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Russian thinking on AI integration and interaction with nuclear command and control, force structure, and decision-making

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1. Introduction

Russian thinking on artificial intelligence (AI), and its application when it comes to nuclear weapons and strategic environments, dates back several decades. Early work on neural networks and their potential use for defense purposes intensified in the early 1960s amidst the widespread interest in cybernetics, driven primarily by the demands of the military.

For instance, the Scientific Research Institute of Physical Problems, established in 1962 in Zelenograd, at the initiative of its head, physicist Vitaly Stafeyev, worked on neural networks for missile defense.[1]

In 1969, the publishing house of the Ministry of Defense of the Soviet Union printed a book by colonel-engineer Viktor Bokarev titled 'Cybernetics and warfare'. One section in this book was dedicated to modelling the human psyche. Bokarev concluded that artificial reasoning could be feasible in the future, yet the path towards it had many obstacles and the possibility was not guaranteed.[2] Throughout the book he pondered over how humans and machines would interact and what that would mean for warfare.

The 'Encyclopedia of the Strategic Missile Forces', published in 2009, defines "artificial intelligence in military affairs [искусственный интеллект в военном деле]" as a:

> "…field of research that develops models, systems, and devices that simulate human intellectual activity (perception of various information and logical reasoning) in warfare. [Область исследований, в рамках которой разрабатываются модели, системы и устройства, имитирующие интеллектуальную деятельность человека (восприятие различной информации и логическое мышление) в сфере вооруженной борьбы.]"[3]

According to the Encyclopedia, the Strategic Missile Forces (RVSN) were using AI for decision support systems; intellectual systems and weapons, specifically onboard control systems; and expert systems. This illustrates RVSN's interest in AI in the era before the deep learning revolution of the 2010s.

Although this long legacy serves as the foundation for today's work on AI in the military field, it is not widely discussed. The current interest in AI is, to a great extent, inspired by technological advancements of the past decade.

In its current form, AI was institutionalised within the purview of the Russian Ministry of Defense by the late 2010s. This was preceded by high-profile attention and endorsement from President Vladimir Putin and Defense Minister Sergey Shoigu.[4]

In its current form, artificial intelligence was institutionalised within the purview of the Russian Ministry of Defense by the late 2010s.

In 2018, the MoD held its first conference on Artificial Intelligence, titled 'Problems and ways to solve them' and adopted a set of recommendations to step up work on AI and consolidate the efforts of multiple stakeholders, including government agencies and academia.[5] The conference has been held annually since then, and from 2021 on it was co-organised with the Government. Later in 2018, the MoD launched ERA, its military techno park,

with AI among its 8 priority research areas.[6] In the following years, informatisation and intellectualisation were frequently mentioned among the priorities of Russian armed forces.[7]

In 2021, the 46th Central Research Institute (46th TsNII) was designated as the leading research organisation of the MoD with respect to development and integration of military-oriented AI technologies.[8] In 2022, a new ministerial department was put in charge of AI development.[9] In July 2022, Defense Minister Shoigu approved the 'Concept for the activities of the armed forces of the Russian Federation in the development and application of weapons systems using artificial intelligence technologies' (a non-public document).[10]

At the scholarly and policy level, the discussion in Russia largely embraced the idea that AI is about to become a crucial – if not the key – technology that would determine the future of warfare.

Vasily Burenok, the head of the 46th TsNII, president of the Russian Academy of Rocket and Artillery Sciences, and one of the most prominent authors on AI in the military field, summarised his review of possible uses of AI in warfare as follows:

> "Thus, the creation and development of artificial intelligence systems becomes one of the main venues for scientific and technological progress. The integration of AI in the military domain will predetermine the degree of efficiency of military and combat actions in the future. [Таким образом, создание и развитие систем искусственного интеллекта становится одним из важнейших направлений научно-технического прогресса. Внедрение систем ИИ в военную область предопределит степень эффективности военных и боевых действий в будущем.]"[11]

Andrey Kokoshin, scholar and former Deputy Defense Minister, summarises that the use of AI should help:

> "…provide state leadership and commanders at all levels with the highest possible degree of awareness of the political-military, operational-strategic and tactical situation under conditions of active information and cyber warfare. Thus, the 'fog of war' noted by Clausewitz should be reduced. [обеспечить государственному руководству и командованию всех уровней максимально высокую степень осведомленности о политико-военной, оперативно-стратегической и тактической обстановке в условиях активного информационного противоборства и борьбы в киберпространстве. Таким образом должен уменьшаться отмеченный Клаузевицем 'туман войны'.]"[12]

At the scholarly and policy level, the discussion in Russia largely embraced the idea that AI is about to become a crucial – if not the key – technology that would determine the future of warfare.

In multiple publications, military scholars explored how AI can be applied to improve individual military tasks, ranging from logistics to air defense or decision-making. In the future, they foresee the use of AI on an ever-larger scale.[13]

Authors from the Combined Arms Academy of the Armed Forces of the Russian Federation writing in their 2023 article 'Prospects for the application of AI in troop command and control', argue that

the introduction of AI should be comprehensive and fully integrated into the command cycle, rather than only being focused on specific tasks.

> "In future armed conflicts in the medium term, the center of gravity will shift to the confrontation between systems that manage means of attack, control, and intelligence, as world's leading countries have chosen the strategy of large-scale use of AI in their weapons and control systems to ensure military dominance, and this forces other countries to follow the same path. [В будущих вооруженных конфликтах в среднесрочной перспективе центр тяжести переместится на противоборство систем управления средствами поражения, управления и разведки, так как для обеспечения военного доминирования ведущие страны мира выбрали стратегию широкомасштабного использования ИИ в своих системах вооружений и управления, а это вынуждает и другие страны пойти этим же путем.]"[14]

Similar ideas were expressed in the 2022 article 'Artificial intelligence in the management of complex military-technical systems' by a group of authors affiliated with RVSN. They describe cases of AI in commercial and military sectors and conclude that the future of military contest will see the broad use of AI:

> "Thus, victory in the wars of the future will still be won by humans. Likewise, it will be up to them whether the war starts or not. However, in the medium term, the center of gravity of the armed struggle will shift to the area of confrontation between control systems. Given the orientation of the United States' actions to achieve military dominance through the broad use of artificial intelligence technologies, the Russian Federation needs to implement mirror measures. [Таким образом, победа в войнах будущего по-прежнему будет добываться людьми. Точно так же от них будет зависеть, начнётся война или нет. Однако в среднесрочной перспективе центр тяжести вооружённой борьбы переместится в область противоборства систем управления. Учитывая направленность действий США по достижению военного доминирования идти по пути широкого использозвания технологий искусственного интеллекта в системах вооружения, Российской Федерации необходимо применять зеркальные меры.]"[15]

Many Russian authors characterise the increased interest and investment among major powers in military applications of AI as an actual or potential arms race, with the US and China as the main competitors.

These authors' emphasis on the role of the United States as the main reason for others to follow suit is widely shared. Many Russian authors characterise the increased interest and investment among major powers in military applications of AI as an actual or potential arms race, with the United States and China as the main competitors.[16]

At the same time, Russian authors also express caution about the potentially destabilising role of AI or unintended consequences of its use in warfare. Different authors emphasise problems associated with international humanitarian law, technical risks including those related to communication between the human and machine, vulnerability to cyber threats (in the worst case this threat

could result in an unintended conflict including with the use of nuclear weapons), dangers of overreliance on AI, or challenges of developing military AI in Russia.[17]

Roman Durnev, associate member of the Russian Academy of Rocket and Artillery Sciences, et al. advocate risk assessment for AI technologies.[18] They identify several possible risks, including both those related to how AI systems are developed and how they are used. Among the latter, possible risks include AI gradually being assigned human functions:

> "At present, goal-setting is a purely human prerogative. However, as the use of such AI systems [with goal-setting functions] will become increasingly beneficial, the volume of 'human' functions transferred to them will also increase. At a certain stage of development, to ensure the possibility of 'rational behavior' in a complex dynamic environment, AI systems will be endowed with goal-setting functions. [В настоящее время целеполагание — это прерогатива сугубо человека. Но в связи с тем, что применение таких систем ИИ будет все более выгодным, то будет увеличиваться и объем передаваемых им «человеческих» функций. На определенном этапе развития в целях обеспечения возможности «рационального поведения» в сложной динамичной обстановке системы ИИ будут наделяться и функциями целеполагания.]"[19]

Among the risks identified are a lack of clear terminology and murky lines of responsibility (e.g. who will be held accountable in case an AI-enabled strike unmanned aerial vehicle engages a target).

Other authors suggest ways to confirm trust in AI technologies used in military systems, or argue that the issue of the 'human factor' should be addressed in a concrete rather than philosophical manner: through testing and evaluations of equipment.[20]

Having outlined the broad perspective on AI and warfare in Russia, this paper will delve into the Russian debate on AI and the nuclear field. This bibliography covers two segments of literature. The sections on auxiliary functions of managing nuclear forces, early warning, and command of nuclear forces are primarily drawn from Russian military journals, such as 'Military Thought', whereas the section on strategic stability and arms control is primarily drawn from international relations journals. These two segments represent respective expert communities that only occasionally overlap. Whereas military authors tend to focus on military and military-technical aspects, international relations authors look at the same problems through diplomatic and political lenses. Where appropriate, scholars' views are supplemented with practitioners' and policymakers' remarks.

2. Auxiliary functions

Tasks that are not directly related to command and control (C2) of nuclear forces are referred to in this paper as auxiliary functions of managing nuclear forces. Along with Russian military's growing interest in AI, researchers explored how these technologies could be applied to improve logistics, security, and other functions of RVSN. As evidenced by remarks of RVSN leadership, some innovations have been introduced into practice.

In 2019, Dmitry Stefanovich, a nuclear policy researcher, summarised recent writings on RVSN's interest in AI applied to logistics.[21] This included a 2015 proposal by authors from the Peter the Great Military Academy of the Strategic Missile Forces. They put forward a mathematical model of an automated logistics management system for RVSN mobile group units armed with ICBMs on mobile ground-based missile systems. The model sought to upgrade existing methods of logistics management "through constructive improvement and modernization of control system elements [за счет конструктивного усовершенствования и модернизации элементов системы управления]"[22] with an emphasis on automation of tasks, albeit without explicit mention of AI. The implementation of a proposed model was estimated to boost performance of several parameters, for instance it would:

> "…reduce the duration of the management cycle by a factor of 1.9 by reducing the time required to gather, process, and analyse information by an average of 2.8 times, reduce decision-making time by an average of 1.3 times and reduce the time required to transmit decisions to operators; [сократить длительность цикла управления в 1,9 раза за счет сокращения времени сбора, обработки и анализа информации в среднем в 2,8 раза, сокращения времени принятия решений в среднем в 1,3 раза, сокращения времени доведения решений до исполнителей]"[23]

It would also double the likelihood of orders being transmitted in the face of adversary's use of nuclear capabilities or electronic warfare. Overall, the authors argued that it would:

> "…improve the organisation, efficiency, and quality of their [logistics management bodies'] activities in the interests of complete and timely material support of RVSN military units and formations in the periods of preparation and wartime. [повысить организацию, оперативность и качество их [органов материально-технического обеспечения] деятельности в интересах полного и своевременного материального обеспечения действий воинских частей и соединений РВСН в периоды подготовки и ведения боевых действий.]"[24]

According to Stefanovich, in 2018, another group of authors proposed a neural-network-based model that would forecast:

> "…the residual operating time of the components of the Strategic Missile Forces' missile systems. The model was built with an emphasis placed on determining the significance and calculating the weight of diagnostic features with the aim of subsequent usage for various models of the weapons and military equipment of the Strategic Missile

Forces. [для прогнозирования остаточного времени работы элементов ракетных комплексов РВСН. Модель была создана с акцентом на определение значимости и расчета весов диагностических признаков с прицелом на последующее использование для различных моделей ВиВТ [вооружений и военной техники] РВСН]."[25]

The model was only tested on air conditioning equipment, yet Stefanovich still argued that given RVSN's use of legacy equipment and multiple extensions of missile systems' service life, "such solutions should be very effective in maintaining combat readiness and cost optimisation. [подобные решения должны стать очень полезными в целях поддержания боеготовности и оптимизации расходов.]"[26]

The most comprehensive analysis of the potential use of AI by the Strategic Missile Forces was presented in 2021 by officers of the 4th Central Research Institution of the Ministry of Defense, Yury Matvienko and Alexander Uvarov.[27] Automated systems are used for multiple tasks in the RVSN, not only related to planning and controlling the use of nuclear weapons, but also to day-to-day management, maintenance of their combat readiness, and security. The authors emphasise a need to improve decision-making in these areas but highlight challenges posed by the high volume, diversity, and contradictions of required data:

> "With the growth of the general dynamics of warfare, there comes to the forefront the problem of improving the quality and efficiency of the decisions made by the military command authorities, using the available automated systems in the emerging situation. At the same time, the information necessary for making such decisions and collected from various sources, on the one hand, is quite voluminous and poorly structured, and, on the other hand, can be contradictory, and sometimes deliberately distorted by the enemy. [В условиях роста общей динамики боевых действий на первое место выходит проблема повышения качества и оперативности вырабатываемых органами военного управления решений с использованием имеющихся автоматизированных систем в складывающейся обстановке. При этом информация, необходимая для принятия таких решений и собираемая из разных источников, с одной стороны, имеет достаточно большой объем и слабо структурирована, а с другой стороны, может быть противоречивой, а порой и заведомо искаженной противником.]"[28]

Automated systems are used for multiple tasks in the RVSN, not only related to planning and controlling the use of nuclear weapons, but also to day-to-day management, maintenance of their combat readiness, and security.

One way to tackle this challenge, the authors argue, is by using AI. When creating systems with AI for RVSN, it is important to be aware of specific characteristics of these technologies:

> "Considering, on the one hand, the high uncertainty of the expected operating conditions of RVSN's [automated systems], and, on the other hand, the importance of the tasks they are intended to perform, the training sample should be large enough to ensure the necessary level of confidence of military authorities in the decisions derived using AI and [artificial neural network] technologies.
>
> At the same time, the intellectual tasks to be solved by the RVSN's [automated systems] will be characterised by high

variability of initial data and their susceptibility to deliberate distortions. In this case, unforeseen situations may arise that simply cannot be anticipated at the state where systems are trained. As a result, the probability that an [automated system] with AI and [artificial neural network] technologies will make a type I or type II error increases.

[Принимая во внимание, с одной стороны, высокую неопределенность ожидаемых условий функционирования АС РВСН, а с другой — важность решаемых с их помощью задач, обучающая выборка должна иметь достаточно большой объем, чтобы обеспечить необходимый уровень доверия органов военного управления к решениям, получаемым с использованием технологий ИИ и ИНС.

Вместе с тем для интеллектуальных задач, которые должны решаться АС РВСН, будут характерны высокая изменчивость исходных данных и их подверженность преднамеренным искажениям. В этом случае могут возникать непредвиденные ситуации, которые просто невозможно предусмотреть на этапе обучения системы. В результате возрастает вероятность того, что АС с технологиями ИИ и ИНС допустит ошибку первого или второго рода.]"[29]

For the user and contract owner to have confidence in AI and artificial neural network technologies, their performance needs to be assessed against functional requirements. Such assessment would depend upon the type of automated systems with elements of AI: those that perform tasks traditionally fulfilled by humans and those that perform tasks not common for humans. In the former case, performance can be measured against specified outcomes, while in the latter case requirements are set for the process (rather than outcome) and include "transparency, interpretability, robustness, controllability. [прозрачност[ь], объяснимост[ь], робастност[ь], контролируемост[ь]]"

According to the authors, required standards for either type of AI systems have not been fully developed, which is a major constraint to the full-fledged integration of AI into RVSN's automated system and military systems more generally.[30]

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Finally, they list eight classes of RVSN tasks that can benefit from the use of neural networks:

1. "Tasks of communication network management and optimisation, including the task of finding the optimal traffic between network nodes, taking into account its current and predicted state.

2. Tasks of information security of the automated systems […].

3. Tasks of automated design for effective solutions in the design of security systems, telecommunication networks of positional areas, taking into account the long transition period and the expected operating conditions.

4. Tasks of decision support for military authorities of different levels in the interests of day-to-day activities and operational

combat management.

5. Tasks of guarding (including security video surveillance) and defense of both stationary and mobile objects, video reconnaissance and recognition, guarding and defense of patrol routes of PGRK [transporter-erector-launcher], engineering reconnaissance of terrain, including the use of UAVs and robotics complexes.

6. Tasks of biometric authentication and intellectual analysis of behavioral features […].

7. Tasks of processing signals from sensors related to the prediction of time dependencies that characterise the reliability of weapons and military equipment of the RVSN based on the use of non-linear adaptive extrapolating filters, implemented in the form of complex neural networks.

8. Tasks of input recognition, including pattern recognition.

1. [Задачи управления сетями связи и их оптимизация, в том числе задачи нахождения оптимального трафика между узлами сети с учетом ее текущего и прогнозного состояния.

2. Задачи обеспечения информационной безопасности АС […].

3. Задачи автоматизированного проектирования для получения эффективных решений при проектировании систем безопасности, телекоммуникационных сетей позиционных районов с учетом длительного переходного периода и ожидаемых условий функционирования.

4. Задачи поддержки принятия решений органами военного управления разных уровней в интересах повседневной деятельности и оперативного боевого управления.

5. Задачи охраны (в том числе охранного видеонаблюдения) и обороны как стационарных, так и подвижных объектов, видеоразведки и распознавания, охраны и обороны маршрутов патрулирования ПГРК, инженерной разведки местности, в том числе с использованием БПЛА и робототехнических комплексов.

6. Задачи биометрической аутентификации и интеллектуального анализа поведенческих признаков […].

7. Задачи обработки сигналов с датчиков, связанных с прогнозированием временных зависимостей, характеризующих надежность вооружения и военной техники РВСН на основе применения нелинейных адаптивных экстраполирующих фильтров, реализованных в виде сложных нейронных сетей.

8. Задачи распознавания вводимой информации, в том числе распознание образов.]”[31]

In 2018, the Commander of RVSN, Colonel General Sergey

Karakayev, said that automated security systems (no mention of AI) were increasingly being used for physical protection of RVSN nuclear facilities and there was a plan to expand their use to detect small targets like reconnaissance UAVs:

> "Currently, direct physical and antiterrorist protection of nuclear facilities of RVSN is ensured using automated security systems in conjunction with technical security equipment sets. In the near future, it is planned to expand the capabilities of automated security systems, primarily through the use of means for detecting and engaging low-altitude small targets such as reconnaissance UAVs and means for crossing obstacles by air.
>
> A significant increase in the capabilities of automated security systems for the early detection of sabotage and reconnaissance formations of the enemy has already been achieved through the use of radar and optoelectronic reconnaissance complexes, as well as a complex with UAVs as part of the Typhoon-M counter-intelligence combat vehicle.
>
> The capabilities of the automated security system for stationary facilities are being enhanced, too. For example, the regiments of the Kozelsk Missile Division have been equipped with a new automated security system with robotic (remote-controlled) firing complexes and new-generation technical security equipment.
>
> [В настоящее время непосредственная физическая и антитеррористическая защита ядерных объектов РВСН обеспечивается применением автоматизированных систем охраны в совокупности с комплектами технических средств охраны. Уже в ближайшей перспективе предусматривается расширение возможностей автоматизированных систем охраны, в первую очередь за счёт применения в их составе средств обнаружения и поражения низколетящих малоразмерных целей типа разведывательных БПЛА и средств преодоления заграждений по воздуху.
>
> Значительное наращивание возможностей автоматизированных систем охраны по заблаговременному обнаружению диверсионно-разведывательных формирований противника уже сейчас достигнуто применением комплексов радиолокационной и оптико-электронной разведки, а также комплексом с БПЛА в составе боевой противодиверсионной машины «Тайфун-М».
>
> Наращиваются возможности автоматизированной системы охраны и стационарных объектов. Так, завершено оснащение полков Козельской ракетной дивизии новой автоматизированной системой охраны с роботизированными (дистанционно управляемыми) стрельбовыми комплексами и техническими средствами охраны нового поколения.]" [32]

A year later, Colonel General Karakayev explained that the introduction of robotic systems into the maintenance of security required additional research and development work. This included research into the joint use and control of various robotic systems, which involved elements of AI. Inter alia, research is focused on using UAVs as part of automated security system of RVSN facilities:

> "The most important and complex part of this work was the definition of the principles of identification of detected objects as 'friend or foe' in the [robotic system], including on the basis of neural networks. [Наиболее важной и сложной частью этой работы явилось определение принципов идентификации обнаруженных объектов по признаку «свой – чужой» в составе РТК, в том числе на основе нейронных сетей.]"[33]

According to Karakayev, some of the research findings had already been tested in military conditions and would be used in the future production of robotic systems for RVSN as well as in RVSN staff guideline documents.

In 2021, Karakayev said that automated security systems of all mobile and stationary strategic missile complexes that will be placed on combat duty around 2030 will include robotic systems and use AI. Among projects under development for the purposes of securing RVSN facilities, he listed UAVs, systems of technical vision, target recognition, situational awareness, including with the elements of AI. According to him, automated security systems of launch sites of Yars and Avangard missiles were equipped with Dym-2, a remote-controlled defense complex including salvo fire, grenade launcher, regular and thermal cameras, etc. Dym-2 can be either controlled by a human operator or can work autonomously, Karakayev suggested. In addition, future Sarmat systems will be protected by remote-controlled turret launchers that use neural networks and human and object recognition systems .[34]

3. Early warning

Stefanovich (2019) suggested that early warning systems and related elements of a nation's military organisation are another area where AI can be applied:

> "Threat assessment and damage prediction are the main objectives for AI technologies in this case. This can help to understand the scale of the attack, its source, and possible intentions as well as quickly develop an adequate response scenario. [Основными задачами для технологий ИИ в этом случае являются оценка угрозы и прогноз ущерба. Это может помочь понять масштабы атаки, ее источник и возможные намерения, а также оперативно разработать адекватный сценарий ответных действий.]"

As far as the command of nuclear forces is concerned:

> "Machine learning and the corresponding technologies will perform decision-making support functions, including when it comes to organising maneuvering to pull out forces and resources from enemy attacks, as well as optimising retaliation planning. Updating information in real time, merging data from various sources, and other modern solutions help to improve the quality of combat control. [Машинное обучение и соответствующие технологии будут выполнять функцию поддержки принятия решений, в том числе в части организации маневрирования для выхода сил и средств из-под ударов противника, а также оптимизации планирования ответного удара. Обновление информации в реальном времени, слияние данных из различных источников и другие современные решения позволяют повысить качество боевого управления.]"[35]

He believes that it is only a theoretical possibility that launches of nuclear weapons within the Perimeter/Dead Hand system would be ordered and executed in an autonomous manner, whereas in reality the human always remains in the loop. Yet, it is not impossible that this would change:

> "However, fully automating the retaliatory nuclear strike is technologically feasible, so the pre-delegation of authority to 'machines' may well return to the agenda in the event of a rapid deterioration in strategic stability. [Однако полностью автоматизированный процесс нанесения ответного ядерного удара технологически осуществим, поэтому в случае стремительного ухудшения стратегической стабильности решение о предварительном делегировании полномочий «машинам» вполне может вернуться на повестку дня.]"[36]

In the case where the human remains in the loop, Stefanovich sees a threat of officers' overreliance on machine-processed data and the growth of malicious activities targeting information systems that produce data used in decision-making.

In the 2020 monograph 'International security, strategic stability, and information technology', Stefanovich further elaborated on the potential uses of AI for early warning:

> "Machine learning and corresponding technologies will perform the decision support function during the transition to retaliatory actions, in particular, in organising maneuvers of forces and means [military equipment] to evade enemy strikes, and optimising counterstrike planning. The fusion of data from various sources and real-time information updates contribute to improved battle management and situational awareness. [Машинное обучение и соответствующие технологии будут выполнять функцию поддержки принятия решений по мере перехода к ответным действиям, в частности, при организации маневрирования для вывода сил и средств из-под ударов противника, оптимизации планирования ответно-встречного удара. Слияние данных из различных источников и обновление информации в реальном масштабе времени способствуют повышению качества боевого управления и ситуационной осведомленности.]"[37]

Stefanovich warns that the integration of AI into early warning systems makes them vulnerable to cyber attacks. This could become especially dangerous if humans become over-reliant on judgements made by powerful machines.

Andrey Zhuravlev, Lieutenant Colonel of the Zhukov Air and Space Defense Academy, made a case for using AI in the field of radar intelligence in his 2021 article (albeit without references to the early warning system).[38] He argued that due to the uncertain and dynamic environment, human operators could not efficiently process huge volumes of radar imagery, which has required signal processing to be fully automated since the late 1970s. In addition, new tasks emerge for radar intelligence, such as recognition of classes of targets, recognition of situations, analysis and prediction of the environment, and adaptation of radar operation. Such tasks are poorly served by traditional methods and require new ways, including those based on neural networks. After summarising the benefits of neural networks, the authors stresses:

> "…the need to introduce neural network technologies in future information processing systems, primarily in radar intelligence systems, which require high-speed processing of large amounts of data in real time to obtain reliable results about the emerging airspace situation. [необходимост[ь] внедрения нейросетевых технологий в перспективные системы обработки информации и в первую очередь в системы радиолокационной разведки, в которых необходимо с высокой скоростью обрабатывать большие объемы данных в режиме реального времени для получения достоверных результатов о складывающейся воздушной обстановке.]"[39]

According to Zhuravlev, using AI in radar intelligence systems bears lower risks of an erroneous decision compared to strike systems. For the same reason it would be conceivable to completely take a human operator out of the radar intelligence process. Zhuravlev describes challenges to using neural networks for processing radar imagery, such as extremely high volume of data that needs to be processed within fractions of a second; the difficulty of formalising algorithms and ensuring high quality of their performance; the need to solve non-traditional tasks; the vagueness of information about

the nature of adversary's actions; the need to operate in different conditions. He suggests that one would need to thoroughly examine the tasks performed at each stage of radar imagery processing and to identify possible ways to improve the quality of output information with the help of neural networks.

In 2021, two senior defense industry officials commented on the prospect of using AI in the early warning system. In his interview on the history of the early warning system, Sergey Saprykin, chief designer of the Scientific and Research Institute for Long-Distance Radio Communications (NIIDAR), was asked about the modernisation or early warning radars and possible innovations within these, such as through AI. He responded that; "…innovations that you mention have not been innovations for us for a long time. [Новинки, о которых вы говорите, для нас давно уже не новинки.]" But he also spoke cautiously about AI:

> "But imagine if the locator, designed to prevent a nuclear missile strike, would start to 'think', gain intelligence. The modernisation is planned, and it concerns capacity building and measurement capabilities. [Но представьте себе, если локатор, предназначенный для предотвращения ракетно-ядерного удара, начнет "думать", обзаведется интеллектом. Модернизация предусмотрена и касается наращивания потенциала и измерительных возможностей.]"[40]

Yury Anoshko, director general of Radio Technical and Information Systems, was also asked about whether elements of AI would be used at new stations of the early warning system. Anoshko said that AI technologies were already being used for some tasks but the decision making ultimately rested with the human for the sake of avoiding mistakes that could be caused by hardware or software errors:

> "It all depends on what we mean by artificial intelligence (AI). In fact, it is just mathematical and logical methods for processing information. They are required when there is more and more information. Naturally, such methods are used for processing radar information, operating the station, and diagnosing its condition. Another question is whether AI makes decisions. In this case, of course, that is out of the question and cannot happen because the information which the ground control stations give out has to be assessed by a human being for its accuracy. Otherwise we may end up in a situation where as a result of a technical or software failure an erroneous decision will be made about a missile attack, which could lead to irreversible consequences. [Все зависит от того, что мы понимаем под искусственным интеллектом (ИИ). На самом деле, это всего лишь математические и логические методы обработки информации. Они требуются, когда информации становится все больше и больше. Естественно, такие методы используются при обработке радиолокационной информации, в управлении станцией, в диагностике ее состояния. Другой вопрос, принимает ли ИИ решения. В данном случае, конечно, об этом речи не идет и не может идти. Потому что информация, которую станции СПРН выдают, должна оцениваться человеком на достоверность. В противном

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случае мы можем получить ситуацию, что в результате технического или программного сбоя будет принято ошибочное решение о ракетном нападении, которое может привести к необратимым последствиям.]"[41]

In 2022, Anoshko was again asked about the use of AI in the early warning system and urged caution:

> "We already use what you call 'innovations'. But you have to understand that artificial intelligence in the nuclear deterrence system is dangerous; your childhood movie Terminator is just about that. [То, что вы называете "новинками", у нас уже применяется сейчас. Но надо понимать, что искусственный интеллект в системе ядерного сдерживания опасен, фильм вашего детства "Терминатор" как раз об этом.]"[42]

In 2023, the head of the Main Centre for Missile Attack Warning, Sergey Suchkov, emphasised the central role of human operators as illustrated by the detection of a DPRK missile launch in March 2022:

> "It is commonly assumed that the [missile attack warning] system operates in a fully automatic mode, and that time [in March 2022] the technology did not fail either. The performance of the radar equipment and command posts made it possible to establish the fact of detection of the launch, but still the final decision on the validity of the launch was made by the personnel, after a comprehensive analysis of the parameters of the launched missile. In that case, it was the professionalism of the combat crew as an integral part of the decision-making system that came to the fore. [Принято считать, что система ПРН работает в полностью автоматическом режиме, и в этот раз техника тоже не подвела. Результаты функционирования аппаратуры РЛС и командных пунктов позволили установить факт обнаружения пуска, но всё же окончательное решение о достоверности пуска принял личный состав, проведя всесторонний анализ параметров стартовавшей ракеты. В данном случае на первый план вышел профессионализм боевого расчёта как неотъемлемой части системы принятия решения.]"[43]

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The Don-2N radar system, part of the Missile Attack Warning System and missile defense of Moscow, has also been mentioned as an example of where Russia draws a line between automation and human control. According to the commander of missile defense of Moscow, Major General Sergey Grabchuk:

> "The radar system digitally processes big volume of various types of radar signals enabling it to detect and track in an automatic mode more than 100 complex ballistic targets and simultaneously to aim at them several dozens of anti-missiles. [На РЛС реализована цифровая обработка большого количества различных типов радиолокационных сигналов, позволяющих обеспечить обнаружение и сопровождение в автоматическом режиме более 100 сложных баллистических целей и одновременно навести на них несколько десятков противоракет.]"[44]

Defense journalist Dmitry Litovkin wrote that even with such significant automation, the system would not launch anti-missiles, but rather propose options to the operator who would have to 'press the button' and take responsibility for making the decision.[45]

4. Command of nuclear forces

The problem of human control over decision-making on the operation and use of nuclear forces is not often addressed in the Russian literature. When it is mentioned, authors usually concur that the role of the human is essential in this sphere.

For instance, a group of authors from the Defense Ministry's Center for Research of Foreign Countries Capabilities stated in 2021:

> "In any case, to ensure the security of the Russian Federation, it is necessary to provide support for decision making regarding the use of strategic nuclear forces, definitely using AI as a tool for analysing the dynamically changing geopolitical and military situation and leaving the final decision-making power to the relevant officials. [В любом случае для обеспечения безопасности Российской Федерации необходимо обеспечивать поддержку принятия решений по применению стратегических ядерных сил, обязательно используя ИИ как инструмент анализа динамично меняющейся геополитической и военной обстановки, и оставляя за соответствующими должностными лицами право на принятие окончательных решений.]"[46]

That said, they noted that the question of complete or partial delegation of the right to use strategic forces such as nuclear weapons to AI systems was the subject of debate.

In 'The prospects of using military robotechnical systems in the interests of the strategic missile forces' (2022), Igor Fazletdinov argues:

> "It is important to note that, for the Strategic Missile Forces, no level of artificial intelligence should be the basis for excluding humans from the control loop of complex organisational and technical systems and complexes, and only humans should retain the absolute right to make decisions. [Важно отметить, что для РВСН никакой уровень искусственной интеллектуализации не должен являться основанием для исключения человека из контура управления сложными организационно-техническими системами и комплексами и только за ним должно оставаться абсолютное право на принятие решения.]"[47]

In 2019, 2020, and 2022, during his annual interviews on the Strategic Missile Forces Day, Commander of RVSN, Colonel General Sergey Karakayev, responded to what was essentially the same question three times: in the future, will RVSN abandon classic duty shifts due to the advancement of the automated combat control system? Every time he responded that he did not foresee the abandonment of duty shifts and emphasised the importance of human control:

> "It will most likely be impossible to completely abandon duty shifts due to the automation of the combat control system. One should not forget that strategic missileers are in the possession of weapons of colossal power that require constant human attention. We can only talk about the automation of certain routine operations previously performed by duty crews. [Полностью отказаться от

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> дежурных смен в связи с автоматизацией системы боевого управления, скорее всего, будет невозможно. Не нужно забывать, что в руках стратегических ракетчиков находится оружие колоссальной силы, требующее постоянного человеческого внимания. Можно говорить лишь об автоматизации отдельных рутинных операций, ранее выполняемых дежурными расчётами.]"[48]

Karakayev stressed that the system of delivering combat orders to weapons was automated but not automatic, and the human presence was mandatory as a guarantee against unauthorised use. Only some tasks could be automated:

> "One can probably speak only about abandoning certain routine operations performed by duty shifts. Thus, for example, as it was done with the creation of a system of remote control and monitoring of the status of command posts and launchers, which significantly reduced the load on duty shifts to collect and summarise this data. [Можно говорить, наверное, лишь об отказе от выполнения отдельных рутинных операций, выполняемых дежурными сменами. Так, например, как это было сделано при создании системы дистанционного управления и контроля за состоянием командных пунктов и пусковых установок, значительным образом снизившей нагрузку на дежурные смены по сбору и обобщению этих данных.]"[49]

In 2022, Colonel General Karakayev repeated the same response again, while adding that the upgraded automated combat control system that was coming online in RVSN used reliable and advanced domestic information and telecommunication technologies.[50]

5. Strategic stability and arms control

In the ongoing discussion on the role of nuclear forces in Russia's national security, policymakers and scholars have long been interested in the changing nature of strategic stability and, accordingly, arms control. The classic definition of strategic stability, as set in the 1990 'Soviet-U.S. joint statement on future negotiations on nuclear and space arms and further enhancing strategic stability', posits that in future negotiations, "the two sides agree to place emphasis on removing incentives for a nuclear first strike." With that as a starting point, the analysis over many years investigated different factors that affect strategic stability.

Until recently, Russian analysis on technical factors affecting strategic stability (that is, advancements in military technology) did not include AI. For instance, in his 2015 article 'Transformation of strategic stability parameters: the role of the technological factor', Vasiliy Veselov lists the following technological factors that affect strategic stability and deterrence: "prompt global strike technologies, new missile defense solutions, spacecraft defenses, and cyber attack capabilities. [технологии мгновенного глобального удара, новые решения в области ПРО, средства поражения космических аппаратов и возможности проведения кибератак.]"[51]

Similarly, Andrei Kokoshin in 'Strategic stability: Scientific–technological, military, and political aspects' (2015) argued that, in general:

> "…it is advisable to view strategic stability as conditions ensured by reserves of stability that make it possible to compensate for the influence of external and internal factors of disturbance. [стратегическую стабильность целесообразно рассматривать как состояние, которое обеспечивается запасами устойчивости, позволяющими компенсировать влияние внешних и внутренних возмущающих факторов.]"

These factors include:

> "…scientific–technological breakthroughs of a counterpart that change the role of particular weapon systems in the whole strategic arsenal, one's own failures to implement any systems within the main components of strategic nuclear forces, etc. [научно-технические прорывы контрпартнёра, изменяющие вклад отдельных систем вооружения в военный потенциал, собственные провалы в реализации каких-либо систем, входящих в состав основных компонентов стратегических ядерных сил, и т.п.]"[52]

Factors offered by Kokoshin include cyber capabilities ("cyberattacks are becoming another threat to strategic stability [проблема кибератак становится ещё одним фактором угроз стратегической стабильности]"[53]), high accuracy long-range non-nuclear weapons, threats to the early warning system, in particular to its space components.

In the late 2010s, AI emerged among factors affecting strategic stability. In 'Mapping global strategic stability in the twenty-first century' (2018), Dmitri Trenin argues that in the current age, strategic stability is put into question by politico-military factors

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(the changes in the global strategic landscape, proliferation, risks of non-state actors acquiring nuclear weapons) as well as technological innovation:

> "On the technology side, the advent of strategic non-nuclear weapons, progress in cyber technology, the dawn of artificial intelligence, and the potential emergence of space-based weapons are all impacting on strategic stability. A combination of systems based on these types of technology and nuclear weapons could destabilise the strategic environment. [На стратегическую стабильность влияет и развитие технологий: появление стратегических неядерных вооружений, развитие кибертехнологий и искусственного интеллекта, возможное размещение вооружений в космосе. Сочетание систем, основанных на этих технологиях, с ядерным оружием может серьезно дестабилизировать стратегическую обстановку.]"[54]

(At the same time, in another article on strategic stability published in 2019, Trenin does not mention AI among technological factors.[55])

In an article published around the same time, 'Three groups of threats from lethal autonomous weapons systems' (2018), Vadim Kozyulin argues that developments in military AI can potentially breach strategic stability. The disruptive effect of AI will manifest itself in different ways: for instance, by creating new opportunities to use nuclear weapons for tactical missions and, vice versa, non-nuclear weapons for strategic missions thanks to autonomy and high precision; by changing the model of confrontation in space due to the introduction of space drones; by boosting cyber and electronic warfare capabilities that could be used to neutralise missile systems at launchers.[56]

Kozyulin argues that the rapid spread of drone technology and competition on the global market for strike drones are another cause for alarm, just as the development of autonomous swarm capabilities. The latter concern is echoed by a group of authors from the Military Academy of the General Staff of the Armed Forces of Russia and Peter the Great Military Academy of the Strategic Missile Forces, who argued, in 2021, that AI-enabled swarming could help the United States hit Russia's nuclear deterrent with cruise missiles:

> "At present, high-precision long-range air and sea cruise missiles flying to the targets at extremely low altitudes remain the main striking power of the U.S. Armed Forces against the troops and facilities of the RVSN ([strategic nuclear forces] of Russia). Their strike methods and tactics have been quite thoroughly tested in modern military conflicts. It is obvious that the most probable employment is their sudden (or possibly covert) use with the maximum possible duration of flight at extremely low altitudes, with loitering if necessary in the target area, the subsequent group rearrangement, including 'swarming' with the help of elements of artificial intelligence. Other types of U.S. Armed Forces (NATO Joint Force) high precision weapons can also be used against targets of the RVSN: JDAM-type bombs; cluster bombs with homing warheads; stealth guided aircraft missiles; as well as Predator reconnaissance and

strike UAVs. [В настоящее время главной ударной силой ВС США против войск и объектов РВСН (СЯС России) остаются высокоточные крылатые ракеты воздушного и морского базирования большого радиуса действия, летящие к объектам поражения на предельно малых высотах. Способы нанесения ударов и тактика их действий достаточно полно отработаны в ходе современных военных конфликтов. Очевидно, что наиболее вероятно их внезапное (или по возможности скрытное) применение с максимально возможной продолжительностью полета на предельно малых высотах, с барражированием при необходимости в районе цели, последующим групповым перестроением, в том числе «роевое» применение с использованием элементов искусственного интеллекта. По объектам РВСН возможно применение и других типов ВТО ВС США (ОВС НАТО): УАБ типа JDAM; кассетных авиабомб с самонаводящимися боевыми элементами; малозаметных управляемых авиационных ракет, а также разведывательно-ударных БпЛА типа Predator.]"[57]

Dmitry Stefanovich argues that AI can be used on airborne systems for targeting and making delivery vehicles – such as hypersonic glide vehicles – more precise and more capable of evading missile defense with the help of smart decoys.[58] This would favour offense and, consequently, could incentivise further development of defensive capabilities.

Viktor Mizin in 'New tenets for strategic stability and prospects for strategic arms control' (2019) calls for a review of the strategic stability concept and lists AI along with other military innovations:

"However, today the development of an expanded concept of strategic stability requires a fundamentally new methodological approach to this concept, taking into account the peculiarities of the current situation and the multiplicity of nuclear actors, as well as new types of weapons (such as cyberweapons, combat drones, artificial intelligence). All of this calls for innovative approaches to nuclear arms reduction and missile defense agreements. Accordingly, strategic stability should encompass not only the spectrum of nuclear weapons, but also the field of new strategic instruments of force - space and high-precision conventional weapons, information weapons and cyber weapons, and even, given recent developments, the field of so-called hybrid warfare. [Однако сегодня разработка расширенной концепции стратегической стабильности предполагает принципиально новый методологический подход к этому понятию с учетом особенностей современной ситуации и множественности ядерных субъектов, а также новых видов вооружений (например кибероружия, боевых дронов, искусственного интеллекта). Все это требует поиска инновационных подходов к соглашениям по сокращению ядерных вооружений и по тематике ПРО. Соответственно, стратегическая стабильность должна охватывать не только спектр ядерных вооружений, но и сферу новых стратегических инструментов силы – космических и высокоточных обычных вооружений, информационного оружия и кибероружия и даже, с учетом недавних

AI can be used on airborne systems for targeting and making delivery vehicles more precise and more capable of evading missile defense with the help of smart decoys.

событий, область так называемых гибридных войн.]”[59]

A 2019 Higher School of Economics (HSE) report on ‘The new understanding and ways to strengthen multilateral strategic stability’ was a high-profile effort to take fresh look on strategic stability. Co-authored by Sergei Karaganov and Dmitry Suslov, the report was based on a situational analysis held by nearly a dozen experts and was endorsed by the Ministry of Foreign Affairs. Rather than presenting one coherent perspective, it reflected the state of debate on strategic stability and arms control. The section on developments in military technology (titled ‘Blurring of the lines between nuclear and non-nuclear weapons’) featured a detailed, albeit inconclusive, paragraph on AI:

> “Experts did not agree on the artificial intelligence impact on strategic stability. On the one hand, its advent reinforces ballistic missile early warning systems, making it possible to determine the speed and trajectory of adversary missiles with greater accuracy. On the other hand, it increases the efficiency of technical intelligence, thus reducing the survivability of road- and rail-based missiles and strategic submarines, making them an easier target for counterforce strikes, including those using non-nuclear high-precision weapons. In any case, its development and use in the military sphere, coupled with the modernisation of high-precision weapons, changes the traditional understanding of strategic balance and enhances the strategic value of non-nuclear weapons. [Эксперты не пришли к согласию о воздействии на стратегическую стабильность искусственного интеллекта. С одной стороны, его внедрение существенно усиливает систему СПРН, повышая точность расчетов скорости и траектории ракет противника. С другой стороны, он повышает эффективность средств технической разведки, снижая тем самым выживаемость мобильных ракетных комплексов и стратегических подводных лодок, делая их более доступной мишенью для контрсилового удара, в том числе неядерными высокоточными вооружениями. В любом случае, его развитие и внедрение в военной сфере в совокупности с совершенствованием высокоточных вооружений меняет традиционные представления о стратегическом балансе и придает неядерным вооружениям еще более стратегический характер.]”[60]

While addressing new technological challenges was not the central topic of the report, among top priority measures to strengthen international strategic stability, the authors recommended:

> “Developing rules of military conduct in areas that are most prone to military clashes, such as information and communication technologies, high-precision non-nuclear weapons, outer space, artificial intelligence, as well as rules and codes of conduct in regional conflicts. [выработка правил поведения в военной сфере в наиболее опасных с точки зрения риска военных столкновений областях – ИКТ, высокоточные неядерные вооружения, космос, искусственный интеллект, а также правил и кодексов поведение в региональных конфликтах]”[61]

As far as AI was concerned, the report deemed it necessary to:

> "…work out rules of conduct and common approaches towards the use of artificial intelligence in the military, especially military-strategic, sphere. At a minimum, the sides should understand how other countries address and solve this issue. [вырабатывать правила поведения и общие подходы к использованию в военной, особенно военно-стратегической, сфере искусственного интеллекта. Как минимум, сторонам важно представлять себе, как к решению этого вопроса подходят другие.]"[62]

Yet, overall, the report took a critical look at traditional arms control: according to the authors, arms control was traditionally one method to maintain strategic stability, but nowadays it is no longer fit for that goal.[63]

Sergei Karaganov once again emphasised the dangers of AI in his controversial 2023 article 'A difficult but necessary decision' in which he called for reviving the fear of nuclear weapons and made a case for why Russia might need to launch a preemptive nuclear strike on Europe. In describing the strategic context, he mentioned among other things that "[t]he advance of artificial intelligence and the robotization of war increase the threat of even unintended escalation. In fact, machines can get out of the control of confused elites." [Внедрение искусственного интеллекта, роботизации войны увеличивает угрозу непреднамеренной эскалации. Машины могут выйти из-под контроля растерянных элит.][64]

In his reaction to the 2019 HSE report, Alexey Arbatov advocated continuing to pursue arms control to maintain strategic stability and critically examined military technologies listed by the HSE authors. While agreeing that the influence of AI on strategic stability was unpredictable, he argued that;

> "The possibility of agreements covering potentially autonomous strike systems equipped with artificial intelligence (such as Russia's new Poseidon super torpedo) does not depend on their control system. Politically, this will depend on the willingness of the powers to put them on the negotiating agenda, while technically, it will depend on the type of launchers, their basing, maximum proven range, and the type of warhead. [возможность охвата соглашениями вероятных автономных ударных систем, оснащенных искусственным интеллектом (например, новой российской суперторпеды «Посейдон»), зависит не от их системы управления. Это в политическом отношении будет определяться готовностью держав включить их в повестку переговоров, а в техническом – от типа носителей, их базирования, максимально испытанной дальности и вида боезаряда.]"[65]

Arbatov believes that verifying limitations on AI-equipped weapon systems such as Poseidon would not be more difficult than verifying limitations on sea-based ballistic missiles.

The underwater vehicle, that would later be called Poseidon, was publicly presented by President Vladimir Putin in 2018. It was declared to be autonomous and capable of being equipped with nuclear munitions.[66] Although Poseidon is regularly mentioned in

Russian discussions on nuclear issues, the implications of this weapon system and, specifically, its autonomy when it comes to strategic stability have barely been studied. In a 2018 article, Alexander Mozgovoy describes the history of Poseidon and presents its purpose as being capable of circumventing U.S. missile defense. In this, autonomy is treated as a given and not investigated further.[67] The same year, Sergey Tselitskiy assessed that three states (United States, Russia, and China) were developing extra-large autonomous underwater vehicles (AUV). He argued that Russia developing a nuclear-armed AUV could become the first step in the arms race, incentivising not only the United States and China to follow the same path. He also envisioned that this would push states to invest in new defensive systems:

> "If AUV race escalates, one could expect development of interceptors for such underwater vehicles that, in its turn, could contribute to further underwater arms race. [Кроме того, в случае эскалации гонки вооружений в области АНПА [автономных необитаемых подводных аппаратов] следует ожидать разработки средств перехвата автономных подводных аппаратов, что будет еще сильнее раскручивать гонку подводных вооружений.]"[68]

In 2020, Vladimir Dvorkin questioned the purpose of Poseidon.[69] According to him, in the foreseeable future Russia's nuclear triad would provide guaranteed nuclear deterrence of the United States even without Poseidon, whereas the deployment of Poseidon could incentivise the Americans to respond and thus would fuel the nuclear arms race. Dmitry Stefanovich wrote that one can only speculate at the impact of Poseidon on strategic stability and its deployment timeline.[70] Significantly, none of these articles focuses on Poseidon's autonomy and the role of AI. In the 2020 monograph, Dmitry Stefanovich briefly mentions (without explicit reference to Poseidon) that a cyber attack against a nuclear-armed AUV can result in the loss of control over it and the threat of catastrophic consequences.[71] He is also concerned about the possibility of an inadvertent collision of autonomous systems belonging to different powers, both under sea and in other domains.

Colonel A. Mikhailov in 'Strategic stability in the 21st century' (2021) argued that nowadays we are witnessing a transition from the Cold War-type strategic stability to "to global instability caused by the United States' desire to maintain its political, military, and economic dominance on the world stage. [к глобальной нестабильности, вызванной стремлением Соединенных Штатов сохранить политическое, военное и экономическое доминирование на мировой арене]".[72] The author identified 12 factors that "substantively undermine strategic stability,"[73] including political, military, and technological. Among them:

> "…further development of artificial intelligence technologies could form a new balance of power in the world and decisively influence the architecture of global risks and the geopolitical and geoeconomic situation. [Дальнейшее развитие технологий искусственного интеллекта может сформировать новый баланс сил в мире и решающим образом повлиять на архитектуру глобальных рисков, геополитическую и геоэкономическую ситуацию.]"[74]

In 2022, Pavel Sevostianov and Viktor Mizin looked into new

areas for Russia-U.S. arms control discussions and examined whether new technologies, including AI, could be subject to future agreements. Echoing the HSE report, the authors write:

> "While most arms control experts conclude that developments such as robots with artificial intelligence, space and cyber weapons pose an immediate threat to strategic stability and the reliability of deterrence, few are clear about the specific future of their use. [Хотя большинство специалистов по контролю над вооружениями приходят к выводу, что такие разработки, как роботы с искусственным интеллектом, космическое и кибероружие, создают непосредственную угрозу стратегической стабильности и надежности сдерживания, мало кто ясно понимает конкретное будущее их применения.]"[75]

In the end, they argue, any limitations on new types of weapons including on those based on AI:

> "…can only be topics of discussion in future Russian-U.S. consultations on strategic stability, including discussion of its new parameters in accordance with new realities. [могут быть лишь темами обсуждения в рамках будущих российско-американских консультаций по стратегической стабильности, включая обсуждение ее новых параметров в соответствии с новыми реалиями.]"[76]

Other authors also briefly mentioned that AI could be subject of future arms control agreements, including Lyudmila Pankova and Olga Gusarova and Alexander Ulanov.[77]

In 2023, the Nuclear Threat Initiative released a report on 'Reducing Cyber Risks to Nuclear Weapons' produced by a Track II process between Russian and U.S. experts. The report is not focused on AI but it briefly mentions cyber risks that could undermine deterrence; "[c]orrupting, spoofing, or poisoning decisionmaker information, or altering automation or machine-learning applications that may be integrated into nuclear weapons systems or operations and used in decision-making support systems."[78] The report makes recommendations through which Russia and the United States could reduce this and other risks, including by refraining from interfering with nuclear weapons and related systems and getting rid of policies that threaten a nuclear weapons response to a cyberattack.

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In 'Technological advancements in artificial intelligence and deterrence of a potential aggressor', Andrey Protasov, Alexander Shirmanov, and Sergey Radomanov of the MoD's 27th Central Research Institute (historically focused on cybernetics and computer systems for military purposes) conclude that the impact of AI on deterrence will be significant and multifaceted but is ultimately ambiguous. According to the authors, AI technologies will help collect and analyse great volumes of information in real time; they will increase the pace of all actions in crises. Moreover:

> "AI technologies can change perceptions about the size of anticipated costs and expected benefits, the balance between offensive and defensive measures, and the results

of conventional and nuclear deterrence calculations, eliminating uncertainty in situation assessment, ensuring near-absolute impartiality in political and military decisions, and completely eliminating the influence of the human factor. [Технологии ИИ могут изменить представления о размерах предполагаемых издержек и ожидаемых выгод, о балансе между наступательными и оборонительными мерами, о результатах расчетов в области обычного и ядерного сдерживания, устранив неопределенность в оценке обстановки, обеспечив практически абсолютную беспристрастность политических и военных решений, полностью исключив влияние человеческого фактора.]"[79]

The authors suggest that these changes can have very different implications.

One possibility is that with the help of AI, each side would know that its opponent can anticipate its behaviour, and neither side would take undesirable steps altogether. "This may result in some sort of universal deterrence, or absolute strategic stability, enhanced by AI technologies. [В результате может возникнуть некое подобие всеобщего сдерживания, или абсолютной стратегической стабильности, усиленной технологиями ИИ.]"[80]

But another possibility is the opposite: "But the same circumstances can also lead to a higher risk of unintended escalation based on confidence in illusorily assured superiority and a propensity for risk-taking. [Но эти же обстоятельства могут привести и к более высокому риску непреднамеренной эскалации на почве уверенности в иллюзорно гарантируемом превосходстве и склонности к риску.]"[81]

The abovementioned review of literature on the impact of AI on strategic stability should come with a caveat that this area is still not widely studied, and such a role is not universally recognised. This is best illustrated by Alexander Savelyev and Olga Alexandria: in December 2021, they conducted a survey among 20 leading Russian experts on international security, arms control, and strategic stability. The participants of the survey were asked to list factors that have and will continue to have a significant effect on strategic stability. In their article, Savelyev and Alexandria analysed the results of the survey: altogether the participants listed 20 factors (the actual figure was higher, but some factors were grouped), among those the 7 most mentioned factors were as follows: space weapons; high precision weapons (including prompt global strike capabilities and hypersonic weapons); cyber weapons; missile defense; non-strategic nuclear weapons; third countries' nuclear weapons; increased conflict among leading world powers (Russia – NATO and the United States; United States – China).[82] Neither this list, nor the article overall mentioned AI. This indicated that in some groups of the Russian expert community, the impact of AI on strategic stability is viewed as far less significant comparative to other factors.

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Commander of RVSN, Colonel General Sergey Karakayev, argues that new factors will not have a significant effect on deterrence for now:

> "Despite the growth of new dangers and threats in the information sphere associated with the rapid introduction of artificial intelligence technologies in new weapons systems, the use of new capabilities of information and communications technologies to control forces and disrupt the control systems of the opposing side, in the near future the doctrine of deterrence based on the use of nuclear weapons will remain practically unchanged.
>
> [Несмотря на рост новых опасностей и угроз в информационной сфере, связанных с бурным внедрением технологий искусственного интеллекта в новых системах вооружений, использованием новых возможностей информационно-коммуникационных технологий для управления войсками и нарушения работоспособности систем управления противоборствующей стороны, практически неизменным в ближайшем будущем останется доктрина сдерживания, основанная на применении ядерного оружия.]"[83]

The review of the debate among experts on strategic stability shows an increasing awareness of the impact of AI. On the official level, mentions of AI in this context are still more rare. One prominent example is a statement by Valery Gerasimov, Chief of the General Staff of the Russian Armed Forces, at a briefing for foreign military attaches in the end of 2021:

> "These days a new approach is required to devising mechanisms of arms control. Russia has proposed a "new security equation", encompassing all types of offensive and defensive weapons influencing strategic stability, as well as new spheres of confrontation, such as cyberspace, outer space and artificial intelligence. [Сегодня необходим новый подход к выработке механизмов контроля над вооружениями, поэтому Россией было предложено "новое уравнение безопасности", которое охватывает все типы наступательных и оборонительных вооружений, влияющих на стратегическую стабильность, а также новые сферы противоборства — это киберпространство, космос, искусственный интеллект.]"[84]

Russia has proposed a "new security equation", encompassing all types of offensive and defensive weapons influencing strategic stability, as well as new spheres of confrontation, such as cyberspace, outer space and AI.

However, the security equation (a term used by Russian officials to describe the scope of issues that should be included in arms control talks) did not always explicitly include AI. For instance, in the run-up to the 2021 Russia-U.S. summit, Deputy Foreign Minister Sergey Ryabkov did not mention AI among factors that should be included in the security equation.[85] Neither did Russian Ambassador to the United States Anatoly Antonov, only referring to 'destabilising military technologies.'[86]

Finally, Secretary of the Security Council Nikolay Patrushev spoke in favor of putting AI under control of the international community, albeit without a specific link to nuclear weapons. At the 2021 Moscow Conference on International Security, he said:

> "Artificial intelligence, new materials, and synthetic biology have all become part of modern life. Even today there are attempts to use these innovations in the interests of

confrontation between states. It is in our power to put them under the control of the entire world community and turn them into instruments of creation rather than instruments of destruction. [Искусственный интеллект, новые материалы, синтетическая биология – все это уже стало частью современной жизни. Уже сегодня наблюдаются попытки использования этих инноваций в интересах межгосударственного противоборства. В наших силах поставить их под контроль всего мирового сообщества и сделать их инструментами созидания, а не орудиями разрушения.]"[87]

6. Conclusion and recommendations

As demonstrated in this literature review, Russian authors and policymakers generally embrace AI as one of several critical technologies for further military development. While it is widely believed that AI can improve efficiency across many military tasks, there are various concerns relating to the use of AI and its potential consequences, including issues of responsibility and its performance when it comes to goal-setting functions.

As far as nuclear enterprise is concerned, authors explored how AI can be applied to improve diverse tasks related to nuclear weapons, ranging from logistics management and diagnostics to guarding facilities. Importantly, these various potential cases do not necessarily imply the actual practice of RVSN, but rather reflect the general interest in conceptualising how a new technology could benefit each specific task. While these discussions often mention that AI systems need to be reliable, there is usually no explicit analysis of their connection to nuclear C2 and high-level decision-making.

With respect to early warning and command and control system, different authors generally agree that a human should remain in full control, although some concede that fully automating these systems may be feasible and should not be excluded.

In the debate on arms control, AI is still not universally recognised as an important factor. Still, those authors who acknowledge its role tend to consider it a destabilising force. Consequently, this leads some to argue that AI should be included in the arms control agenda, albeit there is no obvious clear vision on a possible deal that would control AI, except for basic confidence-building measures and exchange of views between nuclear states. Yet, some AI-enabled weapons may be included into traditional arms control agreements.

To advance dialogue on AI integration into nuclear C2, force structure, and decision-making among the P5, states should consider the following recommendations:

1. **Glossary of AI-related terms:** There seems to be lack of common language, which makes not only international – but also internal– discussions on this topic complicated. States could start addressing this issue by compiling a glossary of shared terms that would contribute to mutual understanding. One possible option is to expand the already existing 'P5 glossary of key nuclear terms' with a new section of AI-related terms or, more broadly, terms related to security of command and control.

2. **'Fear-mapping':** Many debates on AI, especially in connection with nuclear weapons and warfare in general, are infected with fears of the worst possible scenarios (e.g. that an error in, or an attack against, AI-enabled system could trigger a nuclear war). States could address this issue by mapping these fears as they relate to nuclear C2 and decision-making. This would require brainstorming all possible fears and concerns, then dissecting them and analysing how anticipated dangers can be avoided.

3. **Feasibility of non-interference:** In bilateral arms control between the Soviet Union/Russia and the United States, there is a long history of non-interference with national technical

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means. In the recent decade, experts considered whether the non-interference commitment could be expanded to explicitly address cyber attacks; to cover non-military assets in space; and to include more states. States should discuss whether the idea of non-interference could be applied to AI used in the nuclear enterprise, for instance what types of targets should be off-limits to cyber attacks.

4. **Dependencies between auxiliary functions and critical systems:** While the use of AI in command and control is probably the primary concern of states, this is far from the only way that the nuclear enterprise may be transformed by these technologies. States should explore to what extent integration of AI technologies into auxiliary systems may have impact on functions critical to nuclear C2 and ways to mitigate possible risks.

5. **AI risk assessment and audit from other fields:** States should learn from the practices adopted in other fields, where risk assessment and AI safety audits are more mature. In particular, they should survey ways to establish confidence in the process, its transparency and interpretability. This can create space for general discussion about how one tests and evaluates AI systems and to what extent lessons learned elsewhere could inform thinking on nuclear decision-making.

6. **Stabilising uses of AI:** While the debate about strategic stability leans toward perceiving AI technologies as a destabilising factor, States should explore ways in which the use of AI could have a stabilising effect on relations between them.

7. **Impact of conventional AI-enabled weapons on nuclear forces and C2:** One of the concerns raised in Russian literature pertains that AI-enabled drones could be used to target nuclear forces or C2 infrastructure. States should analyse to what extent this can be an additional destabilising factor and how it can be addressed.

8. **Regular exchanges:** States should agree to meet regularly and discuss issues related to AI interaction with nuclear C2 and decision-making, moreover they should attempt to include AI practitioners into such exchanges to provide for more substantive dialogue.

Note on sources

The literature reviewed for this paper includes publications in leading Russian academic journals (with both a civilian and military focus) covering international and national security, military, and international affairs; relevant news stories and official statements. With some exceptions, the time frame of publications is within five and half years, between January 2018 and September 2023.

Reviewed journals include:

- Aerospace Forces. Theory and Practice (Воздушно космические силы. Теория и практика)
- Armament and Economics (Вооружение и экономика)
- Bulletin of Military Law (Вестник военного права)
- Bulletin of the Academy of Military Sciences (Вестник Академии военных наук)
- Bulletin of the Research Center of the Military Academy of the Strategic Missile Forces (Вестник НИЦ ВА РВСН)
- Fatherland's Arsenal (Арсенал Отечества)
- Foreign Military Review (Зарубежное военное обозрение)
- Military Thought (Военная мысль)
- National Defense (Национальная оборона)
- National Security and Strategic Planning (Национальная безопасность и стратегическое планирование)
- National Strategy Issues (Проблемы национальной стратегии)
- News of the Russian Academy of Rocket and Artillery Sciences (Известия Российской академии ракетных и артиллерийских наук)
- Pathways to Peace and Security (Пути к миру и безопасности)
- Proceedings of the A.F. Mozhaysky Military-Space Academy (Труды Военно-космической академии имени А.Ф.Можайского)
- Russia in Global Affairs (Россия в глобальной политике)
- Russian Military Review (Российское военное обозрение)
- Strategic Stability (Стратегическая стабильность)
- World Economy and International Relations (Мировая экономика и международные отношения)

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