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Solice in Quantum

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SOLACE IN QUANTUM

noun so· lace: **comfort** in times of grief or worry¹

AIM

1. The aim of this service paper is to provide a persuasive argument for the British Military to adopt Quantum Computing technologies as a means to keep a competitive edge over its adversaries; The lessons being learnt in Ukraine and the complexities of a technologically advance adversary utilizing Multi Domain Operations (MDO) means that the adoption of Quantum Computing to both process information faster and provide better information for commanders to make decisions quicker, and the ability to protect their information is vital. I will be providing a specific recommendation for a course of action that addresses both investment in this capability and also a recommendation for closing the gap in doctrine to account for this technological ‘step-change’.

INTRODUCTION

2. The British Military, like all military organizations, must be able to adapt to changing global security threats in order to protect the interests of both the United Kingdom and its NATO allies. In this service paper, I will explore some of the ways in which the British Military can best adapt to future threats and address the challenges it may face in the years to come through the adoption of Quantum Computing as a capability and also as a way to re-vamp its doctrine to include the use of Artificial Intelligence, powered by Quantum Computers, in decision making processes, targeting, and also Cyber defense, to protect our information.

3. The invasion of Ukraine in 2022 resulted in a number of significant military lessons for the international community and specifically Britain and its NATO Allies. As each lesson is identified I will outline in broad terms how quantum computing will aid in providing a military advantage. I will use examples of adversary doctrine and use of novel technological capabilities, specifically Russia’s attempt to fight MDO in Ukraine since 2022, as way of highlighting how Quantum Computing can and will provide the competitive edge in a rapidly changing, technologically advanced, future conflict environment.

DISCUSSION

4. One of the key lessons the British Military can take from the conflict in Ukraine is to adapt to future threats through the development and implementation of new technologies to attempt to achieve MDO. This can include the use of unmanned aerial vehicles (UAVs) and other forms of robotic technology, as well as the integration of artificial intelligence (AI), space and cyber operations and machine learning into military operations, as demonstrated by both Russia and Ukraine². The use of these technologies can enhance the military's capabilities in

¹ Oxford English Dictionary

² Preliminary Lessons in Conventional Warfighting from Russia’s Invasion of Ukraine: February–July 2022 RUSI, 30 November 2022

areas such as surveillance, reconnaissance, and target identification, and can also improve the speed and efficiency of decision-making. Quantum Computing will play a vital role in enhancing the capabilities of almost all of these technologies.

5. **Why Quantum?** Quantum computing is a rapidly advancing field that has the potential to revolutionize a wide range of industries, including the military. Quantum computing is based on the principles of quantum mechanics and uses quantum bits (qubits) instead of classical bits. This allows quantum computers to perform certain types of calculations much faster and more efficiently than classical computers. “NATO is developing quantum sensing for the detection of submarines. Quantum-enabled inertial navigation systems could do the work of GPS without satellite signals. Soon the NATO enterprise and Allies will need to upgrade and secure digital infrastructure using quantum-resistant cryptography”³.

6. One of the most significant potential military applications of quantum computing is in the area of cryptography. Quantum computers have the potential to break many of the encryption algorithms that are currently used to protect sensitive military and government communications. This could allow adversaries to gain access to sensitive information and potentially compromise national security. However, quantum computing can also be used to develop new and more secure encryption methods that are resistant to quantum attacks. “The best-known and developed application of quantum cryptography is QKD, which is the process of using quantum communication to establish a shared key between two parties without an adversary learning anything about that key. Even if an adversary can eavesdrop on all communication between two parties. If the adversary tries to learn information about the key being established, discrepancies will arise in the exchanged Quad-bits, causing you to notice”.⁴ This level of security has obvious benefits, but the ability to perform a brute force attack on an adversaries communications crypto is now possible through quantum computing, meaning exploiting adversary encrypted communications is a realistic possibility.

7. Another potential application of quantum computing in the military is in the area of logistics and supply chain management. Quantum computing could be used to optimize logistics networks and improve the efficiency of supply chain operations. This could lead to significant cost savings for the military and could also improve the responsiveness and flexibility of military operations. The rate of expenditure of ammunition has caught most NATO militaries of guard and seen ammunition stockpiles dwindle much faster than they can be replenished. The US for example has had to purchase artillery shells from South Korean⁵ stockpiles to keep up with the demand in Ukraine. If the largest military industrial base in the world is not able to keep up with demand then the calculations and predictions computed before 2022 must have been wrong. Quantum will allow for more accurate data analytics and be able to provide far more realistic and accurate logistical ‘demand signals’ for future conflict.

³ NATO Exploring Quantum Technology for Future Challenges. Oct 14, 2022

⁴ Pirandola, S.; García-Patrón, R.; Braunstein, S. L.; Lloyd, S. (2009). "Direct and Reverse Secret-Key Capacities of a Quantum Channel".

⁵ US to buy South Korean howitzer rounds to send to Ukraine. Apple News. November 11, 2022

8. Further potential applications of quantum computing in the British military is in the area of artificial intelligence (AI) and machine learning. Quantum computing could be used to train and run AI algorithms much faster and more efficiently than classical computers. This could lead to the development of more advanced and capable AI systems, which could be used for a wide range of military applications, such as target recognition, navigation, and threat detection. The Russians deployed an AI enabled ‘Leopard hunter’ in early 2023 “Russia’s combat Unmanned Ground Vehicle (UGV) Marker can reportedly operate autonomously for days, and network with other UGVs and Markers, while sharing critical military data. Marker’s Artificially Intelligence (AI)-enabled system helps identify friendly vehicles and soldiers through camouflage patterns on their combat uniforms and insignia patches.”⁶ The hesitance to allow AI to make the final decision in the ‘kill’ chain by NATO alliance members, will see our adversaries breaking our Observe Orientate Decide Act (OODA) loop and out perform us. They will be able have decisions made faster than us and allow for both Tactical and Operational advantage to be gained by the adversary. By using the faster quantum computers, programmed in ethical and legal ways, our autonomous weapon systems could regain the advantage by out performing the OODA loop of the adversaries AI enabled weapons.

9. Quantum computing could also be used to improve the accuracy and speed of simulations used to design and test new weapons systems. Quantum computers have the potential to simulate complex physical systems much more accurately and quickly than classical computers. This could lead to the development of more advanced and effective weapons systems, giving the military a significant advantage over its adversaries. While the perception that these new weapons will likely be at a higher cost than those currently in service, the Ukrainian and Russian militaries have both adopted low cost technology’s such as small drones for ISR⁷ in a very effective way. Quantum will allow for faster machine learning, and therefore be able to develop weapons that will be tailored to the conflict, not necessarily always ‘bigger’ or more ‘expensive’, but more efficient and lethal for the environment or adversary.

10. Furthermore, to adapt to future threats, it is crucial for the British Military to improve its ability to anticipate and respond to emerging security challenges. This can be achieved through the development of a robust intelligence and analysis capability, as well as through the enhancement of dedicated units for monitoring and assessing emerging security threats. The increase in data capacity and speed of analytical capabilities of a quantum computer, combined with AI, will allow for faster, more accurate intelligence and analytical products. As these computers are strategically placed onto Military networks, some could be set to focus on cyber-security and the ability to counter cyber-attacks which are becoming more frequent and sophisticated. Units that had traditionally not had a technical focus, and wouldn’t be able to instinctively identify or deal with attacks on their information, could also now be protected.

⁶ Russia Unleashes ‘Leopard Hunter’ UGVs; German Report Admits AI-Enabled Marker Big Threat To Ukraine’s Tanks. Eurasianews. February 26, 2023

⁷ Preliminary Lessons in Conventional Warfighting from Russia’s Invasion of Ukraine: February–July 2022 RUSI, 30 November 2022

11. Another important aspect of adapting to future threats is the ability to operate in a wide range of environments, including urban and remote areas, as well as in different climatic conditions. This requires the development of new equipment and training programs that can prepare troops for a variety of scenarios, including asymmetric warfare, counter-terrorism operations, and humanitarian missions. Training has been a critical advantage in Ukraine; “Training is responsible for Ukraine's greatest advantage over the Russian invaders. The Ukraine military ditched the old Soviet style of tactics and began emulating the West, and that included building a competent and empowered non-commissioned officer corps... ”⁸ Quantum will help with analyzing trends from ‘Big Data’ and make more accurate predictions on where future conflict is likely to occur, who with and when. This will enable a more targeted approach to mission specific training, far in advance of our adversaries, leading to better prepared and equipped troops.

12. Additionally, the British Military must also be able to work effectively with other countries and organizations, including NATO allies, to address global security threats. This includes the ability to conduct joint operations and share intelligence, as well as the development of strong partnerships with other countries in areas such as training and equipment procurement. Quantum computing’s enhanced ability to provide secure communications and a next to impossible to break encryption will allow for more depth of sharing of information at higher classifications. Where historically nations fear sharing information outside of trusted systems that haven’t been accredited by the host nations national security apparatus, quantum computing will provide the ultimate reassurance of data security, fidelity and prevent compromise. Deepening of information sharing by NATO allies will only make the alliance stronger.

13. One major lesson from the Ukraine war has been the importance of rapid and decisive action in the face of aggression. Despite the fact that Ukraine had been preparing for a potential invasion for several years, the speed and ferocity of the Russian attack caught them off guard and allowed Russia to quickly gain control of key territories.⁹ Russia was able to successfully conceal its intentions and plans for the invasion, despite the fact that many analysts had been warning about the potential for aggression for some time. This highlights the need for nations to devote significant resources to intelligence gathering and analysis, in order to stay ahead of potential adversaries, allowing them to be constantly vigilant and ready to respond quickly to any potential threats; AI and machine learning will play a major role in analyzing adversary movements, troop placement and also the ability to predict conflict through logistic trends and stockpiling. As previously mentioned, the superior analytical capabilities over regular computers and AI by quantum facilitated AI will be a conflict winning capability.

⁸ Training Key to Ukrainian Advantages in Defending Nation. Sept. 6, 2022. DOD News

⁹ War in Ukraine: A Geopolitical Analysis. June 2022. Dharmendra Kumar Shahi.

14. In spite of having multiple technological advantages, Russia has failed to successfully achieve MDO. The poor control and lack of co-ordination has seen their (initially) technologically more advanced force fail to achieve the Strategic aims of taking control of Kyiv and other major population centers. The lack of ‘Jointness’ of their operations and the incoherence of their application of the multi-domains has ultimately led to the current under performance of their military. This cannot be attributed to any single factor, but one thing that has remained consistent through most western, and now traditionally Russian leaning media commentators, is the need for a more comprehensive C2 system¹⁰. If the British Military were to upgrade its current C2 systems and networks to those of a Quantum capability, they would be able to more easily control and coordinate the most complex of MDO campaigns. MDO gains its effectiveness by providing the adversary with multiple problems across multiple domains simultaneously and at the time and place of our choosing. By having a system, enhanced through AI, that operates faster than regular computers and humans, we would be able to achieve MDO dominance in future conflict. Be able to bring to bear Air, Land, Sea, Space and Cyber capabilities more effectively and faster than your adversary will arguable only be done so by having the best and most capable C2 systems; Quantum is the fastest and most capable.

CONCLUSION

15. In conclusion, the invasion of Ukraine in 2022 highlights the importance of rapid and decisive action, the use of modern technology, intelligence gathering and analysis and the control of air, sea, land, space and cyber domains. These lessons have similarities to previous armed conflicts and should be taken into account by nations when planning for future military operations. The British Military must be able to adapt to a wide range of future threats in order to protect the interests of the United Kingdom and its NATO allies. This requires the development and implementation of new technologies, the ability to operate in a variety of environments, and the ability to work effectively with other countries and organizations. Quantum computing has the potential to revolutionize a wide range of military applications, including cryptography, logistics, weapon design, and faster, more accurate decision making through AI.

16. Additionally, the British Military must also be able to anticipate and respond to emerging security challenges, such as the proliferation of WMDs and the threat of cyber-attacks. To meet these challenges, it must invest in research and development, as well as in training and education programs for its troops. By doing so, the British Military can ensure that it is prepared to meet the security challenges of the future. It is therefore crucial that Britain achieves technological superiority over its adversaries in the field of Quantum Computing and remains at the forefront of this rapidly advancing field. This will be essential in maintaining Britain's military edge and ensuring national security in the future.

¹⁰ Preliminary Lessons in Conventional Warfighting from Russia’s Invasion of Ukraine: February–July 2022 RUSI, 30 November 2022

RECOMMENDATIONS

17. Britain must take a proactive approach to securing its quantum infrastructure, including the development of standards, policies, and regulations to protect it from potential cyber-attacks, espionage and sabotage. This includes ensuring that the supply chains for quantum technologies are robust and secure, and that the necessary personnel and technical capabilities are in place to detect, prevent and respond to any potential threats.

18. In addition, Britain must also work closely with its allies and partners to develop and implement a coordinated approach to quantum security. This includes sharing information and best practices, as well as working together to develop common standards, protocols and procedures.

19. The British Military has the facilities, personnel and capability, in its Development, Concepts and Doctrine Centre, to adapt not only its own doctrine, but also the Allied Joint Publications that it 'holds the pen' for. The acceptance of AI, powered by Quantum computers, in decision making, targeting, predictive logistics and also cyber security should be adopted quickly. Our adversaries are already doing so, and to delay would mean, to be defeated in future conflict. We must find Solace in Quantum.

BIBLIOGRAPHY

- "Direct and Reverse Secret-Key Capacities of a Quantum Channel Pirandola, S.; García-Patrón, R.; Braunstein, S. L.; Lloyd, S. (2009). <https://arxiv.org/abs/0809.3273>
- Russia Unleashes ‘Leopard Hunter’ UGVs; German Report Admits AI-Enabled Marker Big Threat To Ukraine’s Tanks (eurasianimes.com) <https://eurasianimes.com/russia-unleashes-leopard-hunter-ugvs-german-report/> <https://eurasianimes.com/russia-unleashes-leopard-hunter-ugvs-german-report/>
- NATO Exploring Quantum Technology for Future Challenges. Oct 14, 2022
- Training Key to Ukrainian Advantages in Defending Nation > U.S. Department of Defense > Defense Department News <https://www.defense.gov/News/News-Stories/Article/Article/3149975/training-key-to-ukrainian-advantages-in-defending-nation/#:~:text=Training%20is%20responsible%20for%20Ukraine%27s%20greatest%20advantage%20over,building%20a%20competent%20and%20empowered%20non-commissioned%20officer%20corps.>
- US to buy South Korean howitzer rounds to send to Ukraine | AP News <https://apnews.com/article/russia-ukraine-europe-business-south-korea-government-and-politics-15569a7bfdb6c53404cfce5f0df1c28f>
- War in Ukraine: A Geopolitical Analysis. June 2022. Dharmendra Kumar Shahi. ReasearchGate.