Journal of Aerospace & Security Studies
2022 | Volume I | pp. 36-60

Future Warfare and Emerging Military Technologies: An Analysis of US Defence Modernisation

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Abstract

Analysing United States' defence modernisation plans and strategies about Autonomous Weapon Systems (AWS), Joint All-Domain Command and Control (JADC2), space militarisation, hypersonic vehicles and digital engineering and data architecture, the paper discusses what impact such Emerging Military Technologies (EMTs) will have on variables such as speed, lethality, decision-making and nuclear Command and Control (C2) structures in future warfare. The paper emphasises that technological advancements have made war very swift. This, in turn, has increased its lethality leaving decision-makers with compressed response time. The study finds that of the various EMTs under study, digital engineering and data architecture are likely to have the gravest impact on the character and conduct of future wars.

Keywords: AI, Hypersonics, AWS, Speed, Lethality, Warfare.

Introduction

In International Relations, security is discussed as a vital component of foreign affairs. In the present multipolar world, friction between states has also intensified strategic competition. This strategic competition is characterised by influence on economic and political domains but also by having an upper hand on military-technology as it determines the global security environment.[1] Most academics and policy experts have given considerable importance to emerging military-technologies for enhancing military strength and balancing strategic rivalries.[2]

Emerging technologies hold the potential to alter the rules of the game,[3] whether in terms of strategic competition or in warfare. They also act as a factor that drives the most change in the character of warfare as compared to other elements.[4] It is a massive peacetime investment to impact the character of warfare that determines strategic competition as well as strategic reforms.[5] Whichever state holds the authority to impact strategic reforms is then able to demonstrate its military superiority.

More specifically, Emerging Military Technologies (EMTs) provide solutions to strategic and tactical problems such as reducing

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1 Michael Raska, "Strategic Competition for Emerging Military Technologies Comparative Paths and Patterns," *Prism* 8, no. 3 (2020): 61-81, https://ndupress.ndu.edu/Portals/68/Documents/prism/prism_8-3/prism_8-3_Raska_64-81.pdf.

2 Andrew D. James, "Emerging Technologies and Military Capability," in *Emerging Critical Technologies and Security in the Asia-Pacific* ed. R.A. Bitzinger (London: Palgrave Macmillan, 2016), https://doi.org/10.1057/9781137461285_2.

3 Ibid.

4 Alex Roland, "War and Technology," Foreign Policy Research Institute, February 27, 2009, https://www.fpri.org/article/2009/02/war-and-technology/.

5 Warren Chin, "Technology, War and the State: Past, Present and Future," *International Affairs* 95, no. 4 (2019): 765–783, https://doi.org/10.1093/ia/iiz106.

casualties, limiting collateral damage and even responding to quantitative superiority of the adversary.[6] Ultimately, they allow states to continue employing warfare as a policy instrument where political decisions fail to create consensus.[7]

Besides impacting strategic competition, EMTs have continued to make warfare complex. The interplay of man and machine in warfare has assumed unprecedented importance. As Hables Gray explained: 'In postmodern war, the central role of human bodies in war is being eclipsed rhetorically by the growing importance of machines.'[8] There is also the debate about who is superior - humans or machines[9] or who can make decisions faster.[10]

Of various military technologies, future warfare is most likely to be impacted by Autonomous Weapon Systems (AWS), Joint All-Domain Command and Control (JADC2), space militarisation, hypersonic vehicles and digital engineering and data architecture. This paper looks at these military advancements from the lens of United States' defence modernisation plans and strategies and how they will impact the speed, lethality, decision-making and nuclear Command and Control (C2) complexities of future warfare.

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6 Daniel R. Lake, "Technology, Qualitative Superiority, and the Overstretched American Military," *Strategic Studies Quarterly* 6, no. 4 (2012): 71-99, http://www.jstor.org/stable/26270567.

7 Chin, "Technology, War and the State: Past, Present and Future."

8 Ibid.

9 M. L. Cummings, "Artificial Intelligence and the Future of Warfare," Chatham House International Affairs, January 2017, https://www.chathamhouse.org/2017/01/artificial-intelligence-and-future-warfare.

10 James Vincent, "The Future of War Will Be Fought by Machines, But Will Humans Still Be In Charge?," *Verge*, April 24, 2018, https://www.theverge.com/2018/4/24/17274372/ai-warfare-autonomous-weapons-paul-scharre-interview-army-of-none.

Autonomous Weapon Systems (AWS)

Devices capable of operating without human interference fall under the category of Autonomous Weapon Systems (AWS) such as unmanned vehicles or robotics. A machine can become autonomous if three things are mounted on it: first, sensors to monitor external influence; second, Artificial Intelligence (AI) or a processor to decide how to respond to the external environment, and lastly, some set of tools to respond to the external influence.[11]

An AWS can be categorised as semi-autonomous weapons that are pre-programmed only to perform a set of specific tasks and actions without external commands and fully autonomous weapons that can perform tasks independently by choosing an optimal solution based on the information sensed from the external environment. Fully autonomous weapons are not pre-programmed to respond or even have pre-programmed goals, rather they depend on AI to respond to unforeseen circumstances. So far, such weapons have not been brought into the battlefield as there remain serious ethical and moral questions linked to their use.

Impact on Future Warfare

Speed

Military planners in the United States believe that AWS, less dependent on human decision-making and control, will be able to operate at a far faster speed. This will make war operations speedy. The current remotely operated autonomous systems are slower because they rely on distant C2 systems for communication that is often hampered by delays, jamming, or denial. The speed at which AWS will be capable of operating may create incentives to remove

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[11] Peter W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century* (London: Penguin Books, 2009).

humans from the decision-making loop.[12] Referring to speed and intensity of operations conducted by AWS, John Allen and Amir Husain have termed such a war as 'hyper war',[13] while Paul Scharre calls it a 'flash war'.[14]

Lethality

The lethality of an AWS is expected to increase as it will be operated in large swarms of hundreds or even thousands of relatively small and low-cost drones. Even if an AWS operates in smaller number, it can be carrying small explosives that detonate precisely on the target increasing the lethal impact. The future AWS will return mass fighting on the battlefield as such autonomous systems will be able to inflict massive damage on the enemy through autonomous tactical movement in retaliation.[15] Moreover, AWS are capable of tethering to one another providing them the capability of synchronised attack or defence. This will ultimately increase the footprint of impact on the adversary.

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12 Matthew Rosenberg and John Markoff, "The Pentagon's 'Terminator Conundrum': Robots That Could Kill on Their Own," *New York Times,* October 25, 2016, https://www.nytimes.com/2016/10/26/us/pentagon-artificial-intelligence-terminator.html.

13 John R. Allen and Amir Husain, "On Hyperwar," *Proceedings* 143, no. 7, U.S. Naval Institute (2017), https://www.usni.org/magazines/proceedings/2017/july/hyperwar; Jules Hurst, "Robotic Swarms in Offensive Maneuver," *Joint Force Quarterly* 87, no. 4 (2017): 105-111, https://www.hsdl.org/?view&did=804820; Graham Warwick, "Powerful Pairing," *Aviation Week and Space Technology,* (November 27-December 10, 2017): 35-36, https://archive.aviationweek.com/issue/20171127; and Graham Warwick, "Swarm Enabler," *Aviation Week and Space Technology*, (April 3-16, 2017): 31-32, https://archive.aviationweek.com/issue/20170403.

14 Paul Scharre, *Army of None: Autonomous Weapons and the Future of War* (New York: WW Norton & Company, 2018).

15 Ibid.

Decision-making

With greater speed and increased lethality coming at the adversary, the latter's decision-making time and efficiency may decrease. In an attack by an AWS, the competition will be between machine and man. Given that man is making decisions on the other end, his/her decision-making would need to be at a faster or similar pace as that of the machine to effectively respond to the attack. Moreover, if the attack or threat of attack by an AWS is sudden, it significantly compresses strategic decision-making time. In the future, AWS will surpass the speed of political decision-making which may reduce the ability of leaders to manage an escalating crisis.

Nuclear C2

The impact of AWS on nuclear systems remains an understudied subject. However, the present studies suggest that AWS can make nuclear C2 complex as states might deploy risky AWS if their second-strike capability is threatened. AWS would also introduce considerable changes to force posturing and first-strike capability.[16]

Joint All-Domain Command and Control (JADC2)

Joint All-Domain Command and Control (JADC2) is a concept introduced by the US Department of Defense (DoD) (Figure 1).[17] The purpose behind this concept is to connect sensors from all military services - Air Force, Army, Navy, Marine Corps and Space Force - into a single network. Such a network will allow interoperability as compared to traditional military services that deploy their own

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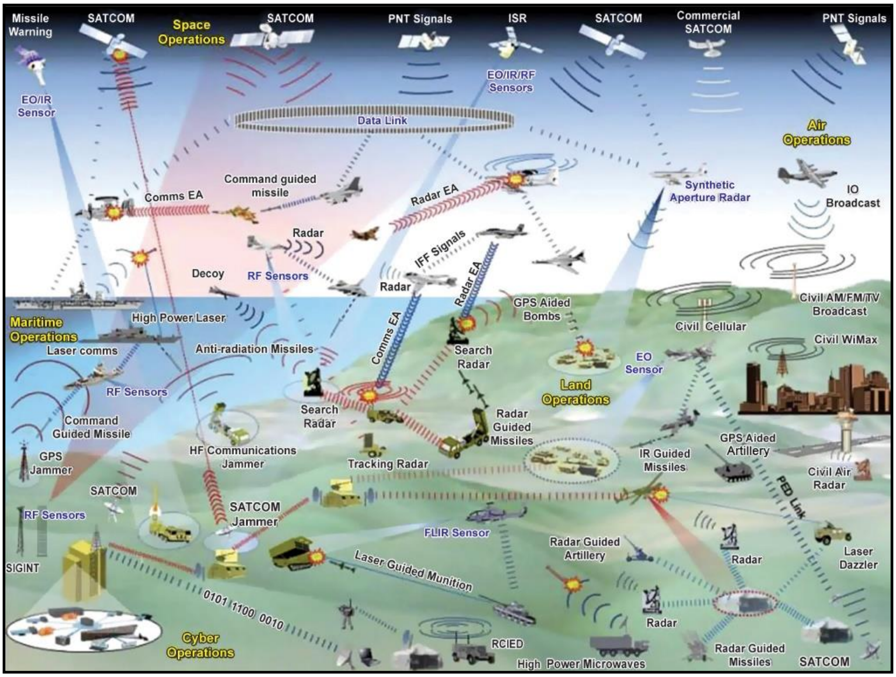
[16] Michael C. Horowitz, Paul Scharre, and Alexander Velez-Green, "A Stable Nuclear Future? The Impact of Autonomous Systems and Artificial Intelligence," Cornell University, December 13, 2019, https://arxiv.org/pdf/1912.05291.pdf.

[17] Congressional Research Service, *Joint All-Domain Command and Control (JADC2),* report (Washington, D.C.: CRS, 2020), https://fas.org/sgp/crs/natsec/IF11493.pdf.

tactical networks which may not be compatible with other services. JADC2 is envisioned as synergy of complementary services such that each capability increases effectiveness and compensates for the vulnerabilities of other services.[18]

Figure 1: Joint All-Domain Command and Control (JADC2)



Source: Congressional Research Service, *Joint All-Domain Command and Control (JADC2)*.

[18] U.S. Department of Defense, *Capstone Concept for Joint Operations: Joint Force 2020,* report (Washington, D.C.: U.S. DoD, 2012), https://www.jcs.mil/Portals/36/Documents/Doctrine/concepts/cross_domain_planning_guide.pdf?ver=2017-12-28-161956-230.

Impact on Future Warfare

Speed

Presently, USAF's air-tasking cycle stretches over 72 hours according to the Air Force Operation Center (AOC).[19] Such a slow process would be incompatible with future requirements as the speed of operations would be greater. JADC2 will reduce this time frame while replacing emphasis from deliberate and thoughtful planning to dynamic and proactive planning to support the speed of operations in a contested and congested environment. It will centralise control of planning, directing, and coordinating a military operation while having decentralised execution to generate required operational speed in order to cope with disorder, uncertainty, and fluidity of combat in air operations.

Lethality

As JADC2 will thread information coming from sensors of US Air Force, Army, Navy, Marine Corps and Space Force into one system, it will increase the lethality of response operations. For instance, a Navy missile fired from offshore could be the most effective and quick response to a threat detected by an Air Force Unmanned Aerial Vehicle (UAV). Similarly, lethality of JADC2 operations would increase when either a rocket artillery, air-to-surface missile or naval gunfire would be able to respond to a call of fire from an infantry battalion.[20] Such a scenario would engage multiple

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[19] Sherrill Lingel, Jeff Hagen, Eric Hastings, Mary Lee, et al., *Joint All-Domain Command and Control for Modern Warfare: An Analytic Framework for Identifying and Developing Artificial Intelligence Applications*, report (Santa Monica: RAND Corporation, 2020), https://www.rand.org/pubs/research_reports/RR4408z1.html.

[20] Jim Garamone, "Joint All-Domain Command, Control Framework Belongs to Warfighters," U.S. Department of Defense, November 30, 2020, https://www.defense.gov/Explore/News/Article/Article/2427998/joint-all-domain-command-control-framework-belongs-to-warfighters/.

asymmetric instruments to respond along a vertical and horizontal axis with varying degrees of impact.[21]

Decision-making

USAF believes that JADC2 would ease the decision-making process for commanders as it would allow them to quickly analyse the information coming from all sensors using their Advanced Battle Management System (ABMS) to understand the battlespace.[22] It would also allow decision-makers to direct forces faster than the adversary while delivering synchronised combat across all domains. The primary challenge under JADC2 would be to institutionalise decision-making, authorities and command relationships as multiple warfighting domains would be involved.[23]

Nuclear C2

JADC2 would increase second-strike capability in case a state's first-strike capability is destroyed. It will focus on cross-domain nuclear deterrence which would broaden the spectrum of strategies to respond to the adversary.[24]

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21 Patrick J. Cullen and Erik Reichborn-Kjennerud, *MCDC Countering Hybrid Warfare Project: Understanding Hybrid Warfare,* report (London: Assets Publishing Service, 2017), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/647776/dar_mcdc_hybrid_warfare.pdf.

22 Congressional Research Service*, Joint All-Domain Command and Control (JADC2)*.

23 Paul E. Bauman, *Cross-Domain Synergy in Joint Operations*, *Planners Guide*, report (Washington, D.C.: Future Joint Force Development, 2016), https://www.jcs.mil/Portals/36/Documents/Doctrine/concepts/cross_domain_planning_guide.pdf?ver=2017-12-28-161956-230.

24 King Mallory, *New Challenges in Cross-Domain Deterrence,* report (Santa Monica: RAND Corporation, 2018), https://www.rand.org/pubs/perspectives/PE259.html.

Space Militarisation

Many states are now exploiting space for military purposes.[25] Although Russia and China established their space forces in 2015,[26] it was not until 2018 when the US released its first 'National Space Strategy'[27] which signalled other states to view 'space' as a potential warfighting domain. Now, most emerging technologies such as network-centric warfare, early warning systems and autonomous systems are dependent on space satellites for communication, navigation, meteorology, imagery, sensing as well as offensive and defensive capabilities. States are now more inclined towards developing their own space forces, military space systems and space doctrines seen as a force multiplier capable of providing real-time global coverage and secure in-theatre communication across all domains namely air, ground, cyber, and naval fleet operations.[28]

Impact on Future Warfare

Speed

With the incorporation of space into warfighting domains, handling information on the battlefield has become proficient and quick. Space Network Management Systems (SNMS) have assisted in

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[25] Jun Nagashima, "The Militarization of Space and its Transformation into a Warfighting Domain," The Sasakawan Peace Foundation, July 17, 2020, https://www.spf.org/iina/en/articles/nagashima_02.html.

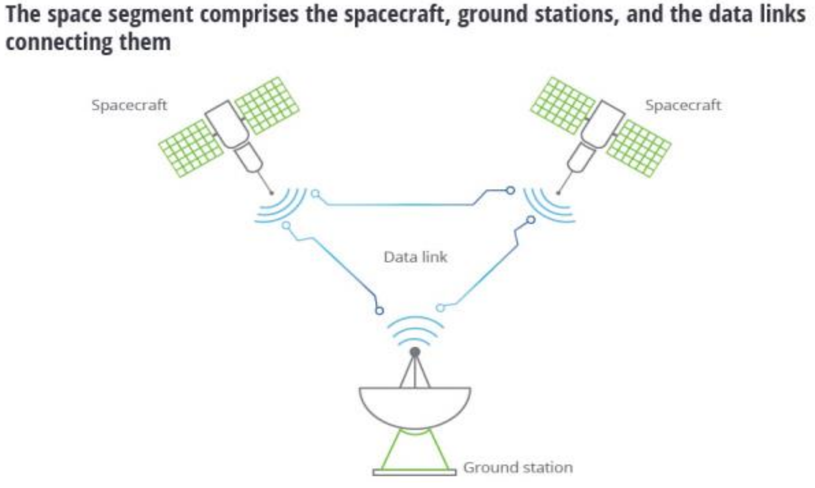
[26] Jen DiMascio, "How Will Russia and China Respond to U.S. Space Force?" *Aviation Weekly Network*, December 15, 2020, https://aviationweek.com/defense-space/budget-policy-operations/how-will-russia-china-respond-us-space-force.

[27] Marcia Smith, "White House Releases Fact Sheet on New National Space Strategy- Updated," *Space Policy Online*, March 24, 2018, https://spacepolicyonline.com/news/white-house-releases-fact-sheet-on-new-national-space-strategy/.

[28] "United States Space Capabilities," United States Space Force, Accessed January 21, 2020, https://www.spaceforce.mil/About-Us/About-Space-Force/Space-Capabilities/.

speeding up standardising and directing highly complex data, users, and nodes.[29] For instance, a satellite might combine various radio frequencies or even re-route data through Inter-Satellite Optical Wireless Communication (IsOWC) to find clear paths of communication to quickly deliver information where required on the battlefield. The use of satellites for gathering and dissemination of intelligence information has made military operations faster. It has been reported that space is now utilised for 90 percent of US intelligence operations.[30]

Figure 2: Present Space Intelligence Network



Source: Reed, Routh and Mariani, "Information at The Edge: A Space Architecture for a Future Battle Network."

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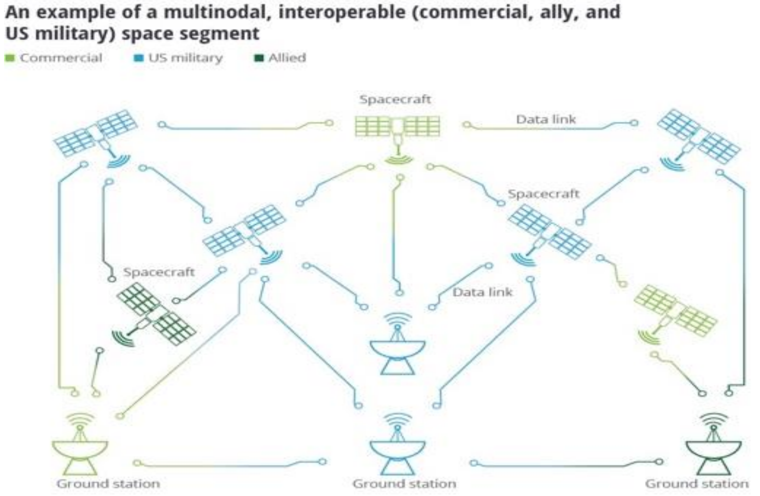
[29] Justin Reed, Adam Routh and Joe Mariani, "Information at The Edge: A Space Architecture for a Future Battle Network," *Deloitte Insights*, November 16, 2020, https://www2.deloitte.com/us/en/insights/industry/public-sector/future-space-weapons-space-architecture.html.

[30] Niall Firth, "How to Fight a War in Space (And Get Away with It)," *MIT Technology Review*, June 26, 2019, https://www.technologyreview.com/2019/06/26/725/satellite-space-wars/.

Figure 3: Future Space Intelligence Network



Source: Reed, Routh and Mariani, "Information at The Edge: A Space Architecture for a Future Battle Network."

Lethality

Space has also increased the lethality of the battlefield by allowing commanders to understand the battlespace swifter and designating the desired and most effective response rapidly and forcefully. Space has also amplified the lethality of warfare with the development of space-based weapons such as Directed-Energy Weapons (DEWs), kinetic energy weapons against surface and missile targets and space-based conventional weapons against surface targets. The lethality of space-based weapons can be gauged by how they can make in-motion and stationary ground targets sitting ducks. For instance, a laser constellation in space can target fighter jets or cruise missiles or even above-ground terrestrial targets such as fuel tanks or fuel trucks, launchpads of missiles or even missiles and other relatively thin-skinned or flammable targets.[31] Nonetheless, satellites in space are also

[31] Bob Preston, Dana J. Johnson, Sean J.A. Edwards, Michael Miller et al., *Space Weapons-Earth Wars*, report (Santa Monica: RAND Corporation,

vulnerable to Anti-Satellite Weapons (ASAT). The satellites targeted in space or objects targeted by space-based weapons do not need explosive devices rather kinetic energy is destructive enough to eliminate the target. Space, therefore, has opened a new domain to inflict lethal destruction on an adversary.

Decision-making

According to a RAND Project Air Force report, decision-making time, against space-based weapons, is reducing drastically as response time is squeezed. For example, the response time to space-based DEWs, laser or electromagnetic spectrum, is calculated to be in seconds. Similarly, the response time to space-based kinetic energy against missile targets is a few minutes while against surface targets is a few hours. Whereas response time for space-based conventional weapons is said to be about ten minutes.[32]

Nuclear C2

The increasing number of space actors have reduced nuclear deterrence. Although not well planned, the threat of nuclear war or nuclear accident in space exists. [33] However, nations would pivot towards restraint of use of space as a battleground for nuclear war due to exponential risks attached to the outcome of such a war or accident.[34] Nonetheless, this does not eliminate space from being an area where deterrence can be ignored.

2002), https://www.rand.org/content/dam/rand/pubs/monograph_reports/2011/RAND_MR1209.pdf.

32 Ibid.

33 Jeremy Grunert, "John J. Klein, Understanding Space Strategy: The Art of War in Space," *Journal of Space Law* 44 (2020): 332, https://heinonline.org/HOL/LandingPage?handle=hein.journals/jrlsl44&div=14&id=&page=.

34 Thomas Graham, "Space Weapons and the Risk of Accidental Nuclear War," Arms Control Association, 2005,

Hypersonic Vehicles

Hypersonic vehicles include hypersonic missiles and jets that are capable of attaining speeds up to Mach 6 to Mach 27.[35] The reason hypersonic missiles are seen to be advantageous to militaries is that they combine hypersonic speeds with low altitude and great manoeuvring capabilities to evade missile defence systems. Prototypes of hypersonic aircraft are being developed with the combination of a conventional turbine engine having dual-mode ramjet/scramjet propulsion. The ramjet would be used in early flight, while the scramjet would assist the vehicle reach hypersonic speed of Mach 6. Hypersonic jets could be made faster if pilots are left out of the cockpit.[36]

Hypersonic vehicle technology has advanced across three broad spectrums that include propulsion systems, airframe material, and embedded electronics. First, the propulsion system is designed so that the flight pattern of hypersonic weapons is unpredictable. They do not adopt a ballistic trajectory like ballistic missiles, rather they follow an unpredicted zigzag pattern as they dodge the missile defence radars. Second, the airframe materials, circuit board and the electronic components they incorporate ensure that they can survive temperatures, vibration, and extreme pressure of the hypersonic flight. Third, hypersonic missiles have secure

https://www.armscontrol.org/act/2005-12/features/space-weapons-risk-accidental-nuclear-war.

35 Richard H. Speier, George Nacouzi, Carrie Lee, and Richard M. Moore, *Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons* (Santa Monica: RAND Corporation, 2017), https://www.rand.org/pubs/research_reports/RR2137.html.

36 Guy Norris, "Hypersonic Skunk," *Aviation Week and Space Technology*, 2017, quoted in Michael E. O'Hanlon, *Forecasting Change in Military Technology, 2020-2040*, report (Washington, D.C.: Brookings Institution, 2020), https://www.brookings.edu/wp-content/uploads/2018/09/FP_20181218_defense_advances_pt2.pdf.

communications with C2 networks that help them evade detection and interception.[37]

Impact on Future Warfare

Speed

Hypersonic missiles are known for their speed. A hypersonic vehicle can fly as fast as Mach 6 to Mach 27 which is about 5000 to 25000 miles per hour. In other words, a hypersonic missile covers one to five miles in a second.[38] This makes warfare complex as such fast missiles and jets introduce a new dimension of threats, defence against which requires equally fast responding technologies.

Lethality

The kinetic energy that comes with the speed of a hypersonic missile can unleash catastrophic impact. However, the precision of hypersonic missiles was once considered to be highly accurate, more recently though, a union of concerned scientists warned that hypersonic missiles still face serious technical challenges to be precise.[39] Nonetheless, their heat and temperature can leave a lethal impact on the targeted area.

Decision-making

A hypersonic missile attack can occur with a warning time of only a few minutes. Additionally, manoeuvrability in hypersonic missiles leaves room for greater unpredictability of its intended target,

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[37] JR Wilson, "The Electronics Design Challenges of Hypersonic Flight," *Military & Aerospace Electronics*, May 22, 2020, https://www.militaryaerospace.com/sensors/article/14176531/the-electronics-design-challenges-of-hypersonic-flight.

[38] Speier, Nacouzi, Lee, and Moore, *Hypersonic Missile Nonproliferation*.

[39] Cameron Tracy, "The Accuracy of Hypersonic Weapons: Media Claims Miss the Mark," Union of Concerned Scientists, March 9, 2020, https://allthingsnuclear.org/ctracy/the-accuracy-of-hypersonic-weapons-media-claims-miss-the-mark.

therefore planning the desired response can be difficult. This may leave leadership of the targeted state puzzled and with less time to respond.[40]

Nuclear C2

Hypersonic missiles are capable of carrying out disarming/ decapacitating first strike.[41] Their use as a pre-emptive strategy will entangle states in a 'use or lose' scenario.[42] Such threats are magnified if nuclear warheads are part of a hypersonic missile's payload. Moreover, nuclear and conventionally equipped hypersonic weapons could trigger an arms race and competition that may initiate a cycle for stability-instability and action-reaction syndrome.[43] China and Russia have developed low yield stockpile of nuclear-armed hypersonic missiles.[44] In case, nuclear deterrence is unstable, contesting states may feel the urge to employ nuclear-armed hypersonic weapons.

Digital Engineering and Data Architecture

According to the US' DoD 'Digital Engineering Strategy', the emerging technologies incorporated in their digital engineering and

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40 O'Hanlon, *Forecasting Change in Military Technology, 2020-2040*.

41 Matteo Frigoli, "The Implications of the Advent of Hypersonic Weapon Systems for Strategic Stability," *Pugwash Conferences on Science and World Affairs,* December 17, 2019, https://britishpugwash.org/wp-content/uploads/2019/12/M.Frigoli-Hypersonics-Stability-and-arms-control-PDF-2.pdf.

42 Sander Ruben Aarten, "The Impact of Hypersonic Missiles on Strategic Stability Russia, China, and the US," *Militaire Spectator,* April 21, 2020, https://www.militairespectator.nl/thema/strategie/artikel/impact-hypersonic-missiles-strategic-stability.

43 Adil Sultan and Itfa Khurshid Mirza, "Hypersonic Weapons in South Asia: Implications for Strategic Stability," *IPRI Journal* XXI, no. 1(2021): 61-81.

44 Alan Cummings, "Hypersonic Weapons: Tactical Uses and Strategic Goals," *War on the Rocks*, November 19, 2019, https://warontherocks.com/2019/11/hypersonic-weapons-tactical-uses-and-strategic-goals/.

data architecture would be cyber, advanced computing, AI and big data analytics.[45] These technologies are highly dependent on digital and data architecture which will give war planners unique methods of combat.

Impact on Future Warfare

Speed

Digital engineering has increased computational speed, processing capabilities and storage capacity of warfighting management systems.[46] In the field of data architecture, AI has upgraded every level of warfare from quick hunt of enemy with sensors to gathering quick intelligence and sorting through complex data with exceptional speed.[47] Stanford University's 'AI Index 2019 Annual Report' found that computational speed of AI doubles every three months and it is outpacing Moore's Law.[48] The speed of machine learning is also said to be reaching the speed of light.[49] This shows that exponential increase in speed of digital and data will directly impact the speed of engagement. It is also believed that this

[45] Office of the Deputy Assistant Secretary of Defense for Systems Engineering, *Digital Engineering Strategy*, report (Washington, D.C.: U.S. Department of Defense, 2018), https://fas.org/man/eprint/digeng-2018.pdf.

[46] Ibid.

[47] Rudy Guyonneau and Arnaud Le Dez, "Artificial Intelligence in Digital Warfare: Introducing the Concept of the Cyber Teammate," *The Cyber Defense Review* 4, no. 2 (2019): 103-116, https://www.jstor.org/stable/pdf/26843895.pdf?refreqid=excelsior%3A4065c0be4120f94a5e5480e3e782133a.

[48] Cliff Saran, "Stanford University finds that AI is outpacing Moore's Law," *Computer Weekly,* December 12, 2019, https://www.computerweekly.com/news/252475371/Stanford-University-finds-that-AI-is-outpacing-Moores-Law.

[49] Anthony Cuthbertson, "Machines Can Learn Unsupervised 'At the Speed of Light' After AI Breakthrough," *Independent*, July 21, 2020, https://www.independent.co.uk/life-style/gadgets-and-tech/news/ai-machine-learning-light-speed-artificial-intelligence-a9629976.html.

increased speed, in an autonomous systems face-off or in a cyber-attack, may push humans out of the decision-making loop.[50]

Lethality

Digital engineering and data architecture may also increase the lethality of future warfare. For instance, AI will be able to give power to machines to decide to kill, such systems are known as Lethal Autonomous Weapons Systems (LAWS). At some point in the future, man might have to give the decision to kill to machines. However, this comes with its consequences. Giving authority/autonomy to a machine to make decisions might not be dangerous but the machine getting out of control due to algorithmic failure or error might be highly lethal.[51] In case of failure or loss of control over a fully autonomous weapon, a machine could cause unintended casualties and conflict escalation.[52] Similarly, cyberweapons could inflict massive damage to critical military systems, nuclear included. Cyber is considered lethal as it is difficult to track and target a hacker. Moreover, damage assessment is difficult in a cyber-attack, as more viruses/malware may be hidden within the data. Likewise, damage repair is also challenging. For these reasons, cyber-attacks should also be prosecutable or at least designated as a 'war crime.' This demonstrates that digital and data attacks can inflict as lethal damage as kinetic war.[53]

Decision-making

With digital engineering and data architecture, the processing of information can be done in early stages of the combat. Efficient AI,

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[50] Konaev, "With AI, We'll See Faster Fights, But Longer Wars."

[51] Scharre, *Army of None*.

[52] Stephanie Mae Pedron and Jose da Arimateia da Cruz, "The Future of Wars: Artificial Intelligence (AI) and Lethal Autonomous Weapon Systems (LAWS)," *International Journal of Security Studies* 2, no. 1 (2020).

[53] Neil C. Rowe, "Ethics of Cyberwar Attacks," in *Cyber War and Cyber Terrorism*, ed. A. Colarik and L. Janczewski (Hershey: The Idea Group, 2007), https://faculty.nps.edu/ncrowe/attackethics.htm.

for instance, can provide real-time actionable intelligence that can help make the right decisions and reduce the risk of collateral damage and casualties.[54]

Nuclear C2

Digital engineering and data architecture have raised new concerns about the security of nuclear C2, e.g., if the latter is automated with the help of AI, a cyber-attack could disable the system. If nuclear weapons become dependent on AI, it may reduce strategic stability.[55] With growing dependence on digital engineering, cyber, coding and software, all aspects of nuclear weapons such as early warning, protection of data, authorisation of use and firing could become more vulnerable because of hackers. This vulnerability can reduce nuclear deterrence and increase the chances of error and miscalculation. [56]

Analysis

From the discussion above, it can be concluded that in terms of the gravity of impact, **digital engineering and data architecture** is likely to have the '*gravest'* impact on warfare given greater acceptability and flexibility of integration (Table 1). The two also need immediate investment to deliver modest outcomes for future warfare. This is the one technology that could affect all other technologies. For instance, if there are advances in AI, such as machine learning holding the capability to mimic the human brain, it would increase

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54 Konaev, "With AI, We'll See Faster Flights, But Longer Wars."

55 Mark Fitzpatrick, "Artificial Intelligence and Nuclear Command and Control," *Global Politics and Strategy* 61, no. 3 (2019): 81-92, https://www.tandfonline.com/doi/full/10.1080/00396338.2019.1614782?scroll=top&needAccess=true.

56 Andrew Futter, *Cyber Threats and Nuclear Weapons: New Questions for Command and Control, Security and Strategy,* report (London: Royal United Services Institute, 2016), https://rusi.org/sites/default/files/cyber_threats_and_nuclear_combined.1.pdf.

the scope of other technologies like robotics to manufacture advanced humanoids, also referred to as a soldier's wingman on the battlefield. Similarly, deeper understanding of algorithms would be able to defend nuclear C2 against cyber espionage and attacks. Furthermore, with emerging technologies crowding the battlefield, there would be an explosion of data which would make manual analysis impractical and ineffective. This is where digital and data would play a critical role in providing the most effective method to analyse data. Moreover, lethal threats would grow at a high rate which would require cyber and AI efficiency to reduce lethality by employing various techniques. Example of lethal threats could be cyber-attacks on C2 to misguide missiles or an adversary taking charge of drones and robots and reversing the offense. Additionally, cyber and AI would be the most cost-effective defensive and offensive weapon as they can not only be launched quickly but also spread and corrupt the adversary's system with low chances of detection and prediction.

On the other hand, **autonomous weapons** would *'gravely'* impact the conduct of warfare. Due to cheap manufacturing and cost-benefit analysis, drones, Unmanned Aerial Vehicles (UAVs) and robots would be the preferred choice of militaries for future warfare. With continuous improvement in AI and machine learning, automation of weapons would be preferred as the speed of conflict would be outside or faster than the framework of human brain calculation. Moreover, future wars would not be blood battles rather machine battles under which AWS would play a key offensive and defensive role such as attack in swarms or performing ISR missions. However, there still remains a lot of scope for understanding the human-machine partnership/interaction on the battlefield and improvement in AWS to avoid errors and failures.[57]

[57] "Autonomous Weapon Systems: Technical, Military, Legal and Humanitarian Aspects," (Expert Meeting, Geneva, Switzerland, March 26-28, 2014), https://reliefweb.int/sites/reliefweb.int/files/resources/4221-002-autonomous-weapons-systems-full-report%20%281%29.pdf.

Space militarisation would have *'significant impact'* on warfare as this is a domain of warfare is not yet perfected by states other than major powers. Slow progress in space is also due to various treaties that prevent deployment, threat, or use of weapons in outer space and ban its weaponisation. The support of space-based communication, navigation and ISR capabilities would increase the effectiveness of military operations. It would also introduce warfare to new technologies such as space-based kinetic and laser attacks that yet do not have counter-attack strategy or technology available. However, space militarisation is an expensive and long-term task that would not only require huge budget for Research and Development but also demand investment in personnel, facilities, training and strategy. However, if space militarisation is invested in, it would increase warfighting capability manifold and ultimately dominate the battleground.

JADC2 would have '*marginal immediate impact*' but is likely to impact future warfare in the longer run. It would enable all forces to work together through data networks to process information quicker and give rapid response, however its processes still face unique challenges. First, JADC2 is dependent on other technologies such as autonomous systems, space-based communication, digital engineering and data architecture as well as integration of all these systems. Once these systems gain efficiency independently, only then, they could be incorporated together to give an effective response. Besides technology, another complex matter is bringing decision-makers and authorities who command JADC2 on the same page. Such a task would require synchronisation across multiple services, forces, brigades as well as synchronisation of monitoring and training. Therefore, a cost and benefit analysis and keeping in view the character of warfare in the future that will move from physical operations to information operations, JADC2 would likely have marginal impact. Nonetheless, if advanced battle management systems are made efficient and joint decision-making is synchronised, they hold the capability to wreak havoc on the battleground.

Hypersonic weapons would likely have '*marginal impact*' on future warfare due to diminishing use of kinetic weapons under greater threat of unintended escalations in highly contested environments. Nonetheless, their speed and maneuverability would offer effective response options. Given that the future warfare is about speed, it could be the ideal weapon for strikes against targets that are time critical. However, such weapons would not be among the initial ones deployed to win a war, rather they are likely to be employed to conclude a standoff as a last resort. Chances of their employment are also low as there would remain ambiguity in detection of whether the warhead used is nuclear or non-nuclear. Additionally, hypersonic weapons Research and Development is an expensive field and there still remain many engineering challenges in hypersonic missiles and jets. Nevertheless, this is certainly a potential future military technology (See Table 1).

Table 1: Impact of Emerging Military Technologies on Future Warfare

Emerging Technologies	Grave/Lethal	Significant	Marginal
Autonomous Weapon Systems	x		
Digital Engineering & Data Architecture	x		
Space Militarisation		x	
Joint All-Domain Command and Control			x
Hypersonic Vehicles			x

Source: Author's own.

Conclusion

Security requirements of states have increased due to growing rivalries between them which is pushing military strategists and policymakers to find creative ways to increase deterrence. This is where Emerging Military Technologies (EMTs) are giving states comparative advantage over each other not only in terms of security but also economically and politically. EMTs are a peacetime investment to alter and shape the rules of warfare in order to gain superiority over the adversary. While introducing new dimensions to warfare, EMTs have changed the relationship between man and machine.

This relationship would change as under the United States' defence modernisation plans and strategies, Autonomous Weapon Systems (AWS) and Joint All-Domain Command and Control (JADC2) would speed up war operations that would require proactive and thoughtful planning to cope with uncertainty and fluidity of combat. Space network management systems have assisted in making warfare rapid through quick delivery of information using satellites to places where more information is required on the battlefield to execute a task. Similarly, hypersonic missiles and jets have also impacted the rapidness of war and introduced new dimensions of threats. Likewise, digital engineering and data architecture have increased computation speed, processing capabilities and storage capacity of warfighting systems.

Speed has directly impacted the lethality of warfare. Autonomous weapons elevate the level of lethality as they bring synchronised mass fighting to the battlefield that can inflict maximum and accurate damage. Lethality would also increase when JADC2 would be able to respond to an attack using sensors that would engage multiple asymmetric instruments along vertical and horizontal axis. An enabling environment would be provided to JADC2 with space-based communication system as well as space-based weapons such as kinetic and Directed-Energy Weapons (DEWs). Kinetic impact would increase the lethality of war, especially the kinetic energy released by hypersonic flight. Similarly, cyber warfare is also considered lethal as it is difficult to predict, track and target a cyber-attack.

The speed and lethality of warfare will reduce decision-making time. Therefore, for future warfare, leadership would need to make decisions at quicker or at the pace of a machine. Such decision-making would need new methods to institutionalise decision-making. The time to make decisions may be reduced from hours to minutes. However, due to technological developments, machines would be capable of providing real-time actionable intelligence to support decision-making that reduces casualties.

The speed and lethality of future warfare would also make decision-making complex, allowing states to deploy risky autonomous systems on nuclear C2 if their second-strike capability is undermined. Likewise, hypersonic vehicles add to nuclear complexity with the threat of hypersonic missile carrying a nuclear warhead. This is likely to push states to increase their second-strike capability in case of decapacitation of nuclear capability. Similarly, digital engineering and data architecture expose nuclear C2 systems such as early warning systems, protection of data, authorisation of use and firing of nuclear weapons to greater vulnerability under the threat of cyber-attack.

Admittedly, all EMTs hold relevant importance on the battlefield. If the level of impact was to be accessed, this study finds that digital engineering and data architecture would have the gravest impact on future warfare.

To conclude, it is important to highlight that future of warfare is only a prediction based on past and current developments in military science. One aspect is certain that EMTs would make warfare more complex, not simpler. It would require new systems of education, training, doctrines, strategies, and imaginative cognition. That is only possible if there is systemic transformation to set new standards and formats of operation. Since technological trends often also drive conflict instead of deterring it, militaries may need to reverse the sequence from what were once (or traditionally) considered winning warfare strategies. In this regard, militaries must make noticeable alterations in their processes to adjust emerging technologies. This is only possible if war fighters are visionary and proactive. However, in the race to keep pace with EMTs, one must be careful of not driving the world towards an anarchic scale of lethality.

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