belgian government wanted to donate these vehicles to Ukraine, the company was offering to sell the vehicles back to the Belgian government for a cost significantly in excess of €500,000.[158] The company argued that, to be effective, the vehicles would need their electronics and, in particular, their radar repaired, and that as the targets they would be used against had changed and the old components were obsolete and no longer available, the radar should also be upgraded.[159] Additionally, the contracts were sales, and not storage contracts, and so the company could increase costs reflecting the urgency of demand and it was its decision as to whether the vehicles were sold. The Belgian government therefore could not control the timeline of retrieving the equipment from storage. No agreement was reached.

Other issues that constrained the acceleration of expanding production were export controls and intellectual property (IP). To continue with the example of the Gepard, ammunition for the weapon was scarce as it had been withdrawn from service in most European operators in the 2000s. Switzerland had produced

154. Michael Holden, 'Britain to Send 14 of Its Main Battle Tanks to Ukraine', *Reuters*, 15 January 2023.
155. RBSL, 'RBSL to Build Next-Generation Challenger 3 Tanks in Major Boost for UK Prosperity', <https://rbsl.com/news-and-events/news/rbsl-challenger-3-contract>, accessed 5 January 2025.
156. Author interviews with team responsible for preparing shipment and sustainment of the vehicles, UK, 2023.
157. In the UK, for instance, this is often done through Govsales. See Govsales, <https://www.govsales.co.uk/>, accessed 5 January 2025.
158. Kasper Goossens, 'Zelfmoorddrones neerschieten kost Oekraïne handen vol geld. België kan die kostprijs helpen drukken, maar weigert voorlopig' ['Shooting Down Suicide Drones Costs Ukraine a Lot of Money. Belgium Can Help Reduce That Cost, But Refuses for Now'], *Business AM*, 5 January 2023, <https://businessam.be/belgie-gepards-oekraine-drones/>, accessed 6 October 2024.
159. Author interviews with the company, Belgium, October 2024.

the ammunition,[160] but, as a neutral country, it did not grant permission for its use in Ukraine. This required production to be established outside Switzerland, further delaying the delivery of key systems.[161] In this instance, the workaround was simple because the IP for producing 35-mm shells was available elsewhere.

With other systems, IP posed more of a problem. For example, EU investment in expanded 155-mm production did not address a key challenge. States had deviated from Standard since the Cold War. So, whichever 155-mm systems were invested in risked favouring some countries with investment over others – giving them economies of scale in production and thus a long-term structural advantage in the market. Furthermore, if production capacity supported specific systems, it would structurally advantage their associated specialist ammunition producers. Even where obsolescence meant that key parts were no longer produced, and the number of systems being serviced made it uneconomical to restart production of the relevant spares, there was nevertheless reluctance in some quarters to share technical drawings or other IP with Ukraine, where workshops might begin making the spares necessary to keep the vehicles in the fight. The intricacies of the various debates over IP and permissions to release equipment are less important than the overall effect. When Europe needed to surge both supply to Ukraine and production of supporting systems, these complications slowed and introduced uncertainties into planning that had a tangible negative effect on equipment reaching Ukraine in a timely manner or at a reasonable cost.

Finally, it should be noted that regulation across Europe has significantly undermined the ability to rapidly develop systems to retain competitiveness. UAV and air defence development is one of the fastest-growing areas of competition in Ukraine. Both Ukraine and Russia have developed an insatiable demand for UAVs, which are employed on a wide range of tasks, from reconnaissance and deception, to both tactical and operational strike.[162] Given that Europe has a large aeronautical industry – European states have extensive experience in manufacturing UAVs, and access to many of the supply chains to obtain the

160. *Reuters*, 'Swiss Again Reject German Request to Re-export Swiss Ammunition to Ukraine', 3 November 2022.

161. Rheinmetall, 'Replenishment for Air Defence: Rheinmetall Delivers 35mm-Ammunition for Anti-Aircraft Gun Gepard to Ukraine', press release, 6 January 2025, <https://www.rheinmetall.com/en/media/news-watch/news/2025/01/2025-01-06-35mm-gepardmunition-fuer-ukr>, accessed 5 January 2025.

162. Justin Bronk and Jack Watling, 'Mass Precision Strike: Designing UAV Complexes for Land Forces', *RUSI Occasional Papers* (April 2024), <https://www.rusi.org/explore-our-research/publications/occasional-papers/mass-precision-strike-designing-uav-complexes-land-forces>, accessed 5 January 2025; Isabelle Facon, 'Proliferated Drones: A Perspective on Russia', CNAS, <https://drones.cnas.org/wp-content/uploads/2016/05/A-Perspective-on-Russia-Proliferated-Drones.pdf>, accessed 5 January 2025; Olena Bilousova et al., 'Ukraine's Drones Industry: Investments and Product Innovations', KSE Institute, 4 October 2024, <https://kse.ua/wp-content/uploads/2024/10/241004-Brave1-report-v.1.pdf>, accessed 5 January 2025.

relevant components – this is an area where European states should have had a significant advantage in mobilising to meet demand.

Most UAV development, however, although often drawing on expertise from across Europe, has been in Ukraine. The reasons for this largely relate to price and regulation. Most European states strictly regulate airspace and expect UAVs to be approved for operation by civil and military aviation authorities. The actual regulations are often more permissive. However, at the beginning of the war in Ukraine, militaries were extremely conservative in this area. The view in many militaries was that while they might have the authority to sign off on risk, if they did so and something went wrong, their permissions would be curtailed, threatening their mission. Across Europe, ministries of defence were largely prepared to suffer mission failure as long as they achieved procedural success. This speaks to wildly inappropriate career incentives in the civil service and militaries within these government departments.

There have been consequences of tight regulation for UAV manufacturers. They have faced the need to design a UAV, and then to keep the production capacity and engineers employed throughout the testing and evaluation period, after which they might receive a contract – probably for a small number of platforms since European militaries are not losing them at comparable rates to the Ukrainian military. Since the UAVs supplied to Ukraine would often fail the regulatory hurdles for adoption into NATO forces, the equipment supplied to Ukraine could not be sold back into European militaries, but instead has had to go through significant subsequent modification. The result was often a 10-fold increase in cost.

Although not a UAV project, the same factors meant that a £20-million contract to deliver a capability to Ukraine came with an estimated cost of £200 million to bring the same system into service with the British Army in comparable numbers.[163] In the UAV space, it is not uncommon for a platform that would cost £2,500 if manufactured for Ukraine to cost between £8,000 and £16,000 if made for the British military.[164] The consequence of this is that European governments – while investing heavily in capability development for the Ukrainians – have not seen that investment drive a parallel modernisation of their own forces. This has, in the longer term, created a divergence of interests between money spent on Ukraine and money spent on force modernisation. But the reason for that divergence is largely regulatory and could be closed with effective policy. Necessary changes include:

163. Author interview with manufacturer and with customers in both Ukraine and the UK, 2022–23.
164. Author interviews with manufacturers, customers and Defence Equipment & Support, 2022–24.

- A reappraisal of electromagnetic spectrum legislation and flight safety regulation to prioritise enabling the military and experimental capabilities, especially in specified geographic areas around military testing sites.
- A reduction in support for defence venture capital and an increase in support available to scale ventures that have a proven track record.
- Alterations to the budgeting for military units to encourage the stockpiling of equipment and the building up of equipment reserves.
- An audit of ammunition life, handling procedures and risk management to simplify the stockpiling, storage and handling of munitions, and to align regulation of NATO members.
- The examination of the terms of reference appointing staff to oversee programmes so that authority to take risk rests with individuals who are being assessed on the effect they achieve against objectives, rather than their adherence to existing policy; if the trajectory of existing policy is towards mission failure, they should be obligated to change the policy.

In summary, therefore, looking at stockpiling and regulation across Europe reveals the reality that militaries are not rewarded or resourced to maintain large stockpiles of equipment. Governments pursue outsourcing to a degree that gives them an inability to control the timelines on access to stockpiles or reserves of equipment. The rules on stockpiling also contribute to a tendency to accept obsolescence entering the supply chains for critical systems, impeding their reintroduction into service. Moreover, safety regulations based on projected degradation – despite real-world data to the contrary – significantly increase the cost to European states of both storing and manufacturing critical defence materiel. Preparing Europe for an industrial war, therefore, requires a re-examination of the incentives on these matters, and, in particular, consideration of how those incentives manifest when action must be taken quickly to achieve mission success. The inadequacy of the current architectures speaks for itself. Three years into the largest security threat to Europe since the Second World War, European NATO still cannot meet the basic defensive needs of one country under war conditions. A great many officials will make excuses for the individual failings outlined in this paper. There is – it seems – always a list of reasons for making the wrong decisions. The question that Europe must answer is how it can ensure that it does not find itself in this position again.

III. Ukraine: The Start-Up War Machine

Ukraine's industrial response to Russia's full-scale invasion is vitally important to evaluating the industrial balance of the conflict. However, this cannot be fully understood without a brief appreciation of the condition of Ukraine's defence enterprises prior to the invasion, where there was both latent capacity and systemic decay. This chapter therefore begins with an overview of the post-Soviet legacy of Ukraine's defence industries, before examining efforts after 2022.

Dismemberment of an Inheritance

In 1991, a significant part of the Soviet military-industrial complex was in present-day Ukraine. It consisted of more than 3,594 enterprises and scientific organisations that produced military and dual-purpose products, with a total of about 3 million personnel. Almost 700 enterprises, including 205 industrial associations and 139 scientific and industrial organisations, with a total of 1.45 million personnel, were directly engaged in the production of military products.[165] Ukrainian scientific research institutions were involved in a high proportion of Soviet fundamental and applied scientific research in the field of security and defence. Ukraine produced intercontinental ballistic missiles (ICBMs) (including the SS-18 Satan), aircraft carrier cruisers (including the nuclear-powered super aircraft carrier Ulyanovsk), cargo planes (including the world's largest An-225 and An-124), main battle tanks (the T-64 and T-80), air-to-air missiles, anti-tank missile complexes and a long list of other hi-tech weapons and military equipment.

The number of Ukrainian enterprises servicing defence declined rapidly after the fall of the Soviet Union. The number of defence-related factories declined by more than 50% by 1993, and there was a massive reduction in orders. After the collapse of the Soviet Union, Ukraine not only stopped buying new weapons for a time, but also became the object of forced demilitarisation, during which weapons and military equipment were destroyed or even transferred to Russia at the expense of Western partners. Ukraine renounced 176 ICBMs (130 SS-19s and SS-24s), about 2,000 strategic nuclear warheads and about 4,000 tactical

165. ZN.ua, « OPK, kotoryi Ukraina poteryala » ['The Defence Industry Ukraine Lost'], 22 August 2020, <https://zn.ua/ukraina-1991-2020/opk-kotoryj-ukraina-poterjala.html>, accessed 5 January 2025.

nuclear warheads. Demilitarisation also affected conventional weapons.[166] As part of the Nunn–Lugar programme, for example, in the late 1990s, Ukraine transferred part of its fleet of strategic bombers to Russia: eight Tu-160 bombers; three Tu-95MS bombers; and 19 Tu-22M3 bombers.[167] Russia was also given 581 Kh-55 cruise missiles with a range of 2,500–3,500 km and 386 Kh-22 cruise missiles with a range of up to 600 km.[168]

Today, it is these strategic bombers that Russia is using to launch missile strikes on Ukraine. To understand how significant the Ukrainian contribution was, it is worth noting that according to experts' estimates, today Russia has no more than 60 Tu-22M3s, of which only half are in a state of combat readiness.[169]

From the mid-1990s to the early 2000s, Ukraine was also forced to destroy 60 Tu-22Ms of various modifications – nine Tu-160s and 21 Tu-95MS – and 487 Kh-55 cruise missiles.[170] In fulfilment of disarmament obligations to the US, 132 mobile operational-tactical missile complexes (Elbrus) with a flight range of up to 300 km, and 185 ballistic missiles were decommissioned.[171] In 2012, S-200B air defence systems, with a range of up to 250 km, were withdrawn from service. The formal reason was that these complexes could potentially use missiles with a special nuclear warhead to destroy group targets. Under the terms of its cooperation with NATO, Ukraine also carried out the systematic destruction of its own conventional ammunition, light weapons and even small arms.[172] Since 2006, 133,000 tonnes of ammunition, 1,000 portable anti-aircraft missile systems, and

166. Tetiana Yarmoshchuk et al., « Ukraina, yaderna zbroya ta pryvody na karti: za slidamy «Satany» » ['Ukraine, Nuclear Weapons, and Ghosts on the Map: Following the "Satan"'], Radio Svoboda, <https://www.radiosvoboda.org/a/ukranian-nuclear-weapons-satan-missile/29228028.html>, accessed 5 January 2025.
167. Rostyslav Khotin, « Chomu Ukraina peredala Rosiyi stratehichni bombardyvalnyky, yaki zarest obstrilyuyut raketamy ukrayinski mistá? » ['Why Ukraine Transferred Strategic Bombers to Russia that Now Launch Rockets at Ukrainian Cities'], Radio Svoboda, 6 May 2023, <https://www.radiosvoboda.org/a/ukrayina-rosiya-bombardyvalnyky-tu-95-tu-160-borhy-haz-peredacha/32398767.html>, accessed 5 January 2025.
168. Missilery.info, « Krylataya raketa Kh-22 (kompleks K-22) » ['Cruise Missile X-22 (Complex K-22)'], <https://missilery.info/missile/x22>, accessed 5 January 2025.
169. IISS, *The Military Balance 2024* (Abingdon: Routledge, 2024).
170. Novynarnia, « «Tse bula derzhavna zrada». Yak Ukraina dobrovil'no pohodylaś na denuklearizatsiyu, davshy Rosiyi zbroyu dlya sogodnishn'oyi viyny » ['"It Was State Treason". How Ukraine Voluntarily Agreed to Denuclearisation, Giving Russia Weapons for Today's War'], 14 January 2023, <https://novynarnia.com/2023/01/14/rozzbro-96/>, accessed 5 January 2025.
171. Zaborona, « Za mizhnarodnymy dogovoramy Ukrayina pozbulaśya ne til'ky yadernoho potentsiyalu, a y dekil'kokh desyatkiv litakiv i soten' raket. Os' skil'ky ozbroennya my vtratyly » ['Under International Agreements, Ukraine Gave Up Not Only Its Nuclear Potential But Also Several Dozen Aircraft and Hundreds of Missiles. Here's How Much Weaponry We Lost'], 3 January 2023, <https://zaborona.com/za-mizhnarodnymy-dogovoramy-os-skilky-ozbroyennya-my-vtratyly/>, accessed 5 January 2025.
172. Government of Ukraine, « U Kyivi Agentsiya NATO z pytan zabezpechennya prezentuvala stan perebihu tryokh proyektiv Tsil'ovykh fondiv NATO » ['In Kyiv, the NATO Communications and Information Agency Presented the Progress of Three NATO Trust Fund Projects'], 15 December 2015, <https://www.kmu.gov.ua/news/248708641>, accessed 5 January 2025.

1.5 million units of small arms have been destroyed in the course of NATO's Partnership for Peace and its provisions on the destruction of 'excess ammunition'.[173]

Preserving Skills and Capacity

The Ukrainian military, meanwhile, was also diminished. The Ukrainian defence industry lost the large internal orders that had previously underpinned its capacity. Instead, legacy Ukrainian industry focused on servicing the lifecycle of weapons and military equipment inherited from the Soviet Union, with new investment focused on modernisation rather than replacement. For the majority of Ukrainian defence enterprises, the only way to survive was to find foreign customers in the market for Soviet legacy arms. In a short time, Ukraine entered the list of the world's largest arms exporters and had significant success, including in competition with Russia. One example of its competitiveness was the contract for the supply of 320 T-80UD tanks to Pakistan from 1996 to 1999.[174] To fulfil the order, the Malyshev plant increased production to 110 tanks each year, just a fraction of the company's total capacity to produce up to 900. At that time, the entire budget of the Ukrainian Ministry of Defence for the procurement of weapons allowed only for the purchase of a couple of dozen tanks per year.

After the fall of the Soviet Union, the number of people in the defence industry declined rapidly,[175] while approximately 95% of all products of Ukraine's defence industry were exported. Until 2014, a significant proportion of these exports also went to Russia, which was never able to completely replace Ukrainian products. Even after the start of Russia's aggression against Ukraine in 2014 – when Ukraine stopped military-technical cooperation with Russia – Moscow remained dependent on the supply of a number of important elements. Of note are the Ukrainian Motor Sich engines for Russian helicopters and airplanes and gas turbine engines for Russian warships produced by the enterprise Zorya-Mashproekt in Mykolaiv. In addition, Ukraine refused to continue servicing the Russian SS-18 Satan intercontinental missile systems, which were developed and produced in Ukraine at the Yuzhmash enterprise, and the SS-19 Stiletto, whose control system was developed in Kharkiv by the Hartron enterprise. Some experts believe that Russian aggression against Ukraine is partly due to Russia's need to regain control over the Ukrainian defence-industrial complex.[176]

173. NATO, 'Largest Ever Demilitarization Project Launched in Ukraine', 19 June 2006, <https://www.nato.int/cps/en/natohq/news_22266.htm?selectedLocale=uk>, accessed 5 January 2025.
174. Nezavisimaya Gazeta, « Pochemu Islamabad postavlyaet oruzhie Ukraine » ['Why Islamabad is Supplying Weapons to Ukraine'], 10 January 2023, <https://www.ng.ru/world/2023-01-10/1_8630_pakistan.html>, accessed 5 January 2025.
175. Herbert Wulf (ed.), *Arms Industry Limited* (Oxford: Oxford University Press, 1993), p. 98.
176. Vladimir Voronov, « Na ukrainskoy raketnoy «igle» » ['On the Ukrainian Missile "Needle"'], Radio Svoboda, 25 March 2014, <https://www.svoboda.org/a/25308098.html>, accessed 5 January 2025.

Paradoxically, the need for Russia to purchase products from the Ukrainian defence industry was one of the factors that allowed this industry to survive until 2014, and the Russian aggression that began in 2014 became an impetus for its subsequent development. After the Russian invasion of Crimea and, later, Donbas, Ukraine faced a de facto embargo on the sale of Western weapons to it,[177] which lasted in various forms until 2018,[178] when the US government finally approved the export of lethal weapons to Ukraine.[179] Under such conditions, the Ukrainian defence industry became almost the only source of increasing the capabilities of the Armed Forces of Ukraine. As in the case of Russia after 2022, initially Ukraine's main emphasis was not on the production of new items, but rather on the restoration and modernisation of equipment that was in long-term storage. As of September 2014, when active hostilities in Donbas were suspended by the start of the Minsk negotiation process, Ukraine restored 12,000 units of military equipment, a significant part of which was restored by the repair units of the Armed Forces of Ukraine.[180] In the following years, the main priorities of the Ukrainian defence industry became the replacement of Russian components necessary for the maintenance of existing weapons and military equipment, as well as rearmament due to the development of new systems. As of the beginning of 2021, Ukraine managed to replace at least half of all Russian components,[181] and start serial production of a whole series of systems that were to prove their high efficiency during the full-scale invasion. In particular, these included the Neptune anti-ship missile complex, the Bogdan self-propelled howitzer and the Bukovel electronic warfare complex. However, this still leaves Ukraine dependent on sourcing some components from the international market, or from Russia.

Before the start of Russia's invasion in February 2022, the Ukrainian defence industry consisted of more than 300 enterprises, institutions and organisations involved in the development and production of weapons and military equipment.

177. Commission on Security and Cooperation in Europe, US Helsinki Commission, 'Chairman Smith Rebukes U.S. Administration: "Delay Is Denial" Regarding Military Aid to Ukraine', 4 March 2015, <https://www.csce.gov/press-releases/chairman-smith-rebukes-us-administration-delay/>, accessed 5 January 2025.
178. Melinda Haring, 'Q&A: Ukraine's Got Javelins Now. So What?', Atlantic Council, 30 April 2018, <https://www.atlanticcouncil.org/blogs/ukrainealert/q-a-ukraine-s-got-javelins-now-so-what/>, accessed 5 January 2025.
179. Josh Rogin, 'Trump Administration Approves Lethal Arms Sales to Ukraine', *Washington Post*, 20 December 2017.
180. *RBC Ukraine*, « Minoborony: z nachala 2014 roku bylo vidnovleno bil'she 12 tys. odynyts' tekhniky » ['Ministry of Defence: Since 2014, More Than 12,000 Units of Equipment Have Been Restored'], 11 September 2014, <https://www.rbc.ua/ukr/news/minoborony-s-nachala-2014-g-bylo-vosstanovleno-bolee-12-tys--11092014173800/amp>, accessed 5 January 2025.
181. *Defense Express*, « V Ukroboronpromi dosi ne importozamischeni ponad 3000 pozytsiy komplektuyuchykh » ['In Ukroboronprom, over 3,000 Components Remain Non-import Substitute'], 28 September 2021, <https://defence-ua.com/weapon_and_tech/v_ukroboronpromi_dosi_ne_importozamischeni_ponad_3000_pozitsij_komplektujuchih-4880.html>, accessed 5 January 2025.

The total number of workers in the defence industry was more than 250,000.[182] Most of these enterprises were state-owned, and most of them were managed through the Ukroboronprom state corporation, which included 118 of the largest defence industry enterprises of Ukraine. The enterprises of Ukroboronprom were engaged in: aircraft construction and aircraft repair; production of high-precision weapons and ammunition; production and repair of armoured vehicles; production of radar, electronic warfare and communication systems; and shipbuilding. The Ministry of Strategic Industries was responsible for the formation of the state military-industrial policy, which covers the activities of both state-owned and private enterprises of the defence industry.

Redirecting the Enterprise

Although the Ukrainian defence industry had wide-ranging structural issues in terms of investment in facilities, its ability to generate revenue for investment from government contracts and limited access to international partnerships, the fact that the state had so much control over it proved significant during the initial transition to war. Ukraine did not implement formal industrial mobilisation. The share of the Ukrainian budget directed to the development of the defence-industrial complex and the expansion of production capacities was also much more modest than Russia's. In 2022, only $60 million was allocated for these purposes. This rose to $300 million in 2023 and $1.2 billion in 2024.[183] These funds were insufficient to either establish significant industrial concerns from scratch, or incentivise independent market actors. However, because Ukraine had large existing enterprises over which the state had control, these funds could go directly into restarting production. The presence of a large number of existing enterprises, as well as hundreds of thousands of qualified engineers and workers, whose jobs had previously been sustained by defence exports, was extremely important. They made it possible to provide immediate repair and maintenance to the Armed Forces of Ukraine for the country's own and captured military equipment, as well as to establish repair and maintenance of Western equipment, and support and increase the production of ammunition and other weapons.

Despite modest investments, Ukraine managed to significantly increase the production of weapons at existing enterprises. Moreover, it launched new ones

182. Government of Ukraine, « Rozvytok oboronnopromyslovogo kompleksu » ['Development of the Defence--industrial Complex'], <https://www.kmu.gov.ua/reformi/ekonomichne-zrostannya/rozvitok-oboronno-promislovogo-kompleksu>, accessed 5 January 2025.

183. Slovo i Dilo, « Dosyahnennya ukrayins'koho OPK pid chas povnomashtabnoï viyni » ['Achievements of the Ukrainian Defence-industrial Complex During the Full-Scale War'], 18 December 2023, <https://www.slovoidilo.ua/2023/12/18/infografika/bezpeka/dosyahnennya-ukrayinskoho-opk-povnomasshtabnoyi-vijny>, accessed 5 January 2025.

during the first two and a half years of the war. The production of weapons and military equipment in Ukraine tripled in 2023, and, according to then Minister of Strategic Industry Oleksandr Kamyshyn, should have grown on a similar trajectory throughout 2024.[184] In autumn 2022, the production of 152-mm artillery shells, used in the Soviet self-propelled howitzers Akatsiya, Msta-S and Hyacinth-S, began in Ukraine for the first time.[185] In September 2024, Ukraine disclosed that it was producing 155-mm projectiles used in NATO artillery systems in Ukraine.[186] This became possible thanks to the transfer of a licence for the production of these projectiles by the Norwegian government, and the provision of relevant machines by another state. According to Ukrainian Prime Minister Denys Shmyhal, every second piece of ammunition used in the combat zone, as of October 2024, was produced in Ukraine.[187] This applies not only to artillery shells, but also to mortar bombs of 82-mm and 120-mm calibres, the serial production of which was established by Ukroboronprom and Ukrainian private companies together with partners from NATO countries.[188] The cost of ammunition produced at Ukrainian enterprises is also significantly lower than prices on the world market. NATO buys 155-mm shells for $4,000–$8,000, whereas Ukrainian shells of the same calibre cost about $1,500. Ukraine, however, suffers from challenges in scaling the production of charges, just as in Europe.

Ukraine has found the development and expansion of indigenous missile production more challenging. Prior to the full-scale invasion, the main effort was the restoration of tactical-operational missile complex 'Tochka-U'. There was also ongoing work to develop a coastal defence cruise missile P360 Neptune as part of the Ukrainian navy's strategy of coastal defence. This project was accelerated after the full-scale invasion to protect Ukraine's coastline, which led to a successful engagement in April 2022 against the flagship of the Black Sea Fleet, the cruiser *Moskva*. Subsequent work was undertaken to modify the Neptune to engage land targets. The capability that emerged had a functional range of 400 km with a 350-kg warhead, compared with the 200-kg warhead of

184. Polska Agencja Prasowa, « Ministr Kamishin: u 2023 rotsi Ukraïna vtrichi zbil'shila virobnictvo zbroï » ['Minister Kamyshin: In 2023, Ukraine Tripled Arms Production'], 25 February 2024, <https://www.pap.pl/ua/ukrainian/news/ministr-kamishin-u-2023-roci-ukraina-vtrichi-zbilshila-virobnictvo-zbroi>, accessed 5 January 2025.
185. *BBC News Ukraine*, « Ukrayina pochala vyrobnytstvo boyeprypasiv 152 mm. Chomu tce vazhlyvo » ['Ukraine Has Started Producing 152-mm Ammunition. Why This is Important'], 29 November 2022.
186. Militarnyi, 'Ukraine Starts Producing 155mm Shells', 15 September 2024, <https://mil.in.ua/en/news/ukraine-starts-producing-155mm-shells/>, accessed 5 January 2025.
187. Government of Ukraine, « Promova Premier-Ministra Ukrayiny Denysa Shmyhalya na Zasidanni Uriadu » ['Speech of the Prime Minister of Ukraine Denys Shmyhal at the Government Session'], 1 October 2024, <https://www.kmu.gov.ua/news/promova-premier-ministra-ukrainy-denysa-shmyhalia-na-zasidanni-uriadu-01102024>, accessed 5 January 2025.
188. *Defense Express*, « Skilky minometnykh min Ukrayina mozhe vyroblyaty za rik i chomu vyrobnitstvo vpyrayetsya v «stelyu» » ['How Many Mortar Shells Ukraine Can Produce Per Year and Why Production is Hitting a "Ceiling"'], 2 November 2024, <https://defence-ua.com/news/skilki_minometnim_min_ukrajina_mozhe_virobljati_za_rik_i_chomu_virobnitstvo_vpirajetsja_v_stelju-17080.html>, accessed 5 January 2025.

the original anti-ship missile.[189] This 'land-Neptune' was used successfully against a number of Russian targets in Crimea and the oil terminal of the Kavkaz port in Russia. A longer-ranged variant of Neptune has since been developed, known as 'Long-Neptune', with a reported range of 1,000 km.[190] In some respects, the return on investment for this programme is quite impressive. Only $40 million was spent on the development of the entire RK-360MC complex, including the cruise missile, command post, launchers, and transport and charging vehicles.[191] At the same time, limited funds and restrictions on access to components have significantly limited Ukraine's ability to scale the output of such programmes. Ukraine has pursued a number of parallel defence programmes, including for ballistic missiles, and a range of jet-powered one-way-attack UAVs and cruise missiles.[192] Although production of these systems collectively is currently small, it is anticipated that the output of these systems will increase significantly in 2025.

The significance of these efforts to the outcome of the war is evidenced by the resources Russia has devoted throughout the conflict in targeting the Ukrainian defence industry with long-range strike. As a result of attacks on defence enterprises during the full-scale invasion, at least 100 workers have died.[193] To identify the locations of defence production, Russian special services actively used the shortcomings of the openness of Ukrainian registers. Such shortcomings allowed them to identify the addresses of production premises, as well as the names of managers and owners of enterprises. To reduce the threat, from the first days of the invasion, Ukraine actively used dispersion and organised the production process in such a way as not to accumulate significant volumes of finished products and components in one place. There was a protracted debate over the relocation of production facilities to hardened and subterranean structures. Early in the war, dispersion was preferred to reduce the disruption of output. However, following Russia's increasingly intensive strikes throughout

189. Howard Altman, 'Ukraine Using Land Attack Variant of Neptune Anti-Ship Missile', *The War Zone*, 29 August 2023, <https://www.twz.com/ukraine-now-using-land-attack-neptune-anti-ship-missile-variant>, accessed 5 January 2025.
190. Kateryna Chornovol, « Dovhyy Neptun: u ZSU anonsuvaly novi «syurpryzy» dlya okupantiv v Krymu » ['"Long Neptune": The Ukrainian Armed Forces Announced New "Surprises" for the Occupiers in Crimea'], *Unian*, 23 April 2024, <https://www.unian.ua/war/dovgiy-neptun-u-zsu-anonsuvali-novi-syurprizi-dlya-okupantiv-v-krimu-12614628.html>, accessed 5 January 2025.
191. *Defense Express*, « Stala vidoma vartist' rozrobky RK-360MTS «Neptun»: tsifra, yaka prigolomshyt » ['The Cost of Developing the RK-360MTS "Neptune" Missile System Revealed: A Figure That Will Shock'], 2 July 2021, <https://defence-ua.com/news/stala_vidoma_vartist_rozrobki_rk_360mts_neptun_tsifra_jaka_prigolomshit-4112.html>, accessed 5 January 2025.
192. Bartłomiej Wypartowicz, 'Ukraine Tests Hrim-2 – Its First Indigenous Ballistic Missile', *Defence 24*, 28 August 2024, <https://defence24.com/industry/ukraine-tests-hrim-2-its-first-indigenous-ballistic-missile>, accessed 5 January 2025.
193. Figures provided by the Ukrainian government.

2024, the government is now actively investing in the construction of protected locations for defence manufacture.

Harnessing Private Investment

Although Ukroboronprom and its subordinate enterprises have had success in expanding the production of critical weapons systems and developing key classes of complex weapons, the concentration of the defence industry under government ownership has been criticised within Ukraine. It is widely argued that the government was not able to invest in emerging technologies such as UAVs to properly enable their development. The restrictions on profit margins for sales to the Ukrainian Ministry of Defence prior to the full-scale invasion also limited the capital available to invest. Nevertheless, at the start of the invasion, a large number of Ukrainian private companies sought to transition their activities to defence production and, in the initial phases, were not especially motivated by profit. When in 2022 it became clear that UAVs were a transformative capability for reconnaissance and strike, Ukraine also found that it could not source enough robust UAVs from the international market.

Instead, an indigenous manufacturing ecosystem emerged. Although the UAV manufacturing ecosystem in Ukraine comprises more than 120 companies, it may be subdivided into three broad categories.

In the first tier are companies with the technical expertise to design and produce highly effective UAVs and to update them to remain effective in a contested electromagnetic environment. There are, in effect, fewer than 15 such enterprises and they often have close relationships with particular units of the Armed Forces of Ukraine. This enables rapid testing, evaluation and therefore refinement of capabilities.

The second tier contains companies that can design and produce simple UAVs that are moderately effective. Companies in this tier can also produce UAVs designed by the more capable enterprises.

The third tier consists of companies that can replicate simpler successful designs but are not able to design effective UAVs. This comprises the bulk of enterprises.

The number of entities in this ecosystem drives an extremely fast adaptation cycle. However, it is also quite inefficient in terms of the speed that it can scale a given capability. The failure to consolidate many of the lower-tier enterprises means that there is a higher-than-necessary overhead cost for output. Nevertheless,

output of UAVs has climbed month-on-month so that Ukraine now produces more than 100,000 UAVs, of all types, per month.[194]

Although the UAV enterprise is the most widely promoted, it is not the only area of private defence innovation. Another good example is the distributed air defence enterprise, the backbone of which is the Sky Fortress sensor system, which uses distributed microphones across Ukraine to detect and track the acoustic signature of aerial targets transiting Ukrainian territory and thereby provide live tracking for the coordination of air defence groups.[195] The key part of this system is its ability to accumulate the acoustic data in real time and undertake the algorithmic analysis of the acoustic data. The initial development of this system was achieved at a cost of about $5 million. The scaling of the system was achieved by using commercially available sensors and bearers so that parts of the system could be maintained and updated quickly and cheaply.

Private companies have also begun to emerge in the production of legacy military systems, including armoured vehicles, artillery systems and even missiles. In 2024, the Ukraine's private company KZVV began to produce 15 Bohdan self-propelled artillery systems of 155-mm calibre each month.[196] Such levels exceed France's monthly production of the CAESAR wheeled howitzer. In sum, as of 2024, Ukraine's defence-industrial complex, together with private companies, covers 500 enterprises, employs 300,000 personnel, and is an important element of the Ukrainian economy.[197] In 2023, of the 4.9% increase in Ukrainian GDP, 1.5 percentage points came from the defence industry.[198]

Nevertheless, a lack of funds remains the main challenge for Ukraine's defence industries. Of the $40 billion in Ukraine's defence budget for 2024, $30 billion was spent on salaries and other payments to military personnel, and only $6 billion was assigned to the purchase of weapons.[199] At the same time, the lack of long-term contracts with the Ukrainian Ministry of Defence, or special

194. Exact monthly production rates vary considerably depending on parts availability and the types of UAVs prioritised on the different production lines.
195. Audrey Decker, 'Ukraine's Cheap Sensors are Helping Troops Fight Off Waves of Russian Drones', *Defense One*, 20 July 2024, <https://www.defenseone.com/defense-systems/2024/07/ukraines-cheap-sensors-are-helping-troops-fight-waves-russian-drones/398204/>, accessed 5 January 2025.
196. Author interviews with Ukrainian Ministers, Ukrainian Ministry of Defence, and Armed Forces of Ukraine representatives.
197. Ministry of Strategic Industry, « Rezul'taty diyal'nosti Minstratehpromu ta Ukroboronpromu za 2023 rik » ['Results of the Activities of the Ministry of Strategic Industry and Ukroboronprom for 2023'], 28 December 2023, <https://mspu.gov.ua/news/rezultaty-diialnosti-minstratehpromu-ta-ukroboronpromu-za-2023-rik>, accessed 23 March 2025.
198. *Ibid*.
199. Yuriy Tarasovskyi, « Vyrobnychi mozhlivosti Ukraini vtrychi perevyshchuyut byudzhet na zakupivlyu ozbroien' Kamishyn » ['Ukraine's Production Capabilities Three Times Exceed the Budget for Weapons Purchases, Kamishyn'], *Forbes Ukraine*, 15 April 2024, <https://forbes.ua/news/virobnichi-mozhlivosti-ukraini-vtrichi-perevishchuyut-byudzhet-na-zakupivlyu-ozbroen-kamishin-15042024-20529>, accessed 5 January 2025.

government bank interest compensation programmes (as introduced in Russia), have made it impossible to attract bank funds for crediting operations of the defence-industrial complex. The government attempted to resolve this problem in November 2024, when it adopted a programme of preferential lending to defence enterprises at a rate of 5% per annum.[200] Although this is a step in the right direction, the size of the loans (about $2 million for working capital up to three years and about $10 million for investment projects) will not meet the problem of underfinancing of the industry.[201] The Ministry of Strategic Industries continues to assess a significant level of slack capacity in Ukraine's industries owing to a lack of finance.

It is likely that foreign purchases of defence materiel from Ukrainian defence enterprises or joint ventures are the key to addressing this issue. An example of the former approach was the Danish government's decision in early 2024 to finance the production of 18 Bohdan self-propelled howitzers, which could subsequently be gifted to the Armed Forces of Ukraine.[202] They were manufactured and handed to the Ukrainian Ministry of Defence two months after the contract was signed. In September 2024, the Danish defence minister signed a further agreement with his Ukrainian counterparts for an additional $630 million of investment under this scheme. It is worth noting that most of this amount, almost $440 million, will be financed by Russian assets frozen in Denmark. In October, the Ukrainian Ministry of Defence announced that Lithuania plans to finance the production of the Ukrainian rocket-drone Palyanytsia for $10 million.[203] At the beginning of November 2024 Norway also signalled its intention to start purchasing weapons for the Armed Forces of Ukraine from Ukrainian manufacturers.[204] Since September 2024, Ukrainian manufacturers have also been invited to tenders held for weapons purchases by the UK and Latvian

200. Government of Ukraine, « Pilhove kredytuvannia dlia vyrobnykiv OPK vid Minstratehpromu, uriad pidtrymav postanovu » ['Preferential Lending for Defence Industry Manufacturers by the Ministry of Strategic Industries, Government Supports the Resolution'], 5 November 2024, <https://www.kmu.gov.ua/news/pilhove-kredytuvannia-dlia-vyrobnykiv-opk-vid-minstratehpromu-uriad-pidtrymav-postanovu>, accessed 5 January 2025.
201. *Ibid*.
202. *Defense Express*, « Pislja uspishnoji zakupivli SAU «Bogdana» Daniya zamovit v nashogo OPK bilshe zbroji, peredusim za hroshi RF » ['After Successful Purchase of the "Bogdana" Self-Propelled Artillery, Denmark Will Order More Weapons from Our Defence Industry, Primarily with Russian Funds'], 29 September 2024, <https://defence-ua.com/weapon_and_tech/pislja_uspishnoji_zakupivli_sau_bogdana_danija_zamovit_v_nashogo_opk_bilshe_zbroji_peredusim_za_groshi_rf-16752.html>, accessed 5 January 2025.
203. Evgeniya Sokolenko, « Litva vklade milyony yevro u vyrobnytstvo ukrajins'koyi rakety «Palyanytsya», Minoborony » ['Lithuania Will Invest Millions of Euros in the Production of the Ukrainian "Palyanytsya" Missile, Ministry of Defence'], *Unian*, 23 October 2024, <https://www.unian.ua/weapons/litva-vklade-milyoni-yevro-u-virobnictvo-ukrajinoskoji-raketi-palyanicya-minoboroni-12796845.html>, accessed 5 January 2025.
204. Vitaliy Sayenko, « Voennaya pomoshch Ukrainye: Norvegiya budet finansirovat ukrainskoe proizvodstvo oruzhiya » ['Military Aid to Ukraine: Norway Will Finance Ukrainian Weapons Production'], *Unian*, 16 November 2024, <https://www.unian.net/weapons/voennaya-pomoshch-ukraine-norvegiya-budet-finansirovat-ukrainskoe-proizvodstvo-oruzhiya-12821181.html>, accessed 5 January 2025.

ministries of defence.[205] Financing the Ukrainian defence industry is important to ensure jobs and the stability of the Ukrainian economy in the event of a ceasefire or similar pause in high-intensity fighting, and will reduce what may otherwise be required in financial aid.

The model of a joint venture has significant additional long-term benefits. First, it means that Western governments can order from their own industrial manufacturers. However, the cost of production can be driven down by producing elements of a system in Ukraine. It also means that systems with sensitive elements – such as guidance units – for which countries may be reluctant to transfer IP, can be added into weapons where much of the body and other sub-systems are manufactured in Ukraine. Finally, there is the opportunity for this to create a bridge from Soviet legacy systems to Western systems, allowing Ukrainian joint enterprises to compete with Russia for contracts around the world. A good example here is projects relating to air defence. Due to the shortage of ammunition for the Soviet air defence systems, which remain in service with the Armed Forces of Ukraine, the Buk and Kub systems are being adapted so that they can use AIM-7 Sparrow anti-aircraft missiles. NATO has a significant interest in maintaining large-scale production of air-to-air missiles because of the centrality of airpower in its way of war. Moreover, this project is extremely important because it shows how cooperation between Ukrainian and Western defence industries can find solutions that allow Russia's role in the market for the maintenance of Soviet systems to be replaced, even where Russia has a complete monopoly.

In summary, therefore, Ukraine has been able to significantly increase its defence-industrial output with the assistance of its international partners. There were two critical enablers for this expansion: the large pool of talent available because of the previously high level of defence-industrial production from the 1990s; and the significant level of government control of the defence-industrial sector, which allowed for the rapid pivot of activities. Access to capital, however, was a major constraint on defence production and innovation prior to, and during, the full-scale invasion. The question is whether market power among Ukraine's international partners can be harnessed to expand the production capacity of the Armed Forces of Ukraine.

205. Government of Ukraine, « Velika Brytaniya ta Latviya ogolosili tender na zakupivlyu FPV-droniv » ['The United Kingdom and Latvia Announced a Tender for the Purchase of FPV Drones'], 6 June 2024, <https://mod.gov.ua/news/velika-britaniya-ta-latviya-ogolosili-tender-na-zakupivlyu-fpv-droniv>, accessed 5 January 2025.

Conclusions

Comparing the Russian, European and Ukrainian defence-industrial response to the 2022 full-scale invasion of Ukraine reveals important lessons on how to effectively translate investment into defence-industrial output. These lessons relate to financing, the amount of latent capacity, the level of government control, and the regulatory environment of the products that emerge.

On preparation, one of the clear differences between Russia, Europe and Ukraine is that Moscow had a mobilisation plan and stockpiles from which to draw. The mobilisation plan included legislative changes. The Russian industrial-mobilisation process was largely successful. Ukraine lacked such a clear plan but had many of the same mechanisms in place due to its Soviet legacy. It was therefore able to implement a level of industrial mobilisation, albeit at a slower rate. European states either had no plan or did not activate it. Nor did they have the data to rapidly develop and execute a plan. This lack of preparedness meant that European states were slow and took many false steps. The lesson is simple: NATO members need industrial annexes to their national defence plans and these should be deconflicted between members.

The contrast in government involvement in military-industrial processes is also important. In Russia and Ukraine, the government retained an extremely high level of ownership over defence enterprises, which allowed them to be highly responsive to government direction. In the US, the law allows the government to direct companies to service the defence industries, and key areas such as ammunition production remain part of the Department of Defense. These arrangements have made it possible to significantly expand output. Other countries such as France, where the government retains significant control over defence industries, have also largely succeeded in meeting planned output increases – with an increase in production of artillery systems and a steady increase in shell production – although their plans were not especially ambitious.

For most of Europe, however, the market has proven a very poor driver in response to the conflict. The incentives of the market – increased profits – are not necessarily aligned with maximising the volume of materiel produced for a given level of investment. Moreover, governments did not incentivise private industries to behave constructively. The refusal to give long-term orders or to consolidate orders, for example, made it very difficult for defence companies to justify the risk of expanding capacity rather than extending existing order books. The lack of government involvement in much of the supply chain also meant that governments lacked the data to understand where expanded capacity would

most effectively enable increased production. Orders for shells without investment in special chemistry, for example, drove up prices more than it increased output. At the same time, governments did not create or enact legal mechanisms that would have allowed them to impose a sense of mission on defence industry. Given that governments are the customers of these enterprises, and there is limited investment beyond government, it is evident that the state did not exercise the leverage it could have.

Latent capacity is also relevant for industrial readiness. In Russia, there was significant latent capacity in its defence industries: civilian industries were pushed into the defence sector. In Ukraine, there was similarly significant underuse of the defence-industrial base prior to the full-scale invasion. More importantly, both countries had significant reserves of trained scientists and engineers with experience in the defence sector who could be brought back into the industry. This was existentially important to Ukraine. Across Europe, there is a large pool of talent in these areas, but the lack of mobilisation left a significant body that was not related to defence. Moreover, with very few countries producing defence materiel throughout the supply chain, there was significant unevenness in the availability of trained personnel. It has been especially difficult to attract workers to areas such as special chemistry, an area from which Europe divested for a long period. Thus, even where companies have tried to expand, they have struggled to find the right talent. The main impact of this has been to extend the lead times on capital, which has led to increased outputs. A key question for Europe's readiness for a major conflict, therefore, is to understand the areas where it has surplus talent in one country that is needed in another, or where there is simply a lack of skills and it is worth investing to train personnel.

The financial landscape also differed. Russia has made massive investments in the defence industries, going well beyond the funds allocated to defence within the state budget. Such investments represent the partial mobilisation of the economy to a war footing, which has allowed Russia to significantly expand and modernise its defence-industrial enterprise, although this is at the expense of the rest of the economy, including critical sectors such as education and health. Much of the investment has gone into expanding production facilities, as up-front costs. It is anticipated that, in 2026, funds will be redistributed to other ministries, but this will not reduce the level of orders placed with the defence-industrial enterprise.

Ukraine had both similar latent capacities and high levels of state control of the sector. However, the government did not move to a full mobilisation footing. The lack of funds for the sector has also remained a major limiting factor in the expansion of critical defence enterprises and the scaling of production.

In Europe, in aggregate, large sums of money were made available. However, the investments in each country represent very modest increases in investment, such that they have not stimulated a proportional increase in defence manufacture. Relatively small, one-off orders have generally not incentivised the defence sector to expand its production capacity. Investment has also overwhelmingly focused on products rather than fundamentals in the supply chain, such that investment has driven competition in the higher tiers of the supply chain and increased cost, rather than expanded output. The profile of investment, therefore, has been poorly suited to enabling an expansion of defence-industrial output.

European countries should not embark on a level of mobilisation at the expense of the wider economy, as pursued in Russia, and the prioritisation of R&D spending in many European enterprises has undoubtedly produced highly capable weapons. However, NATO does emphasise the importance of deterrence to prevent the outbreak of war. Deterrence is psychological. In this context, the European response to the invasion may be deemed a failure: Russia assessed the policies that were pursued and deemed them inadequate. It is worth emphasising that a relatively modest increase in expenditure across NATO could have had a significant effect on Russian calculations, if that money translated into tangible outputs. At present, the debate on budget inputs across NATO is largely divorced from the debate about military outputs.

Finally, it is worth comparing regulation. In Russia, regulation has proven extremely lax for the storage of ammunition, working conditions and quality control. This has led to munitions striking Russia rather than Ukraine and stores being detonated by small numbers of low-yield munitions, and has arguably made defence-industrial output less efficient.

In Ukraine, the freedom to test equipment under battlefield conditions as well as easy access to training areas has enabled rapid R&D for both Ukrainian and European defence enterprises. At the same time, failures of security at enterprises have exposed them to significant risk from the Russian special services, while information handling and the approach to IP during the war has arguably reduced the willingness for collaboration from international partners, and the availability of investment capital.

In Europe, the general approach to regulation has been detrimental to increased defence production. In the first instance, restrictions on access to testing and evaluation facilities have led to large numbers of systems being produced that do not meet requirements. This is only discovered at a late stage. Where effective systems have been procured, the risk that businesses must take on in developing them before they are certified has hugely increased costs. Planning laws and other processes have also increased cost and reduced the speed at which defence enterprises can expand. Moreover, few countries have demonstrated a joined-up

approach to such issues in government so that the UK, for example, has yet to achieve its announced ambition of expanding 155-mm artillery manufacture.

Perhaps the greatest difference, and the most important area of policy consideration, is that Russia and Ukraine ultimately have a single authority responsible for the enterprise. In Europe, each country is too small to be self-sufficient but there is no multinational coordination of the defence industry. Member states have opposed the EU playing such a role. NATO lacks authorities and information. As competitors, European defence enterprises tend to be very secretive about their capacity with both other governments and other companies. The result is that there is neither efficiency nor the data and authorities anywhere to rationalise the process. Coherence of multinational supply chains is in the interests of all European NATO members if they need to transition to war. So, whether in NATO or the EU, the establishment of an entity with this responsibility seems critical. If Europe wishes to deter war, it must demonstrate that it is developing the capacity to wage it.

About the Authors

Oleksandr V Danylyuk closely cooperated for many years with the Ukrainian government structures in the defence, security and intelligence sectors. In 2014, he was the Chief Advisor to the Minister of Defence of Ukraine. He subsequently served as a Special Advisor to the Head of the Foreign Intelligence Service of Ukraine and Assistant to the Commander-in-Chief of the Armed Forces of Ukraine, and for many years was also a member of the Parliamentary Working Group on Countering Hybrid Threats. For the past few years, he has been the coordinator of the Ukraine–NATO platform for the early detection and countering of hybrid threats.

His main field of practical and academic expertise is Russian multidimensional warfare, active measures and subversive activities of Russian and Soviet special services, as well as whole-of-government and whole-of-society approaches to countering Russian hybrid aggression. He is the author of many articles and reports as well as several books on this topic, in particular: *Interagency and International Cooperation in the Early Detection and Counteraction of Hybrid Threats'* (2021) and *Anticipation and Countering of Hybrid Threats* (2022), which was prepared in cooperation with the National Institute of Strategic Studies of Ukraine.

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