

EVOLUTION OF TECHNOLOGY: FROM SMART TO NEXT GENERATION WEAPON SYSTEMS

MANOJ KUMAR

EVOLUTION OF TECHNOLOGY

The evolution of technology occurs due to need-based drivers creating the environment for the emergence of new socio-economic paradigms. This concept is derived from Kondratiev's/Joseph Schumpeter's explanation of technology waves.¹ While studying macroeconomic structures on agriculture and commodities, Kondratiev postulated that there are developments in technology and new innovations every five decades or less, which open new vistas of economic models using these advancements. The fifth wave that started in the early 1990s was based on Information Technology (IT) and the present wave (sixth) is based on sustainability and green technology.

Air Commodore **Manoj Kumar** VSM (Retd) is an engineering graduate from IIT BHU, India, and Post Graduate of DIAT, Pune. He is a resource person with the United Nations Environment Programme for protection of the Ozone Layer and writes extensively on Technology Management and Resource Optimisation for Environmental Protection. He has published three books and many research papers.

1. https://www.researchgate.net/figure/Waves-of-innovation-The-Kondratiev-cycles-five-long-term-technology-and_fig1_259513304 and <https://goodnewenergy.enagas.es/en/innovative/the-waves-of-innovation-since-the-industrial-revolution/>. Accessed in November 2024.

Network-centric warfare, where information (based on data on a real-time basis) is exchanged between multiple frameworks and end users to optimise decision-making, has now been deployed ubiquitously.

While the economic drivers are obvious for evolution, the fascinating aspects are the changes and the pace of change being observed in technologies that are getting deployed now. The complexities are increasing multifold but only in the background; the User Interface (UI) is becoming easier and especially now with the deployment of Artificial Intelligence (AI), a new frontier of disruptive growth in UI is on the horizon. The human-to-human and human-to-nature interconnections have increased but are being exercised remotely and

with built-in systems that have been designed to put all these interactions only in the background. These systems were put in place through a fixed boundary paradigm that was defined by the intelligence of the designer. Recently, all these frontiers have been crumbling with neural, self-learning processes in IT disrupting the incremental way forward.

Putting these developments in the military perspective, network-centric warfare, where information (based on data on a real-time basis) is exchanged between multiple frameworks and end users to optimise decision-making, has now been deployed ubiquitously. Once considered an advantage, it has now 'devolved' to a basic standard in the war-waging apparatus. Incorporating this advancement required not only advanced or smart hardware but also development of a new species of weaponry. Development and deployment of swarm and hand-held drones to kamikaze drones as part of loitering munitions, digital scene mapping navigation homing systems to the latest generation of Multiple Independently Targetable Reentry Vehicle (MIRV) warheads² using various IT-based navigation systems, and hypersonic missile systems, are but a few examples of how the technology evolution is changing the war arena. There are many such examples in the

2. <https://armscontrolcenter.org/wp-content/uploads/2017/08/MIRV-Factsheet.pdf>. Accessed in October 2024.

fields of weapon metallurgy, bioengineering, robotics and reusable weaponry, which point us towards the rapid and disruptive evolution in war-fighting technologies that are pushing the envelope for military strategists.

Most of the advancements mentioned above showcase the increasing complexities of new weapon systems, from the smart to the new generation of reusable, cost-effective, stealthy, and extremely difficult to counter kind of weaponry that is now being rolled out or is in the process of being deployed. The economics of these developments is hard to miss and is essential for sustaining long drawn war efforts, as being seen in the battlefields over the last few years. These aspects would be alluded to in subsequent sections of the paper.

Socio-economic imperatives of minimising battle losses, and collateral damage and enhancing the efficiency of the war effort, led to the development of guided (smart) weapons.

DRIVERS FOR SMART WEAPONS

Usage of bombs and rockets and other unguided projectiles that employed rough trajectory calculations for hitting a target, had huge issues of collateral damage. The packaging of explosive had to be heavy, and the type had to be one that had the maximum detonation effect so as to cover a large area in case the projectile missed the target by some margin. These 'dumb' projectiles were not efficient as, more often than not, the target required more than one 'visit' for ensuring destruction. This had consequences in the waging of war efforts as losses were many, with the element of surprise lost.

Socio-economic imperatives of minimising battle losses, and collateral damage and enhancing the efficiency of the war effort, led to the development of guided (smart) weapons. These weapons kept on becoming smarter with improvement in guidance systems, both in the types of guidance as well as in the introduction of autonomy of operations, with passive navigation systems being deployed for terminal guidance in some cases. The need for efficiency of efforts also led to improvement in packaging of warheads and

counter-measures capabilities. Now the projectiles could be made smaller as the warheads required smaller amounts of explosive to be packaged, with pre-fragmented shells directing the detonation and shrapnel affect. Thus, the efficiency improved as a greater number of projectiles could be carried for an air attack per aircraft. The guidance system developed from the Global Positioning System (GPS) to laser guidance that required constant laser designation of the target, to better technology like digital scene mapping, which introduced an element of autonomy. Since the guidance improved, the probability of hitting the bull's eye improved, leading to lower collateral damage, and this made air power deployment more 'palatable' to the policy-makers as major flare-ups associated with its deployment were now contained.

The 'smartness' of the weapon systems improved as newer applications of existing technologies were applied. The electronics and metallurgy advances allowed increased miniaturisation, thus, allowing for better packaging and advancement in guidance systems. Since the speed of deliveries was increasing, the developments now started focussing on autonomous targeting so that real-time delays could be reduced. This was the harbinger of the direction that the technology evolution was taking.

The development of smart weapons opened up the race for effective counter-measures. GPS spoofing, anti-laser active protection systems and other anti-electronics systems were soon up and running and the innovations took place in small bursts. The innovations for counter-measures normally contended with technologies that were within the capabilities contained in the ongoing technology wave. This has been the norm for any system that derives its origin from a particular innovation. This is now set to change; for the counter-measures to be effective against the new age weapon systems, there would be a need to go beyond the technology wave that spawned the specific weapon system as the complexities of these systems are many and the conventional thought processes of counter-measures that have worked until now, may not work. This aspect would be discussed in more detail later on.

NEXT GENERATION WEAPON SYSTEMS

A theory advanced by Ram Jaulus in his book *The Age of Urgency: Organizational Survival in the World of Disruption*³ points to a change in the evolutionary pattern of technology, especially with AI now taking a much firmer root, leading to disruptive growth. He says that the technology evolution time is now decreasing from many decades to a few years as the quantum of innovations within the same evolutionary wave has increased multifold. The disruptive nature of the evolution of weapon systems has followed a similar pattern. Within the larger set of smart weapons evolved the next generation weapons, using many of their fundamental properties of accuracy, reliability, adaptability and effectiveness.

The need for resource optimisation and new economic paradigms highlighted inadequacies related to the sustainability of smart weaponry. This led to efforts in developing next generation weaponry like Directed Energy Weapons (DEWs), Hypersonic Missile Systems (HMS), electromagnetic weapons, cyber warfare, etc. An important aspect of the next generation weapon systems is the ability to communicate with other systems/ operators in a networked environment that modern-day warfare demands. It is essential to distinguish the next-generation weapons from smart weapons, by the salient contexts of economy of effort, resource optimisation and sustainability.

The Iron Dome⁴ air defence system being used by Israel has demonstrated its ability to safeguard the Israeli airspace over many years. In the recent Israeli operation against various actors, the Iron Dome system was extensively used as an effective air defence system against aerial attacks by cheap rockets, drones and ballistic missiles. Each interception by the air defence system costs anywhere from US 70,000 to 3 million (depending on the type of missile launched to intercept) as per various open-source information available on

3. <https://urgencyage.com/the-7th-wave-model/#:~:text=The%20Seventh%20Wave%20%2D%20The%20Age%20of%20Continuous%20Disruption&text=It%20is%20not%20characterized%20by,continuous%20disruption%20that%20is%20created.> Accessed in December 2024.

4. [https://www.rafael.co.il/system/iron-dome/.](https://www.rafael.co.il/system/iron-dome/) Accessed in November 2024.

the Internet. The adversary did not have to strike the actual targets to ‘bleed’ the state of Israel. Just by launching and overwhelming the Iron Dome system by continuous use of cheap aerial weapons like unguided long-range rockets and drones, each interception depleted the war-waging resources of Israel, so much so that the US had to supply these interceptor missiles at the height of the crisis.

The “Iron Beam” air defence system, long in development by Rafael Advanced Defence Systems and Elbit Systems of Israel is now set to be deployed by October 2025.⁵ The Iron Beam system uses high powered lasers to engage aerial targets from several metres to many kilometres away, with almost *zero cost of interception*.⁶ It retains all the characteristics of the smart weapon and adds sustainability to its repertoire; thus, taking it to the category of next generation weapons. This is also a classic example of how the counter-measure systems are originating from a different technology wave period to counter weapon systems innovated in a different period.

Germany and the US are developing next generation weapon systems that take them to a still higher level of lethality. Thus, mounting of lasers on small drones, combined with facial recognition, to take on targets like small weapon systems and personnel, is next in the line of development.⁷ This sophistication of mounting lasers on small drones was unthinkable considering the power requirement to make lasers lethal enough to take on military targets. The technological advances in miniaturisation of electronics would make this possible. Similarly, the German defence industrial complex is now developing a seamlessly networked next generation weapon system that will have many next generation airborne weapon systems communicating across multiple domains, called the Multiple Domain Combat Cloud.⁸

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5. <https://economictimes.indiatimes.com/news/defence/israel-launches-new-era-of-warfare-iron-beam-laser-defence-system-heres-how-it-works/articleshow/114872647.cms?from=mdr>. Accessed in November 2024.
 6. <https://www.rafael.co.il/system/iron-beam/>. Accessed in November 2024.
 7. <https://www.armyupress.army.mil/Journals/NCO-Journal/Archives/2023/July/Future-Weapons-Technology-of-2040/>. Accessed in December 2024.
 8. <https://defence-industry.eu/german-defence-industry-develops-technologies-for-next-generation-weapon-system-ngws/>. Accessed in December 2024.

The capabilities of cyber warfare are increasing day by day. This potent tool of warfare is extremely cost-effective and sustainable, and its economy of effort is unimaginable. As our lives are increasingly becoming dependent on IT, cyber attacks allow disruption of lives that has much more potency than a few 1,000 lb bombs that cause localised destruction of targets. When cyber warfare is combined with traditional weaponry, as witnessed in Israel's attack on Hezbollah targets using their own pagers and walkie talkies, an unprecedented sophistication in attacks is being witnessed. Bringing down public utilities, defence command and communication centres without any collateral damage, and seriously degrading economic activities with complete denial of responsibility, in the most efficient and effective manner, is the acme of next generation warfare. It is obvious that this kind of warfare knows no borders and is highly sustainable due to its 'no contact' nature.

Most of these next generation weapons fit the bill of sustainability from the economics standpoint. The initial development cost of these weapons has been tremendous as the Research and Development (R&D) efforts required large capital investments and synergetic joining of knowledge. So much so that quite a few of these weapon systems required pooling of resources between countries or at least between different industries.⁹ Similarly, the Iron Beam programme of Israel required pooling of resources for developing power laser technology and miniaturisation.¹⁰ India and the US have entered into an initiative on Critical and Emerging Technologies (iCET) for partnering on critical and defence technologies.¹¹ The resource optimisation of next generation weapons makes them stand out. The reusability factor of such systems would have been lauded from the engineering point of view, had the

9. "The Next Generation Air Dominance Systems Being Developed by the US", <https://www.airforce-technology.com/projects/next-generation-air-dominance-programme-us/?cf-view>. Accessed in December 2024. This project requires collaboration among Boeing, Lockheed Martin, GE, P&W and others. Similarly, F-35 development required collaboration between many countries.

10. Ibid.

11. <https://www.whitehouse.gov/briefing-room/statements-releases/2023/01/31/fact-sheet-united-states-and-india-elevate-strategic-partnership-with-the-initiative-on-critical-and-emerging-technology-icet/>. Accessed in December 2024.

The paradigms of war are evolving rapidly and, thus, replacement of 'one time use' smart bombs and missiles by 'multiple use' DEWs is the natural progression.

end usage not intended to lead to destruction of life. This characterisation has been alluded to merely to demonstrate that next generation weapons fall into the next wave of technology evolution where sustainability and green technologies are leading the development.

THE OVERLAP

Like in all technology development cycles, there would be certain overlaps between the two stages of evolution. It is correct to say that many of the innovations have been pooled from a combination of existing technologies¹², even from different technology waves. The latter is normally the case unless the innovations are disruptive and showcase a leap that has not been sourced from the existing sets of technologies.

While cyber warfare and use of swarm Unmanned Aerial Vehicles (UAVs) fall in the category of next generation weapons, they will still be considered as an overlap of smart weapons with the next generation weaponry. Similarly, use of guidance systems in the next generation weapon systems shows the overlap in technology evolution stages. Therefore, some of these weapon systems like DEW and HMS can also be categorised under smart weapon systems. However, the paradigms of war are evolving rapidly and, thus, replacement of 'one time use' smart bombs and missiles by 'multiple use' DEWs is the natural progression. Since their efficiency and economy of effort are so huge, their categorisation under next generation weapons, is more appropriate. Development of electromagnetic weapons within the ambit of DEWs that use electromagnetic energy (including microwave) to directly target an adversary or sometimes even hurl a projectile, are developments that are increasingly differentiating these systems from mere smart weapons. Equipping UAVs with high powered lasers may be seen as a natural progression considering that laser designating pods were long

12. W. Brian Arthur, *The Nature of Technology: What it is and How it Evolves*, (Free Press, First edition, August 2009).

mounted on UAVs for use in conjunction with smart weapons but miniaturising them to an extent that they are mounted on UAVs and are still powerful enough to destroy a target, makes them a highly potent technology, taking it into the realm of next generation weapons. High energy lasers/radio waves and high-powered microwave are the two technologies that are seeing real traction in the weapon development programmes. When these weapon systems are interconnected within a network of secure and very high-rate data transfer, their usage becomes futuristic; combined with facial recognition and similar technologies that allow them to be used autonomously, makes them far more potent and enhances their effectiveness.

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Another significant technology that is increasingly being studied and developed for defence-based applications is quantum technology. Using the principles of quantum mechanics physics i.e. use of physics laws associated with subatomic particles, a new stream of innovations is possible in the fields of securely coded (crypted) communication, navigation, fast computing of extremely complex problems and quantum sensors that will detect with optical resolution hitherto unknown.¹³ Quantum physics enhances the use of the present smart technologies to the extent that their usage can be categorised as a next generation innovation. For example, quantum inertial navigation and quantum magnetometry increases the precision of navigation tremendously, hitherto not possible with the existing set of technologies.¹⁴ Similarly, quantum radars and quantum key distribution are new technologies that have dual use applications. Quantum communication networks would be required for securely connecting quantum computing devices, transferring

13. <https://www.nokia.com/about-us/newsroom/articles/quantum-technologies-explained/>. Accessed in December 2024.

14. <https://epjquantumtechnology.springeropen.com/articles/10.1140/epjqt/s40507-021-00113-y>. Accessed in December 2024.

data in qubits. Thus, this is the direction in which the technology evolution would take place.

In 2021, the NATO Summit in Brussels identified nine areas of innovations that may prove disruptive to the defence sectors.¹⁵ These areas were:

- Artificial Intelligence (AI)
- Autonomous Technologies
- Quantum Technologies
- Biotechnology
- Energy and Propulsion
- Space
- Novel Material and Manufacturing
- Human Enhancement
- Next Generation Communication Network

The paper has already mentioned how most of these technologies and their mutual interaction would play out in the context of next generation weapon systems. A word about autonomous technologies at this stage would be apt. The autonomy using split-second decision-making at critical junctures renders a sinister edge to these weapon systems. Not being dogged by human compunction and working on pure logic, the autonomous weapon systems have the ability to take warfare into the sci-fi domain. As an example, deploying counter-measures against autonomous targeting loitering munitions is extremely difficult, if not almost impossible. The unpredictability of attacks and the lack of reaction time would make any counter-measure ineffective.

The limitation of counter-measure technologies and deployment of vastly improved algorithms integrating the radar and interceptor missiles in advanced missile defence systems, is showing the way to the development of HMS. Of course, HMS also enhance the efficiency of the war efforts,

15. <https://www.thegeostrata.com/post/emerging-and-disruptive-technologies-in-defence#:~:text=LETHAL%20AUTONOMOUS%20WEAPONS%20SYSTEMS&text=Unmanned%20Aerial%20Vehicles%2C%20Unmanned%20Surface,have%20revolutionised%20surveillance%20and%20reconnaissance>. Accessed in December 2024.

when seen in the context of time of execution and probability of target neutralisation. The counter-measures to these next generation technologies would have to emerge out of a disruptive application of existing technology rather than merely optimising the processes that were the hallmarks of incremental improvements seen in older waves of technology evolution. This is due to the fact that the next generation weapon systems are becoming increasingly independent of human rationalisation, thereby removing the 'box' itself that used to be a barrier of the human thought process. The advent of quantum mechanics in transferring data would vastly reduce the difference between how humans perceive and decide vs decision-making by a machine using AI. It's a matter of time when the principle of quantum mechanics will become scalable to provide real-time changes in the ways of communication and computing. This issue would be discussed in greater detail later in the paper.

SUSTAINABILITY OF EFFORTS

Consider the development of reusable rockets used in the launch of satellites. Needless to say, the requirement was essentially driven by economic considerations as space technologies and their end use see rapid commercialisation. With an even more strong need to increase the value for money when deployed in the non-profit and non-commercial forays of the military, 'reusability' and 'sustainability' have high overtones. Sustainability would be the driver of new generation weapons, not only for economic reasons but also due to providing an edge in war-waging efforts.

Management of the logistics of the weapons inventory during the war-preparatory phase and during the actual operations remains a huge challenge for any military commander. The depletion of the inventory takes place not only as per the planned offensive operations but is equally dependent on defensive operations that cannot be accurately predicted in both time and space. New fronts and new timelines crop up at any moment during operations, defeating the best drafted war plans. At this stage, the reusability of weapon systems would provide a definite advantage to any

military commander by reducing his/her dependence on weapon logistics. It can be a game-changer, specially if the enemy has a vastly larger weapons inventory but the same does not give him the planned tactical advantage associated with it.

FUTURE OF NEXT GENERATION WEAPONRY

The development of next generation weapons is advancing very rapidly but they still have to be sufficiently miniaturised, ruggedised, achieve stand-off range and, above all, achieve economy of scale for them to be treated as drop-in replacements for the ubiquitously available current generation of smart weapons. Like in all weapon systems, the development of a particular technology is almost simultaneously followed by the development of its counter-measures. Counter-measures to DEWs are also in the development stage. Going by experience, this cycle of next generation weapons technology development and its decay is likely to hold interest for most of the current century. As the systems embedded with AI and using quantum computing for data transfer become more robust and scalable, the weapon systems would see a different track of development. The current thought process is limited to data-centric weapon equipment being deployed in theatres of war. The future would drive towards increased autonomous decision-making, bringing the coinage of terms like Autonomous Weapon Systems (AWS).¹⁶ The developers of AI have been long advocating that ethical and legal guidelines and protocols/framework need to be developed to ensure that AWS don't lead to a new arms race, which can have catastrophic consequences for mankind. Even the UN was not able to arrive at a consensus on this issue in the Convention on Certain Conventional Weapons (CCW) of the Group of Government Experts (GGE) of higher contracting parties related to emerging technologies in the areas of Lethal Autonomous Weapon Systems (LAWS) in May 2023, and

16. <https://gja.georgetown.edu/2024/07/12/war-artificial-intelligence-and-the-future-of-conflict/#:~:text=AI%20use%20in%20warfare%20is,decided%20without%20meaningful%20human%20control>. Accessed in February 2025.

decided to meet again in 2024.¹⁷ In November 2024, the same group came up with a provisional description of such futuristic weapon systems and how to maintain human control over their usage/deployment at all times, recognising the potential of the catastrophe that can be unleashed if this area is allowed to go unchecked.¹⁸ It should be noted that the world is still far from even defining such systems let alone agreeing on a framework on their development and deployment. If we are to consider the history of the development of nuclear and chemical weapons and their stockpiling, even while coming up with their control, it does not give much confidence in this foray of control of AWS under the aegis of the UN.

It is the recognition that the more the independence of decision-making by a weapon system, the more difficult it would be to counter it once it is deployed. This takes on ominous overtones if the weapon system is not designed to receive a destruct or any other signal from the human-in-the-loop. The counter-measures to this scale of autonomy may utilise the data so ubiquitously used for AI models that can be so presented that it is able to fail the models being used to arrive at autonomy. The rapid increase in the quantum of data to be processed may not be sufficient if used alone and would have to be juxtaposed with such contradictory inputs simultaneously that the modelling fails to arrive at real time-based decision-making, thus, failing the logics of decision-making. A data overload by contradictory sets of data mimicking the actual set is one way to counter such weapons. Another way could be to present high data volumes at a substantially better speed of transfer wherein the weapon system starts recognising it as a superior node within the same network and, thus, prioritises this over other data in the network. Such technology combinations would be needed to counter the network-centric weaponry of the future.

17. <https://meetings.unoda.org/ccw-/convention-on-certain-conventional-weapons-group-of-governmental-experts-on-lethal-autonomous-weapons-systems-2024#:~:text=The%202023%20Meeting%20of%20the,days%2C%20from%204%20to%208>. Accessed in February 2025.

18. [https://docs-library.unoda.org/Convention_on_Certain_Conventional_Weapons_Group_of_Governmental_Experts_on_Lethal_Autonomous_Weapons_Systems_\(2024\)/Revised_rolling_text_as_of_8_November_2024_final.pdf](https://docs-library.unoda.org/Convention_on_Certain_Conventional_Weapons_Group_of_Governmental_Experts_on_Lethal_Autonomous_Weapons_Systems_(2024)/Revised_rolling_text_as_of_8_November_2024_final.pdf). Accessed in February 2025.

While the development of non-lethal AI-based autonomous military systems for surveillance and reconnaissance may pass under the threshold of human acceptance, a small leap from thereon to make the system lethal akin to what was seen in the case of UAVs is very much on the anvil, with dangerous repercussions.

All such AI and quantum computation using stand-alone weapon systems would need a high amount of power. The next set of counter-measures could also be ones that feed it algorithms that deplete its power source extremely rapidly. Such software codes are indeed possible and are currently in the process of development. The feeding of an independent network would be easier if its gateways are easily accessible. However, for completely autonomous AWS, if allowed to be developed and deployed, only offline and physical modes of transfer will work to counter them. This demonstrates the

difficulty in being able to stop the completely autonomous weapon systems. While the development of non-lethal AI-based autonomous military systems for surveillance and reconnaissance may pass under the threshold of human acceptance, a small leap from thereon to make the system lethal akin to what was seen in the case of UAVs is very much on the anvil, with dangerous repercussions.

TRAJECTORY OF TECHNOLOGY GROWTH: DRIVER OR DRIVEN

The way technology is advancing, with the usage of AI now slowly pervading all aspects of our adult life, from the Internet of Things (IoT) to virtual and augmented reality, leading us to the Internet of Understanding, one question is always below the surface: are we the drivers of the technology evolution or is it now out of our control? On the face of it, the socio-economic drivers are the impetus for innovations. However, there are instances wherein the combination of innovations has led to the development of an ecosystem that was not even imagined at that time, so its requirement was not the driver for its implementation.¹⁹ The Internet came about as a means for fast and

19. <https://online.ucpress.edu/gp/article/2/1/27353/118411/How-Is-Technology-Changing-the-World-and-How>. Accessed in December 2024.

cheap data transfer for communication. The entire e-commerce based on this data transfer has opened a new world that has not only helped life become convenient for all sections of the society but also brought the ills of cyber crimes into our realm of reality, leading to much consternation amongst the same set of people who were/are the biggest votaries of this technology. It is debatable whether e-commerce forays were ever the need of the society when the same started, however, they are now an inescapable necessity. It can be said that society has been 'lifted' to be part of an ecosystem that has been developed by a few using the existing innovation and combining it with their imagination even though the system was not the need of the people at that time. The resulting convenience is always the rationale for more such changes to be implemented.

It can be said that society has been 'lifted' to be part of an ecosystem that has been developed by a few using the existing innovation and combining it with their imagination even though the system was not the need of the people at that time.

Something similar is happening in the development of weapons and the world is not yet ready with their counter-measures. The study of DNA is the need of the hour to fight cancer²⁰ and similar diseases. Using this technology, scientists are now able to predict the probability of a person likely to face cancer in his/her lifetime as well as how to fight the same. Development of this technology is the need of the society. However, now gene modification technology, which has taken a leaf out of the same study, as mentioned above, is being planned to develop super soldiers.²¹ This cannot be categorised as dual use technology.²² There is no need for such technologies to be developed for military applications but till the time 'boots on the ground' are essential for war, the presence of disruptive technology

20 <https://www.icr.ac.uk/blogs/science-talk/page-details/dna-day-how-we-re-turning-the-tables-on-cancer#:~:text=By%20understanding%20and%20exploiting%20cancer's,many%20patients%20with%20the%20disease>. Accessed in December 2024.

21. <https://tdhj.org/blog/post/gene-editing-soldiers-crispr/#:~:text=For%20example%2C%20genes%20associated%20with,efficiently%20and%20for%20longer%20durations>. Accessed in December 2024.

22. Technologies that are used for civil as well as military applications.

will be the driving force, and it is not the societal need that is driving its evolution. AWS is another example wherein easy availability of technology is becoming a driver to its need for new arenas of deployment. It can be observed that wherever the availability of technology becomes the driver for change and not the actual need, the society 'advances' in a direction that may not always be desirable. It may even result in the 'dumbing' of future generations.

The development of AI-based weapon systems is a prime example of this facet of technology acting as the driver. The extremely rapid pace of development in this space is leading to disruptions that are beyond imagination. The US majors came up with the development of semi-conductors that pack in the kind of computation needed for AI chatbots to be effective, albeit within higher costs of data centres, power source and allied infrastructure. However, the economics and sustainability of development shown by the Chinese AI developers have opened new vistas of AI-based equipment to be now in the realm of everyday usage, even for the military. At a fraction of the cost of development and using far less numbers of chips, and different ways of AI modelling, the Chinese system can potentially impact every facet of the human-machine interface. It is, thus, no wonder that the world leaders and top technology executives met in France in February 2025 for discussing the future course of AI in many fields, including security and the challenges likely to be encountered.²³ At this stage, this technology has such huge potential for disruptive growth in every facet of human life that vistas not even imagined would become the norm as AI would be seen to drive the way of life that till now was solely charted by human needs.

END OF CONVENTIONAL WARFARE

Smart weapons were brought into use to improve the economy of effort in war as well as to lower the collateral damage. The new generation of

23. <https://www.cnbctv18.com/technology/paris-ai-summit-2025-key-debates-leaders-agenda-19555914.htm>. Accessed in February 2025.

weapon systems would differ from smart weapons currently in use, by being more sustainable, with demonstrably much higher economy of efforts. The technology for this envisaged end-use is progressing rapidly with weapons like directed energy weapons and hypersonic missiles already seeing active deployment. The next generation weapons that are already deployed would see further miniaturisation and robustness, making their deployment more and more innovative.

Then there is another set of next generation weapons in the offing, which would utilise the developments in the fields of metallurgy, medical sciences in deciphering the human DNA, AI and quantum mechanics. These weapons are envisaged to increasingly become autonomous in deployment and in war-time engagement. The AI models for such weapon systems would be continuously improved towards this end. The quantum computation for rapid communication is yet to cross the significant cusp of development for field level deployment but the basics of the technology are being designed and breakthroughs are being reported in open sources. It's the leap from the lab to everyday usage which is awaited.

The conventional thinking in present-day war-time engagement still takes ethics into account. These paradigms are likely to see rapid changes in the short term. It has always been felt that deployment of a machine like a UAV is not as aggravating as deployment of manned fighters, when air power deployment is envisaged. When the machines become increasing lethal, sustainable and bereft of human compunction, their deployment may start getting considered an enhancement in the level of engagement.

The world has realised the lethality that can be unleashed by uncontrollable development of next generation weapon systems as designing their counter-measures may require more breakthroughs in the present technology evolution cycle. Therefore, countries and large technology companies are discussing ways to control this technology, something that has only been seen in the instance of nuclear and chemical weapons. This should give an idea how the next generation weapon systems, even though derived from the present technology

evolutionary wave, are vastly different from the smart weapons currently in use in conventional wars. It is the right time for the human race to realise the implications of this technology in military usage and take the necessary control measures.