A roadmap for making India a leader in non-kinetic warfare solutions

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pwc

Preface

The drivers for the evolution of warfare are increasingly non-kinetic. Global conflicts today are seeing the growing use of NKW technologies to increase military effectiveness. These technologies have the potential to increase lethality and reduce the OODA cycle time, which in turn can boost combat effectiveness.

With technology revamping warfare and the ever-changing geopolitical scenario, NKW could help in strengthening the defences of our country. Past and ongoing conflicts have demonstrated the importance of CW, NCW, EW and AS not only during war but also in the grey zone and peacetime. This report presents a strategy based on collaboration between the military and civil sector to strengthen India's defence capabilities.

It lays down a broad strategic roadmap for making India a leader in the NKW space by 2047. The focus is on achieving self-reliance in the development of non-kinetic solutions by 2027, along with building technological capabilities and establishing an NKW ecosystem in the country by 2027. Implementing measures that promote these efforts will pave the way for India to emerge as a key exporter of NKW solutions by 2032 and ultimately become a leader in NKW by 2047.

A key theme of the strategy for achieving this goal is a 'whole-of-nation' approach. The private sector, Government (military, defence R&D organisations and public sector) and academia need to come together and take ownership for developing strategic capabilities. Although the private sector needs to play a major role in the realisation of this vision, the Government must also act as a facilitator in bringing together the military and civil capabilities to drive the national defence ecosystem.

PwC's New Equation strategy is aligned with the vision of combining human ingenuity, experience and technology innovation, in order to deliver sustained outcomes while building trust. This report mirrors the strategic focus of the New Equation as India aims to establish a strong defence ecosystem and attain 'atmanirbharta' in this sector.

Vishal Kanwar

Executive Director, A&D

PwC India

Foreword

The report proposes a strategy for strengthening India's defence capabilities through increased collaboration between the military and civil sector. As technology evolves and reshapes warfare, the role of CW, NCW, EW and AS has become more critical. NKW enables defence forces to harness the technological advancements in computing power, data collection, processing, storage and networking to boost military effectiveness.

This report presents a roadmap for the growth of the defence sector, with the goal of enabling India to achieve a 10% share of the global market in NKW solutions. As per our proposed model, by leveraging various defence and technological initiatives, the A&D and IT industries have the potential to generate a revenue of nearly USD 26 billion by 2032. Additionally, strategic capabilities developed in R&D, production, infrastructure, talent and global alliances will drive India's transformation into an NKW leader by 2047.

All defence stakeholders will play a key role in the realisation of this goal. While the Government would need to facilitate the amalgamation of military and civil capabilities, the private sector and research institutes would drive this collaboration.

This report charts out the development of an NKW ecosystem in the country. We hope that private companies in defence, IT, start-ups in emerging tech, as well as defence public sector units and the defence ministry find it insightful.

In the coming decade, we need to work together to strengthen national defence and make India a leader in the development of non-kinetic solutions by 2047.

Pallab De

Partner and Leader – Operations and Manufacturing Consulting, A&D

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Foreword

NKW technology solutions are essential for the defence of our country. They are important across the spectrum of peace, grey zone and war. NKW consists of electronic systems in cyber, net-centric and electronic warfare and autonomous systems.

India is known for its significant capabilities in the IT sector. This report presents a strategic view of how India can use that strength to become a global leader in NKW technology solutions over the decade.

The report brings together insights and data from our interactions with local and international NKW technology experts, both in the government and private sectors. Our assessment is based on the projection that India can achieve 10% of the global market share, amounting to a USD 26 billion market in NKW technology solutions. The strategy document also brings forth the critical role that the Indian IT sector would play to support the development of NKW technologies.

A key part of the strategy is a 'whole-of-nation' approach. Towards achieving the vision for India to 'Become a NKW leader, defending our country in peace, increasing our lethality in war and becoming a net exporter in non-kinetic technologies', we need to develop strategic capabilities across production, R&D, talent and skilling, infrastructure and alliances.

This report aims to stimulate a discussion around the collaboration required to develop this segment of the defence industry. The private sector, Government (military, defence R&D organisations and public sector) and academia need to come together and take ownership for developing strategic capabilities. The report would be relevant to private companies in defence, IT services, new start-ups in emerging tech, as well as public sector units and the defence ministry.

In the next decade, NKW technologies will enable India to strengthen its defences. Moreover, the development of the country's strategic capabilities will also boost the technological growth of its civil sector, and thus increase the GDP.

Arnab Basu

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Executive summary

Technology has been transforming warfare globally. Over the years, the focus of warfare has shifted to precision weapons, minimal collateral damage, real-time information, surveillance and target acquisition. This has increased military effectiveness – through reduction in the OODA reaction time – and lethality. With the advent of the information age, technology redefined warfare, with information systems becoming critical to military effectiveness. Further, information warfare has the potential to create uncertainties prior to and/or outside of traditional kinetic warfare. Uncertainties arise when involved states, acting in their own self-interest, create informational asymmetries to shape public opinion and take advantage of their adversaries' inefficiencies. These intentionally induced uncertainties are capable of boosting military effectiveness by increasing the OODA reaction time of adversaries.

This report lays down a strategic roadmap for India to achieve self-reliance in the development of non-kinetic solutions by 2027. It highlights the possible initiatives that can be introduced to develop technological capabilities and establish an NKW ecosystem in the country by 2027. This will pave the way for India to become a niche exporter by 2032, and ultimately, a global leader in NKW by 2047.

NKW is a vast domain covering information, psychological, diplomatic and economic warfare. Two important components of information warfare – i.e. cyber and electronic warfare – have been selected for the study. In addition, the study also looks at autonomous systems that have potentially widespread applications in India's defence industry in the near future. Apart from these components, net-centric warfare is also discussed, given that command, control and communication are expected to significantly impact the outcomes of war in modern warfare. The private sector has established a foothold in cyber defence and is taking a lead in the development of autonomous systems. At an ecosystem level, efforts have been made through iDEX to promote the development of a defence-inclined start-up ecosystem in the country. India's defence R&D expenditure is about 3%[1] of the defence budget. As per industry estimates, 30% of this R&D budget is currently directed towards developing NKW solutions.

The findings of a baselining and benchmarking study and a study of the evolution of warfare have been combined to determine the best practices that could help it in the selected NKW domains. The recommendations include:

- self-reliance in the production of electronics and hardware
- increased focus on R&D for non-kinetic technologies (a share of approximately 60–70%)
- attraction, retention and focus on talent development and upskilling
- establishment of shared infrastructure
- forming alliances with other countries, and between industry and academia in India and abroad to develop capabilities.

The path to achieving these capabilities involves 13 pillars – i.e. four strategic goals, six strategic capabilities and three enabling capabilities. The report details two types of initiatives to be taken by 2027 to achieve the goals and technology initiatives, which will enable the Indian defence industry to contribute towards increasing military effectiveness and generating the targeted supply. Further, the initiatives required to build the strategic capabilities – i.e. productive, R&D, talent, infrastructure, alliances and military culture, and doctrine – have been defined. The enabling capabilities primarily include formulation of strategies and policies to enable and incentivise private sector participation and promote seamless collaboration between military and civil. Another important enabling capability that India needs to focus on is data collection and management, as data and information are the backbone of NKW. This also requires a greater focus on the interoperability between forces and formation of international alliances for data sharing.

[1] Defence budget of India, 2020 and PwC analysis

The investment required to achieve the strategic goals (by 2027) and build the relevant strategic capabilities has been estimated to be USD 23 billion. Investments of around USD 19 billion are required by 2027 to establish an NKW ecosystem and another USD 4 billion is required to achieve the strategic goals. It is important to note that the investments for developing strategic capabilities like R&D and infrastructure will lay the foundation for growth in NKW in the next 25 years. Such investments will also prove beneficial for the civilian market, which is projected to be significantly greater than the defence market.

To this end, a broad strategy roadmap has been developed for India, highlighting the key strides that the country needs to take in the short, medium and long term in order to achieve the target of becoming a leader in NKW by 2047.

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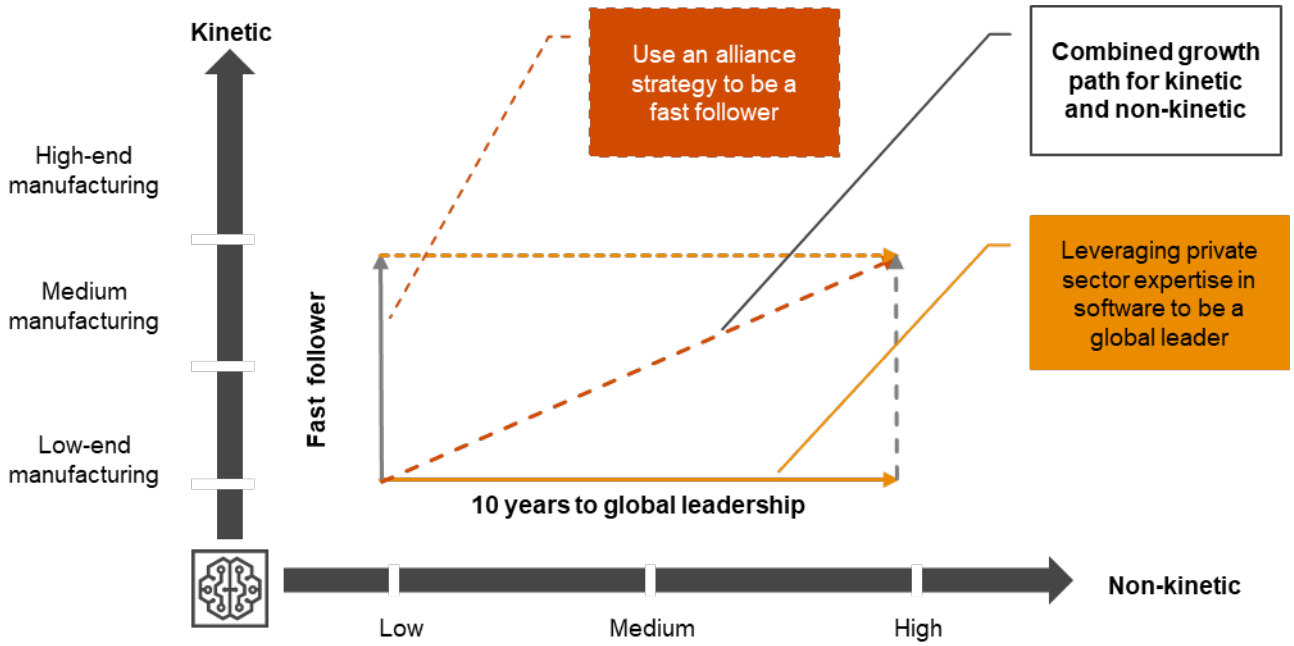
01 Introduction to NKW

Traditionally, adversaries have engaged in warfare by means of direct military confrontation, using kinetic means like munition, bombs, rockets and missiles across land, air and sea. Due to technological evolution, nations now have the capabilities to engage in NKW such as psychological, behavioural, functional and systematic warfare, which helps avoid direct military confrontation.

1.1 Why NKW?

India has traditionally focussed on developing conventional kinetic warfare capabilities and has been a fast follower for many years. Now, through Government and industry initiatives supporting its defence technology growth, the country has steadily veered towards attaining self-reliance in kinetic warfare solution development. In addition, by virtue of its rapidly developing IT infrastructure, the country has a strong advantage in developing non-kinetic solutions and becoming a leader in NKW in the next 25 years. Also, an upcoming industry for manufacturing of advanced sensors and strong thrust for developing space capabilities is expected to further boost India's non-kinetic capabilities.

Figure 1: Vision for the Indian defence sector



Source: PwC analysis

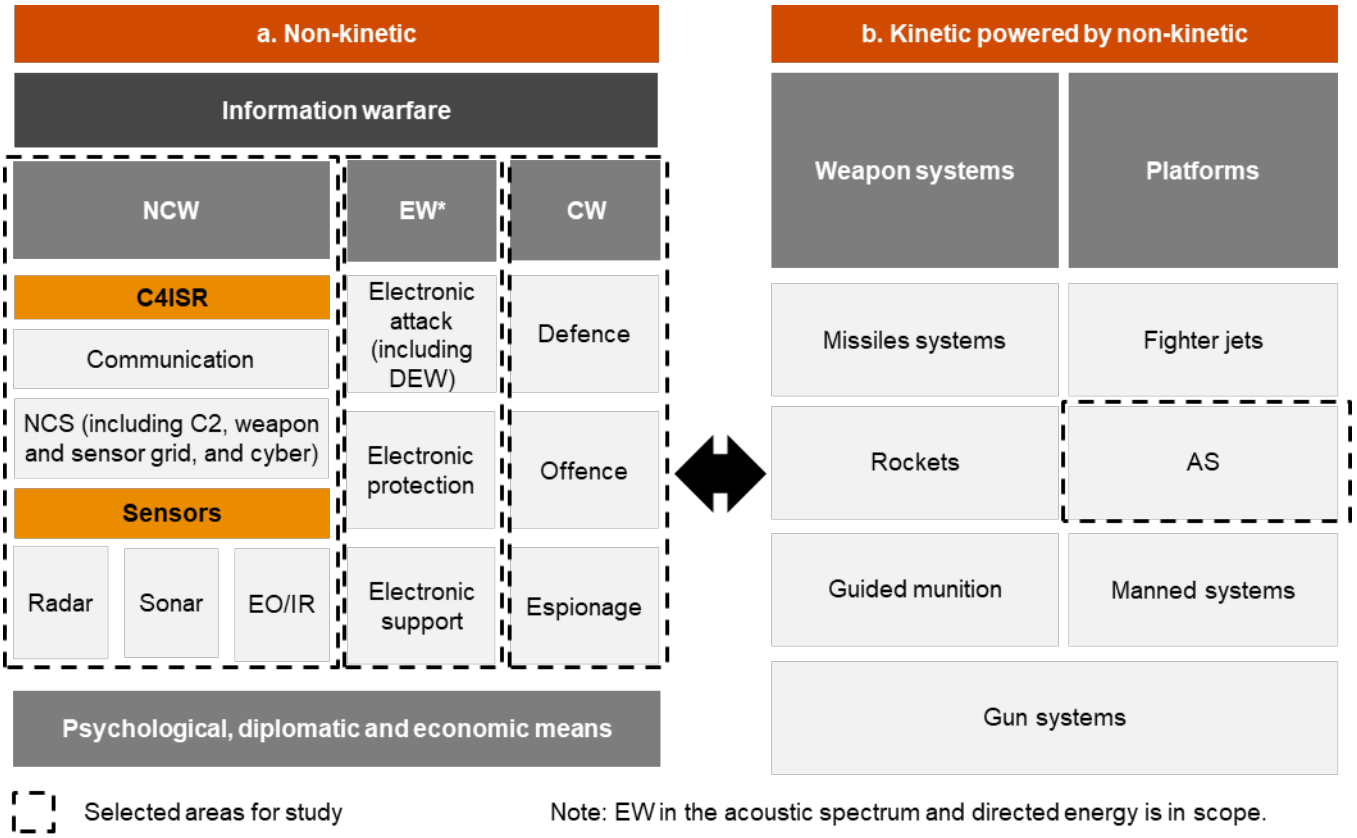
Figure 1 depicts the combined growth path that India can target through leapfrogging in the development of non-kinetic capabilities supported by self-reliance in kinetic warfare.

1.2 Scope of the study

Information, psychological, diplomatic and economic warfare are all different forms of NKW. Non-kinetic technologies also augment kinetic platforms – such as missiles, autonomous systems, guided munition, manned systems and fighter jets – increasing their attack precision, thereby enhancing lethality. Information warfare elements, CW and EW have been included in the scope of the study. In addition, AS has been taken into account, considering the high degree of technology absorption and its importance in redefining India's surveillance, attack and defence measures. Finally, NCW has been included in the study as a domain, considering that it is a facilitator for CW and EW along with most kinetic platforms. NCW has emerged as a critical element of modern warfare for use in translating information advantage into competitive advantage through robust networking between geographically dispersed forces.

Psychological, diplomatic and economic warfare have been excluded from the scope of the study.

Figure 2: NKW domains



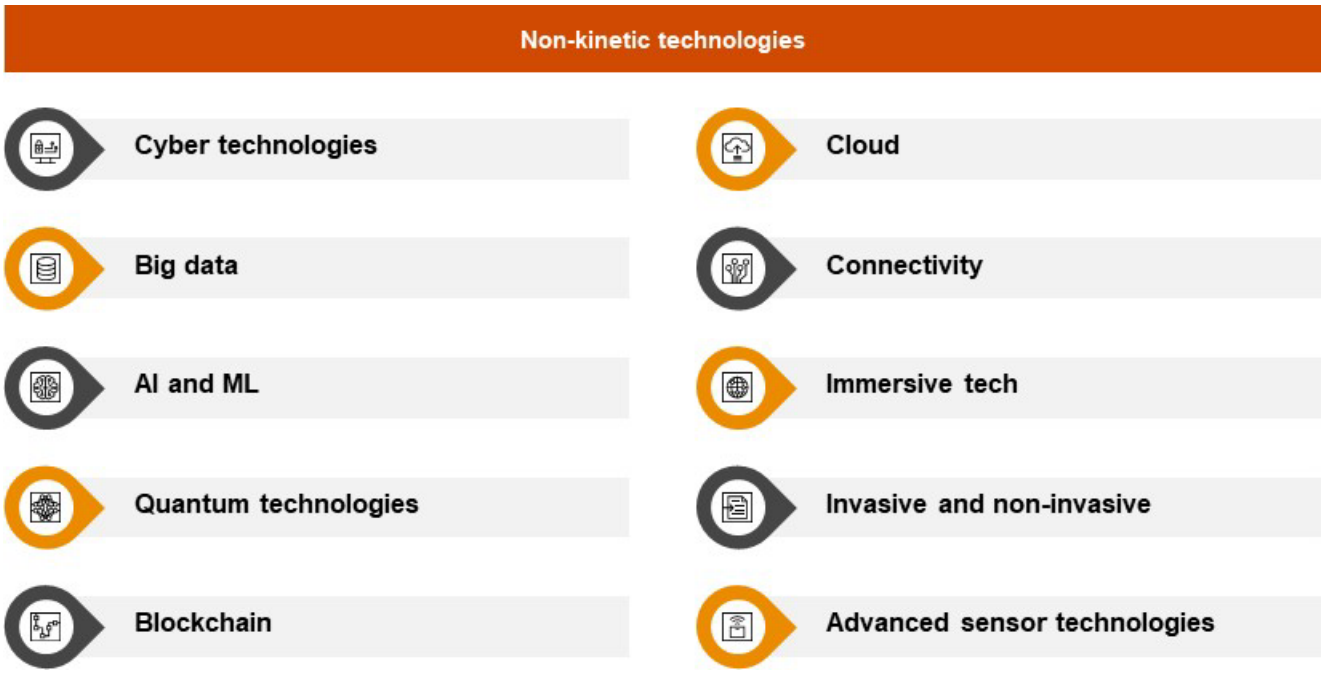
*NCW has been considered as a domain for the study considering the vast role of technology in NCW and capability development requirement in NCW to facilitate NKW.

Source: PwC analysis

NKW technologies

NKW domains, as highlighted in the above section, are enabled by disruptive and emerging technologies known as non-kinetic technologies. A set of ten non-kinetic technologies have been identified for the study and are expected to be critical in changing the dynamics of future warfare.

Figure 3: Non-kinetic technologies



Source: PwC analysis

Conventionally, military effectiveness is measured by its capability to reduce its OODA loop time. To put it simply, the OODA loop refers to the response time to an attack and the level of lethality of an attack, which is defined by firepower, precision, stealth, agility and frequency of the attack. In addition to the OODA loop, NKW has added another element for measuring military effectiveness, i.e. the capability of the military to increase the OODA loop of adversaries. The table given below depicts the level of impact of the NKW technologies in increasing military effectiveness.

Figure 4: Impact of non-kinetic technologies on military effectiveness

Tech capabilities	Military effectiveness		
	Reduce own OODA	Increase adversary's OODA	Increase lethality and precision
Cyber			
Big data			
AI and ML			
Quantum technologies			
Cloud and connectivity			
Immersive tech			
Invasive and non-invasive			
Advanced sensor technologies			

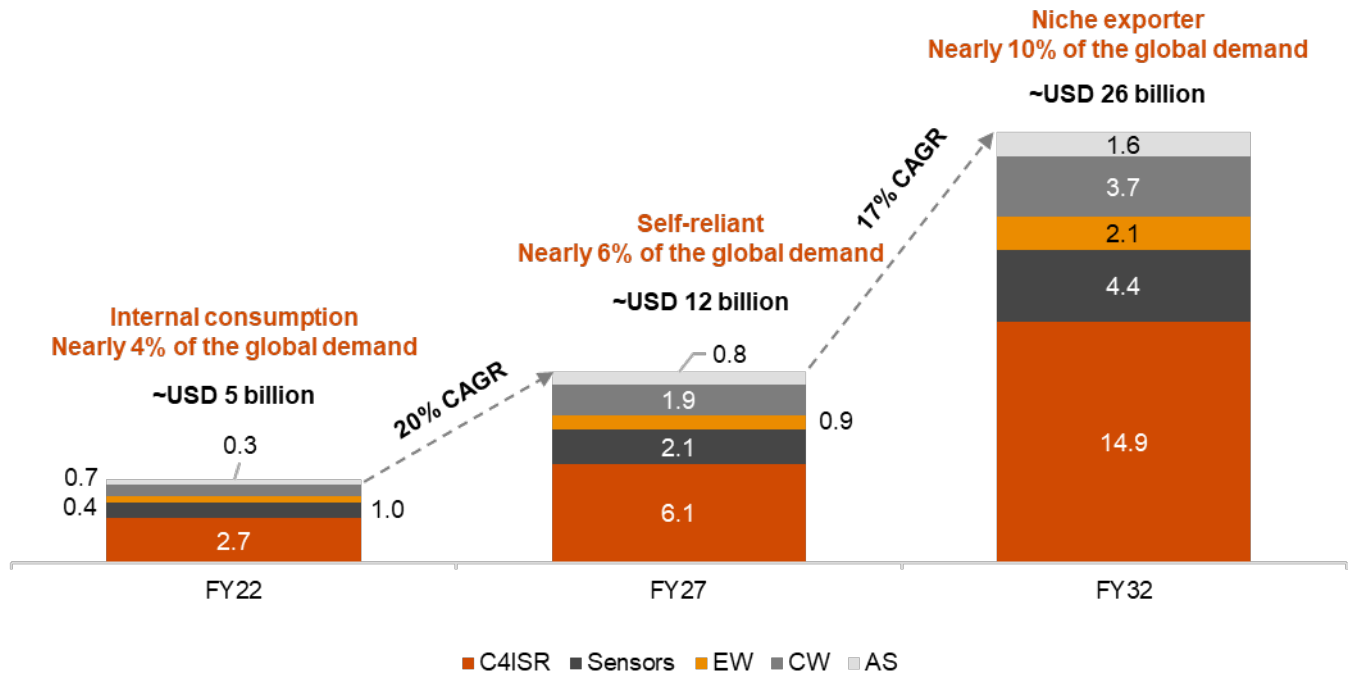
High thrust Medium thrust Low thrust

Source: PwC analysis

1.3 Becoming a leader in NKW

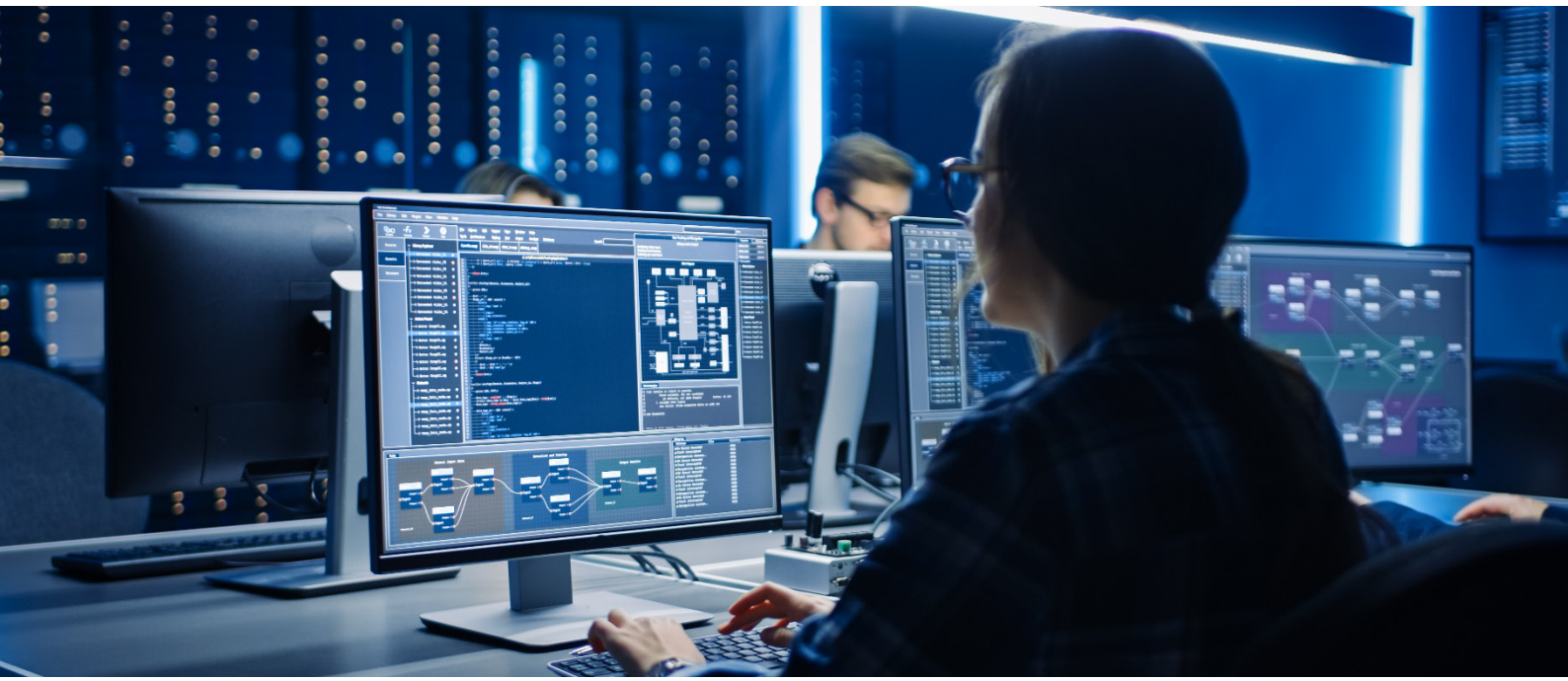
In order to become a global leader in NKW by 2047, India needs to ensure an exponential growth in the development of NKW solutions and aim to achieve self-reliance by 2027. Further, the country can elevate its rank by becoming a niche exporter of NKW solutions by 2032, which will ultimately boost its chances of becoming a global leader by 2047. The strategic and technological capabilities that India builds will support the military as well as the technological growth of the civil sector. Also, with the diminishing battlefield boundaries and emergence of grey warfare, enabling the civil sector will go a long way in ensuring national security.

Figure 5: NKW ambition for India

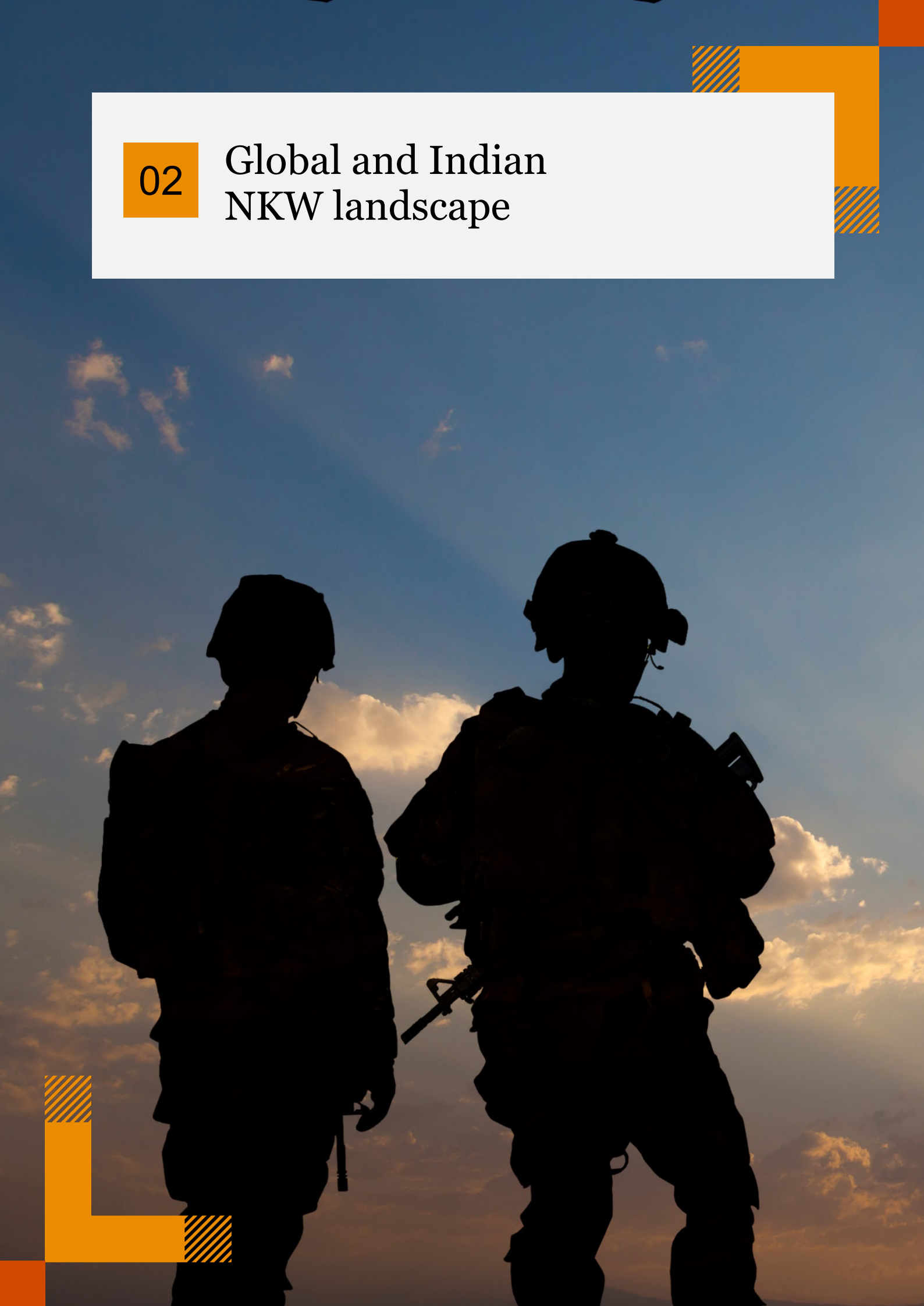


Note: Market size for NCW has been estimated based on market size for C4ISR and sensors.

Source: PwC analysis



02 Global and Indian NKW landscape

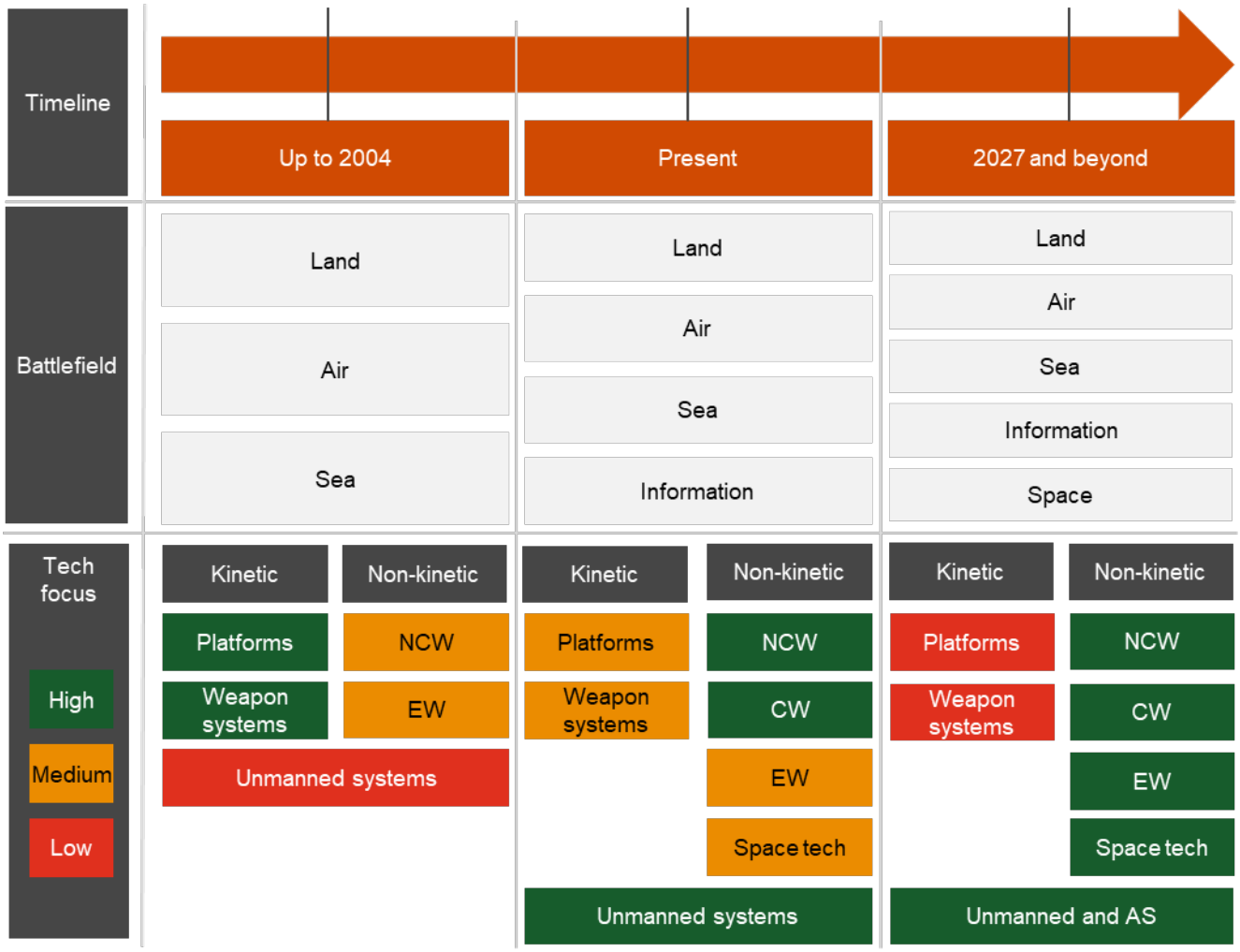


2.1 Evolution of nature of warfare

The rapid adoption of digitalisation in armed forces across the world has led to a paradigm shift in the current manner of warfare and the possible changes to it in the future. Digitalisation is defined as the ability to harness collective technological advances in computing power, data collection, processing, storage and networking between computer devices.

Although defence forces have actively pursued digitalisation, a seamless adoption of the same has not been possible due to complex procurement processes, policy and regulatory ecosystem, and the peculiarity of defence use cases. The rapid adoption of new technologies by nations has also opened up new battlefronts like the space, while conventional war has been revolutionised by a tectonic shift from platform primacy to NKW. These technological advancements have also resulted in enhancing the role of non-state actors and enabling the evolution of information warfare.

Figure 6: Evolution of warfare over the past two decades and beyond



Source: PwC analysis

Globally, digitalisation in defence has witnessed fast-paced adoption in countries like the US, the UK, China, Israel, Japan, Australia, France, Germany, Belgium and South Korea. A large part of this digitalisation is focused on AI systems, cloud computing, big data analytics, IoT and AS. These technologies find large-scale applications in a variety of defence use cases and are also supported by strategic partnerships between defence and civil OEMs merging capabilities in disruptive technologies.

2.1.1 Trends in non-kinetic technology adoption

Based on a study of the global share of R&D investments by start-ups in top technologies in 2022, AI, robotics, AS and CW technologies have seen the largest portion of investments in R&D. This indicates that as warfare evolves, there is a shift towards hybrid approaches, and these are set to replace traditional approaches. CW, AI, autonomous systems and IoMT find high usage in the hybrid warfare scenario, and are expected to bring significant optimisation of defence operations and military efficiency.[2]

As seen in the ongoing conflict between Russian and Ukraine, Russia has employed advanced military hardware, including drones, cyber capabilities and electronic warfare systems. Ukraine, on the other hand, has also developed its own drones[3] and enhanced cybersecurity.

In addition, to increase confidentiality of military data and counter cyberattacks, start-ups are increasingly adopting blockchain technologies.

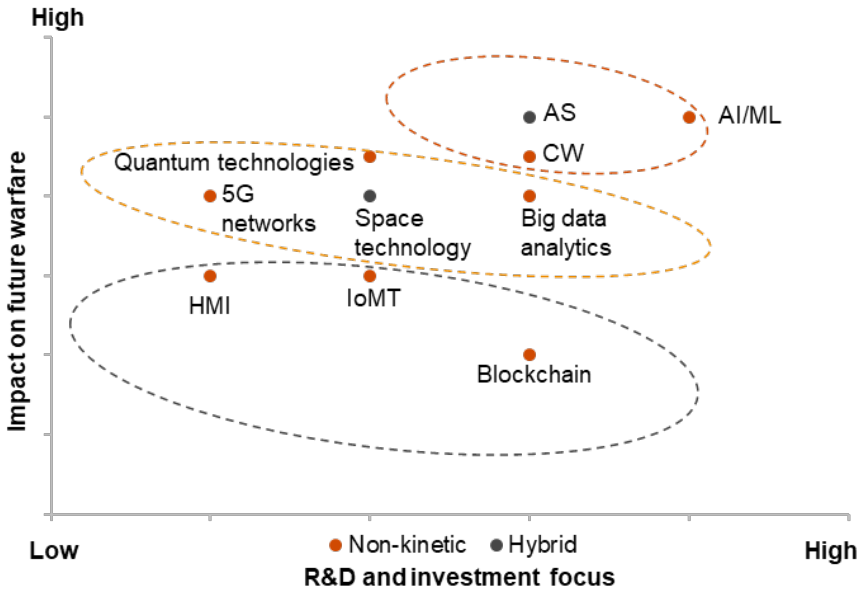
2.1.2 Impact of technologies on warfare

To evaluate the impact of the rapid adoption of emerging technologies on the overall efficacy of military operations, a framework has been developed to rank considered technologies based on their impact on the OODA loop time, lethality, capability to infringe on the enemy's OODA loop and the associated R&D investments. These factors will have a direct impact on the actual adoption of these technologies and the timelines therein. Based on this assessment, a matrix with three main categories has been developed:

- high impact, high focus
- high impact, low focus
- low impact, low focus.

This categorisation helps in understanding the evolving pace of different technologies, their long-term impact on the nature of warfare, and technologies that may not have a huge impact on warfare, but are still in focus due to their specific applicability in the defence sector.

Figure 7: Fastest-growing technologies with the highest impact on warfare



Key insights

- AI/ML, CW and AS will impact the nature of warfare in the long term.
- Quantum tech and 5G networks have high impact but are not evolving as fast as AI/ML, CW and AS.
- HMI, IoMT and blockchain will have limited, direct impact on warfare. However, there is a higher focus on blockchain due to its applicability in cyber defence.

Source: PwC analysis

[2] https://government.economictimes.indiatimes.com/news/technology/new-defence-technologies-need-to-be-developed-in-cyber-space-underwater-and-info-warfares-ajay-kumar-defence-secretary/90476633

[3] https://www.economist.com/science-and-technology/2023/05/08/how-ukrainians-modify-civilian-drones-for-military-use

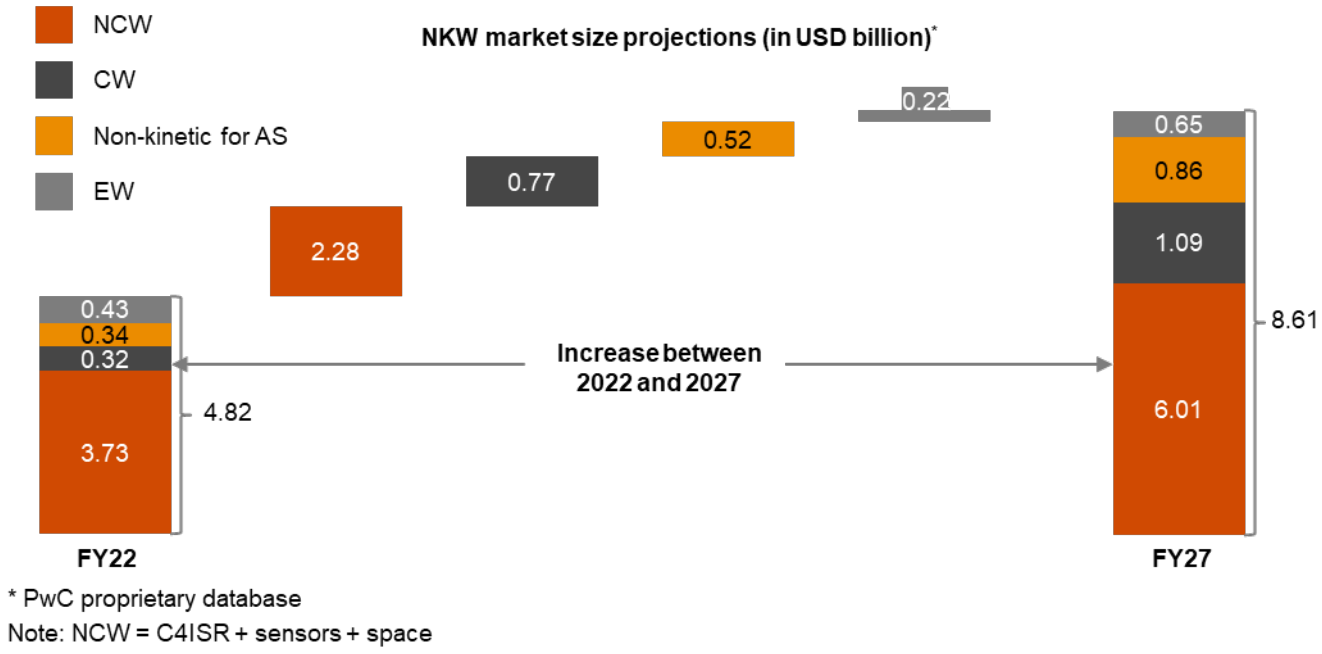
2.2 India's position and potential

2.2.1 India's NKW ecosystem

2.2.1.1 India's NKW market size

In recent years, India has experienced a surge in technological adoption across the country owing to Government initiatives such as Digital India. With the MoD's focus on modernising Indian military forces and considering the increased participation from the private sector and MSMEs in providing NKW solutions, the country's NKW market is expected to reach USD 8.61 billion[4] by 2027.

Figure 8: Indian NKW market size projection



Source: PwC analysis

2.2.1.2 Current NKW ecosystem of India

NKW domains

Although public sector companies dominate in both NCW and EW domains, increasing competition has been observed from major private sector players. Moreover, there has been an increase in the number of private players supporting both the public sector and large private companies in these domains. Currently, private companies seem to be taking the lead in cyber defence and AS. Among the NKW domains, a significant presence of defence MSMEs/start-ups has been witnessed in autonomous platforms' domain as compared to NCW, EW and CW. Also, it is observed that there is a strong competition from foreign-origin companies across the NKW domains.

NKW technologies

Technologies like AI/ML, big data and IoT that augment the NKW domain are being developed by both Indian and foreign-origin companies. Leading Indian IT companies have established their presence in the ecosystem which is expected to help the country gain lead in the NKW domain.

[4] PwC analysis

2.2.1.3 Strengths and opportunities

The strength and opportunities across the NKW domains are synthesised using SWOT analysis.

NCW

The SWOT analysis of India's NCW positioning shows significant capability requirements in 5G/6G, quantum technology, AI/ML and critical sensors. With the significant presence of both public and private companies, India needs to build capabilities across:

- quantum tech to develop quantum radars and sonars, SQUID, quantum communication satellites
- emerging tech to build AI/ML-enabled products
- developing and manufacturing sensors required for AR/VR, haptic feedback, EO/IR, transducers.

Building these capabilities will address the demands of AR and VR in battle management and planning in defence and space, and homeland security applications along with quantum tech for enemy detection with minimum exposure. This will also address the demands for computing technologies such as AI, deep learning, ML and predictive analytics to help detect man-made signals.

EW

A SWOT analysis of India's EW positioning reveals that there are significant capability requirements in EM spectrum denial, quantum technology and AI/ML. Currently, India is still importing significant portions of EW hardware. Moreover, the R&D capabilities in the EW domain are limited. With the combination of DPSU, MSMEs and start-ups that are active in this domain, India can indigenise the development of EW systems. However, the following capabilities are required in order to do so:

- preventing the use of the EM spectrum by adversaries
- enabling widespread development and adoption of quantum computing to create a new generation of satellites, radars and communication systems, which can render even the most modern EW systems redundant
- enhancing operational efficiencies by building the next generation AI/ML-enabled EW products.

These capabilities will address the demands of defence systems by providing advanced functionalities such as spoofing, jamming and deception, and help in the advancement in nano-electronics.

CW

A SWOT analysis of India's CW positioning reveals requirements regarding capabilities in AI/ML, network hardware design and augmentation of a skilled workforce. Although a significant number of private players deal with cybersecurity in India, a substantial number of hardware and software systems deployed at defence establishments are not manufactured in the country. Therefore, it is essential that capabilities across hardware design and manufacturing are developed, in addition to the following:

- improving protection of underwater optical cables from cyberattacks
- identifying and countering critical cybersecurity threats using AI/ML
- creating a national pool of trained and amateur cybersecurity personnel to respond to national emergencies.

MeitY has urged ministries to spend 10% of their IT budgets on cybersecurity and appoint a CIS officer. To address the issue, the Government of India announced INR 30 billion and INR 993 million respectively, for the 'skills and education' segment in Union Budget 2020, along with announcing the launch of cyber forensic university.[5]

[5] https://economictimes.indiatimes.com/news/economy/policy/budget-2020-allocates-inr-99300-crore-for-skill-development-quality-education/videoshow/73833400.cms?from=mdr

Non-kinetic for autonomous

A SWOT analysis of India's non-kinetic for autonomous reveals capability requirements in 3D printing, AI/ML, critical sensors and nanotechnology. Uncertainties in user acceptance of autonomous features are hampering the growth of the autonomous military vehicle market. Hence, India still relies on foreign industry players for sophisticated systems. With the increase in the number of private industry participants (MSMEs, start-ups) involved in the development of autonomous unmanned systems and setting up of DTIS labs, India needs to build capabilities across:

- miniaturising components and large-scale computing capabilities using advanced algorithms
- improving the technology readiness levels on par with established and leading unmanned systems
- developing technologies concentrated in 3D printing, sensors, AI, visual data processing and cybersecurity, and building advanced materials for stealth capability
- augmenting capabilities in terms of range, endurance and redundancy to meet global standards.

Developing and augmenting these capabilities will address the demands of anti-drone systems, AI, cyberspace, secure systems and communication systems.

2.3 Global NKW landscape

To understand the global NKW landscape, seven military mature countries – namely, China, France, Israel, Russia, South Korea, Turkey and the US – have been studied. These countries have demonstrated expertise across the NKW domains, with China and the US accounting for the highest global market share. Additional key geographical insights are as highlighted below:

- For NCW solutions, Russia, France and Turkey are the major suppliers.
- Critical AS suppliers include Russia, followed by South Korea and Israel.
- Russia, France and Turkey assert global prowess in the EW domain.
- Finally, across CW, Israel qualifies as one of the top solution providers, closely followed by South Korea and Russia.

In the subsequent sections, we analyse each country's acceleration towards NKW based on the NKW ecosystem development initiatives undertaken by them. Key development areas include talent, infrastructure, notable alliances, R&D capabilities, policy thrust initiatives and technology. The study of each country has been conducted with the aim to analyse and synthesise key learnings from the approach adopted by these countries to build NKW and core technology capabilities.

2.3.1 China

NKW ecosystem development approach

Through the formation of specialised technical universities of international calibre along with cross-country expertise exchange, China has accelerated the development of its technical capabilities. Under the MCF strategy, China aims to integrate military and civil across all fields of national economy and defence.[6] As a part of this strategy, undertaking educational reforms to incorporate military influence is a required parameter to build niche talent. Through such dual-use science and technology endeavours, China has developed shared infrastructure and is building critical systems in space, undersea and mobile communications networks.

China's global alliance strategy has revolved around academic tie-ups with global private companies and large investments in international technology-based start-ups for knowledge sharing. To boost R&D efforts, major private companies in China are designated as technology 'champions'. These champions then become leaders for setting national technological standards, and enable extensive cooperation with China's national security community.

[6] http://www.indiandefencereview.com/news/military-civil-fusion-strategy-of-china/

Under the MCF strategy, China aims to integrate military and civil across all fields of national economy and defence.

2.3.2 France

NKW ecosystem development approach

To enable growth in the NKW talent, France has allowed a free flow of expertise among government/military, private and academia through collaborative technology projects. Moreover, this talent has provided the required support for research (focused on quantum computers, sensors and communications) in the industry and academia. To enable infrastructure development catering to NKW domains, France has increased investments on resources for intelligence, cyber and space battles while also bringing dual-use technologies into critical space, satellite and computing systems. To leverage alliances, France has undertaken several R&D partnerships with various countries for key NKW technologies – such as AI and quantum computing – as well as promoted development of such technologies by private sectors using joint public–private investments. Finally, in addition to the R&D investments, France has undertaken critical foreign and economic policy measures to boost its NKW and defence innovation strengths.

France has increased investments on resources for intelligence, cyber and space battles while also bringing dual-use technologies into critical systems.

2.3.3 Israel

NKW ecosystem development approach

Through technical defence training of high-achieving STEM students, Israel has promoted core-skill development of the youth in Israel. Further, early exposure to the needs of the defence forces has helped in building innovative, tech-savvy leaders, capable of modernising the forces with their ventures. The 'Talpiot' programme and training under 'Unit 8200' allow the youth to have first-hand experience of military training and technologies, while also building technical know-how in emerging fields such as big data, AI, ML and natural language processing. Through the Israel Innovation Authority and the Directorate of Defense Research and Development, the government has supported the defence technology industry by establishing sufficient infrastructure in addition to providing funding support, to achieve the desired milestones of the defence ministry.[7] Joint R&D initiatives with the US on emerging technologies such as counter-unmanned systems and AI as well as undertaking of several research partnerships with foreign universities in key NKW technologies across western nations has aided the defence development in Israel.[8] The Israeli government has aided the development of the defence technology ecosystem through proactive policy and investment initiatives, as well as by sharing risks and rewards with the players in the domestic landscape. Lastly, regular conferences held across all ecosystem stakeholders and government-supported funds for start-up innovation has resulted in the country building capabilities in robotics, self-powered systems and encryption.

The government in Israel has supported the development of the defence technology ecosystem through policy and investment initiatives, encouraging disruptive ideas, and sharing risks and rewards with the industry.

7 https://english.mod.gov.il/About/Innovative_Strength/Pages/Directorate-_of_Defense_Research_Development.aspx
8 https://www.dasadec.army.mil/News/Article-Display/Article/2342531/accelerating-military-innovation-lessons-from-china-and-israel/

2.3.4 Russia

NKW ecosystem development approach

Russia's development of niche talent by allowing free flow of expertise among government/military, private and academia in technology projects has accelerated the technical know-how and NKW ecosystem growth in the country. Further, by providing research support for AI, hypersonic vehicles, EW, UUVs, cognitive technologies, and DEWs, Russia has managed to promote disruptive research across the country. The infrastructure of NKW domains has been supported by increasing investments in the development of consolidated research institutes to enhance military R&D as well as science and technology. Russia prioritises research areas like AI, small spacecraft, robotics, automated control and IT systems, computer science and engineering and pattern recognition. The country has also introduced strategic R&D organisations, including advanced research foundations in the field of hypersonics, space, AI, EW, IT and CW.

> **The infrastructure of NKW domains has been supported by increasing investments in the development of consolidated research institutes.**

2.3.5 South Korea

NKW ecosystem development approach

To become a self-sufficient defence technology leader, South Korea has designated ten universities as 'AI Engineering' schools[9] to address the engineering gap in experienced and skilled AI talent. In continuation of these efforts, South Korea aims to train 36,000 semiconductor experts over the next decade and build technical leadership. It also offers limited restrictions pertaining to foreign direct investments in the defence sector. In addition, KoDi is focused on harnessing digital infrastructure and enhancing emerging technologies. The ROK–US long-term alliance has been pivotal for the growth in defence technology innovation over the years. Such international alliances have been leveraged to hone capabilities in 5G and AI. The government also provided sufficient start-up funding, national technological infrastructure and promoted the establishment of KRIT in 2021 to support the development of defence technologies.

> **KoDi is focused on harnessing digital infrastructure and enhancing emerging technologies**.

2.3.6 Turkey

NKW ecosystem development approach

To join the leading countries in the global defence industry with cutting-edge defence offerings in every domain of military technology, Turkey has initiated continuous evaluation of infrastructure and capability gaps for active decision support from industry leaders and subsequent infrastructure and capability development. It has also established defence-focused youth programmes and other academia opportunities to aid cooperation with think tanks developing early innovation activities. Moreover, Turkey has leveraged alliances in the form of joint centres of excellence for cooperation across cyber, autonomous systems and aerospace technologies and honed its NKW capabilities through promotion of public–private partnerships for joint technology production and efficient resource utilisation in the national defence industry.

> **Turkey has initiated continuous evaluation of infrastructure and capability gaps for active decision support from industry leaders and subsequent infrastructure and capability development.**

[9] https://www.trade.gov/country-commercial-guides/south-korea-information-and-communication-technology

2.3.7 US

NKW ecosystem development approach

The US is focused towards preserving and expanding its military advantage in new digital operating environments such as space and cyberspace. This would include closer collaboration among government, private defence players and non-defence civil mission partners. The US develops niche talent through establishment of innovation challenges, incubators and accelerators led by the government, which assist in the technology development and absorption. The country has also made sufficient efforts for pivoting the shift towards moving to cloud-based environment by establishing new data centres and enhancing the existing ones. Future R&D initiatives rely heavily on promoting emerging tech by leveraging the capabilities of civil industry with a focus towards making defence systems interoperable and connected.

> **The US develops niche talent through establishment of innovation challenges, incubators and accelerators led by the government, which assist in the technology development and absorption**.

2.4 Gap assessment

Through the benchmarking exercise, strategic best practices as adopted by benchmarked countries were synthesised across various areas like talent, strategy and policy, alliances, R&D, and infrastructure. India's adoption level of these best practices were also analysed through the study.

For the adoption of best practices in the above-mentioned areas 14 strategic gaps were identified. Considering that the identified best practices have been highly adopted globally, it can be assumed that these will be critical in accelerating India's growth in the development of its NKW capabilities.

Figure 9: Strategy gaps identified across talent, policy, alliances, R&D and infrastructure

Ecosystem enablers	Best practices	Global adoption*	India adoption*
Talent	Talented workforce developed from an early age through defence tech- focused educational programmes	◕	○
	Free-flow of knowledge through utilisation of domestic and foreign experts from government/military to participate in technology projects	◕	◔
	Specialisation in focused studies of NKW domains through formation of technology clusters	◑	○
Policy	Incentivising the private sector to support domestic defense ecosystem in NKW tech	◕	◔
	Providing foreign governments with grants to build partnerships and support the domestic defence industry	◕	○
	Establishing an official AI policy to promote AI-focused R&D in domestic defence ecosystem	◕	◔
Alliances	Promoting establishment of COEs among domestic private sector, global companies and academia	◕	◔
	Developing G2G frameworks for joint capability development	◕	◔
Infrastructure	Collaborating with military and civil for sharing resources and investments; promoting efficient and effective research	◑	○
	Setting common military and civilian standards to make ensure adequate infrastructure during emergencies and wartime	◔	○
	Introducing state-driven mid to long-term technology programme for infrastructure development and mass training in AI and other emerging tech	◑	◔
R&D	Developing technology clusters for cooperative R&D among all NKW stakeholders	◕	◔
	Establishing government-sponsored technology platforms to aid turnaround time for R&D	◑	◔
	Re-organising think tanks to drive innovation in R&D labs for critical technologies	◑	○

*Index

○ Absence of strategy adoption	◑ Adopted by 2–3 countries (medium)
◔ Adopted by one country (low)	◕ Adopted by 4–6 countries (high)

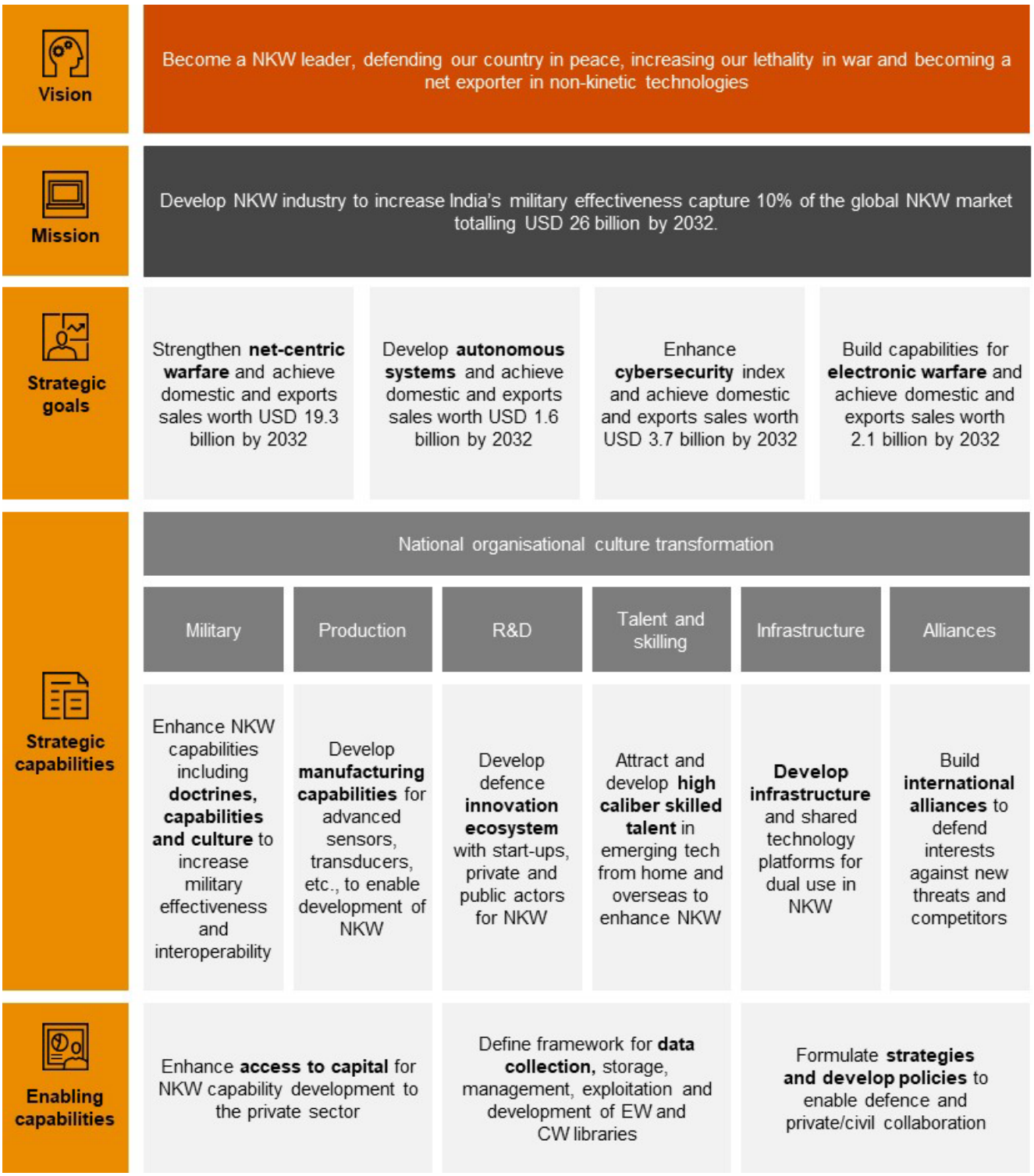
Source: PwC analysis

The identified best practices and gap areas of India were further analysed to formulate strategic inputs for the country, while defining strategic goals and formulating strategic and enabling capabilities required to support the achievement of these strategic goals.

03 Vision for making India a leading manufacturer of NKW solutions

India has traditionally been an importer of high-tech kinetic warfare solutions, but recent policy shifts and greater involvement of the private sector have given the country the required boost to aim for self-reliance in manufacturing kinetic warfare solutions in the near future. Due to the head start major militaries have over India, India may be a follower in this area. But as one of the largest IT/ITeS suppliers to the global market, India has an inherent advantage to grow in NKW solution development. India's strong software capabilities, if augmented by development of electronics and hardware manufacturing capabilities, can craft the way for the country to become a leader in NKW solutions in the next 25 years, i.e. by 2047.

Figure 10: NKW solution strategy



Source: PwC analysis

3.1 Strategic goals

The strategic goals, as defined in the NKW domains (Figure 10), may be achieved through the identified four approaches. This report focuses on these approaches that have defined technology initiatives and ecosystem development initiatives under each, based on the baselining study of India and the global benchmarking study. The ultimate target is to achieve self-reliance by 2027 and become a global leader in the manufacturing of NKW solutions by 2047.The technology initiatives proposed have been evaluated in detail to understand the total global addressable market and India's potential to cater to this demand. Geopolitical conditions have been factored to synthesise the projected supply potential of the Indian industry.

The first strategy is to harness the existing potential of the country to develop new NKW solutions that cater to all the four domains. Technology initiatives that can be undertaken by 2027 have been proposed for each NKW domain. The supply potential through these initiatives has been assessed and detailed in subsequent sections.

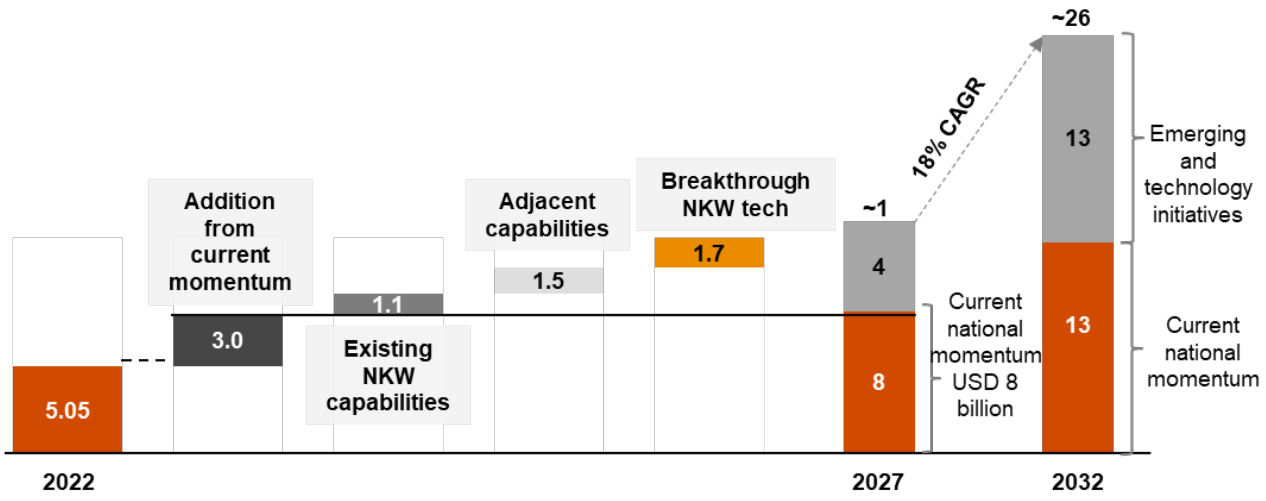
The second strategy focuses on developing adjacencies. This would require investments in the NKW ecosystem and collaboration between industry stakeholders to reap faster results. Technology initiatives have been detailed for this, in addition to the supply potential of the industry.

The third strategy pushes for increasing focus on the development of technology solutions for defence-based disruptive technologies. To achieve this, India would be required to define its R&D focus areas upto 2027 and make consistent investments in the talent and skills required to develop these solutions. Given their high market potential, disruptive technologies can also be a research focus area for the private sector with these technologies finding use cases in the civilian sector.

The last strategy emphasises on increasing the country's focus towards export of NKW solutions. India can focus on developing export versions of these solutions, primarily the software components, to friendly countries.

Figure 11 shows the supply potential of the Indian industry by 2027 and subsequently by 2032, growing at a CAGR of 18%.

Figure 11: Supply projections of NKW solutions from Indian industry (in USD billion)

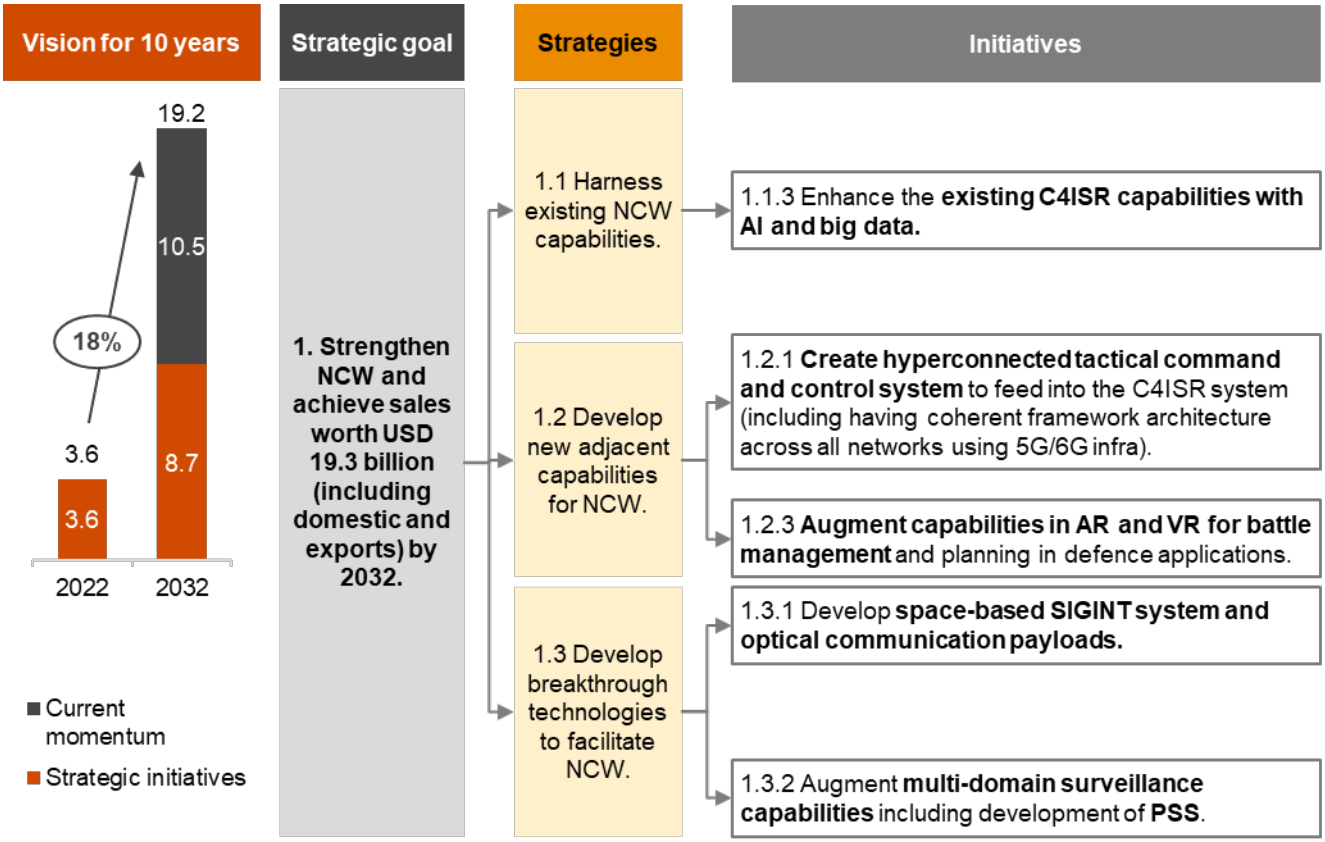


Source: PwC analysis

3.1.1 Strengthen NCW

With a goal of achieving sales worth USD 19.3 billion – including both the domestic and export markets – by 2032, technology initiatives have been defined.

Figure 12: NCW strategy and initiatives

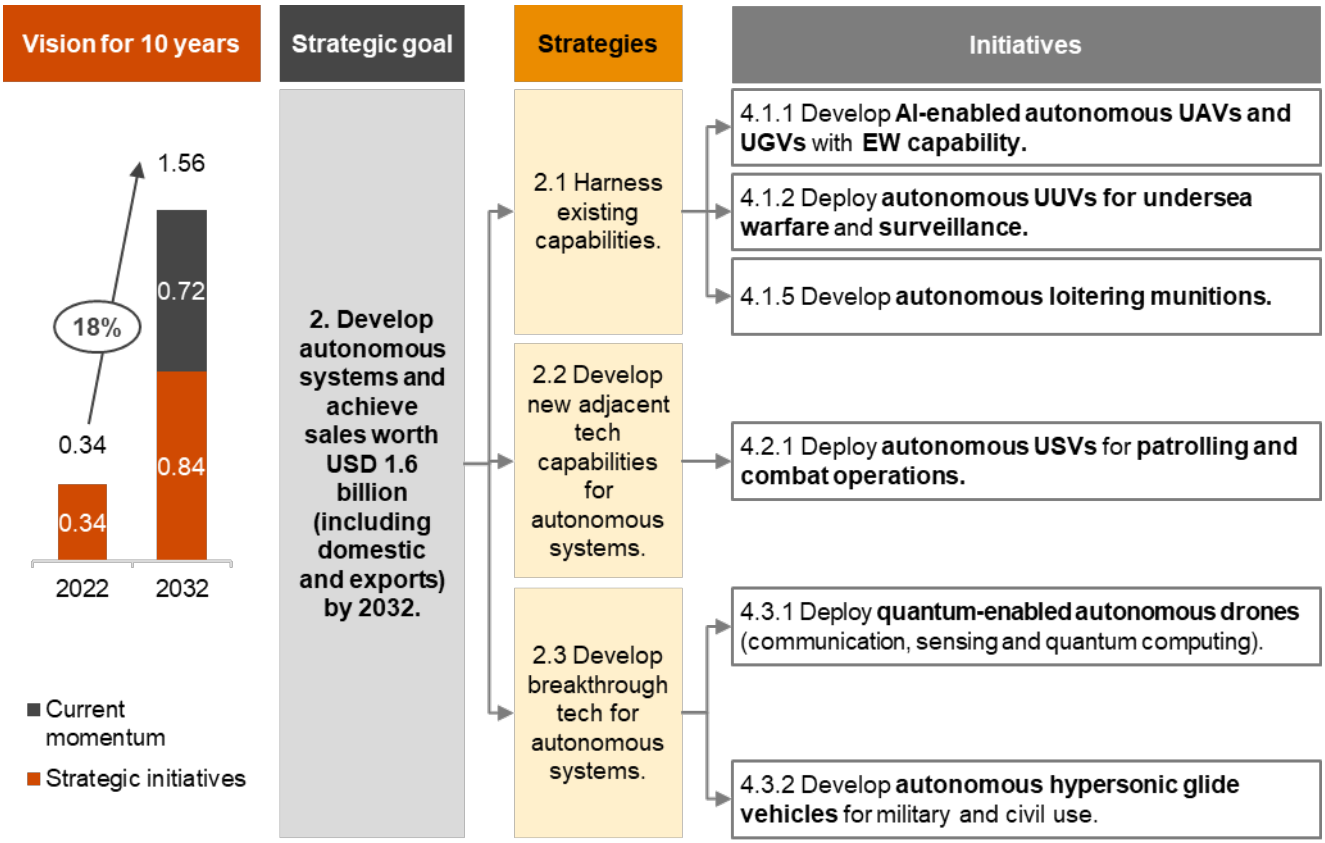


Source: PwC analysis

3.1.2 Developing non-kinetic technologies for AS

Development of the highlighted technology initiatives in AS could help in achieving USD 1.6 billion in revenue (domestic and export) by 2032.

Figure 13: AS strategy and initiatives

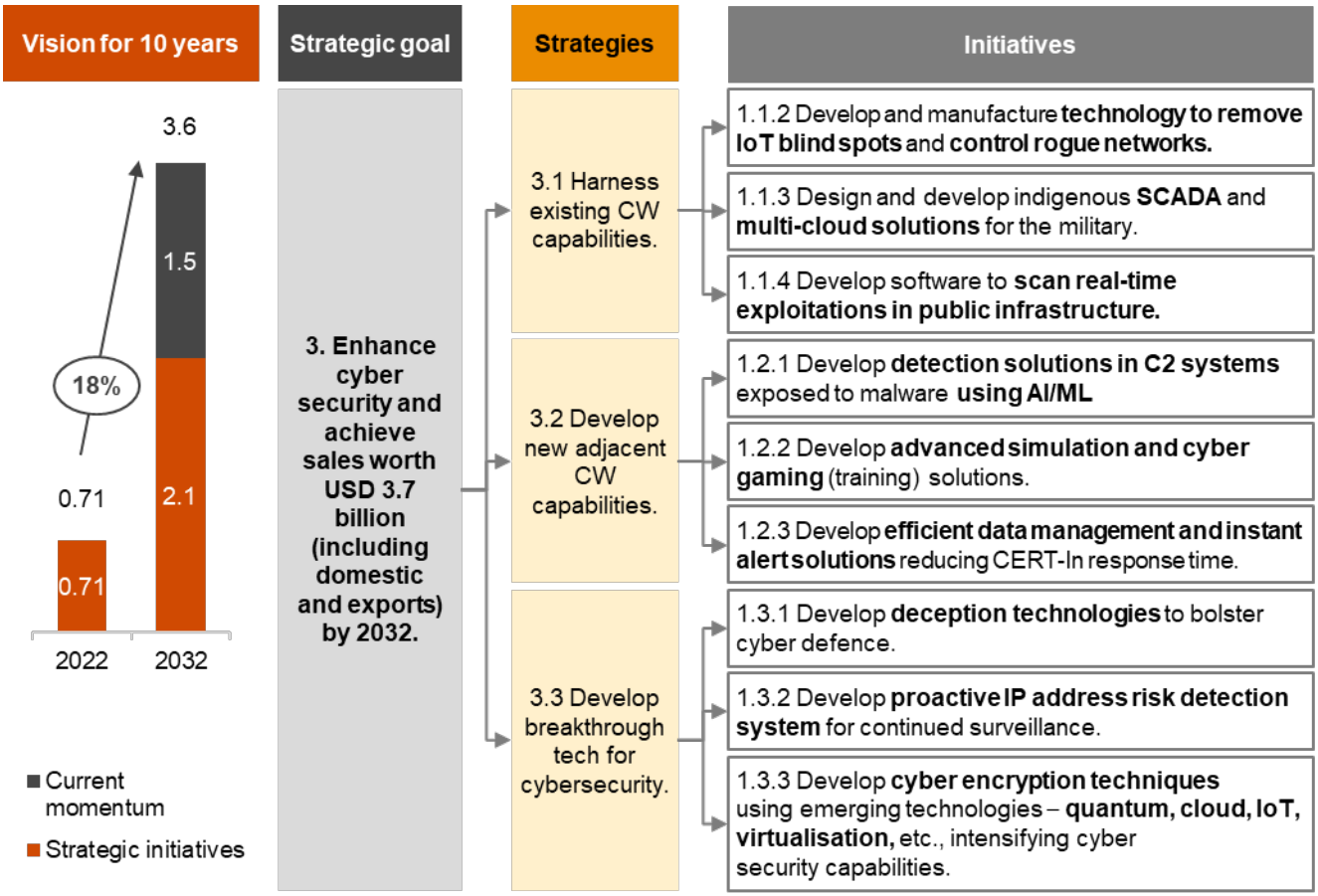


Source: PwC analysis

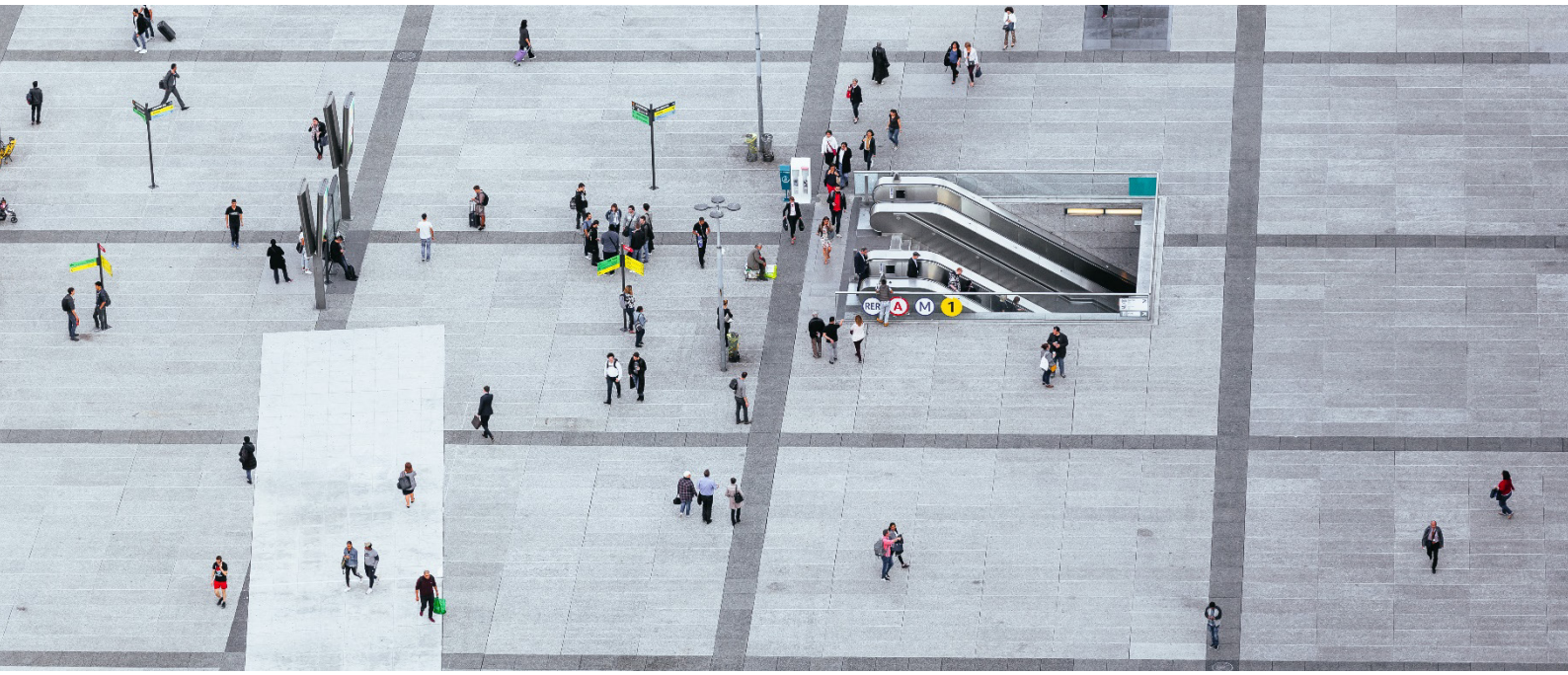
3.1.3 Enhance CW

India has the potential to achieve sales worth USD 3.7 billion (including both the domestic and export markets) by 2032.

Figure 14: CW strategy and initiatives



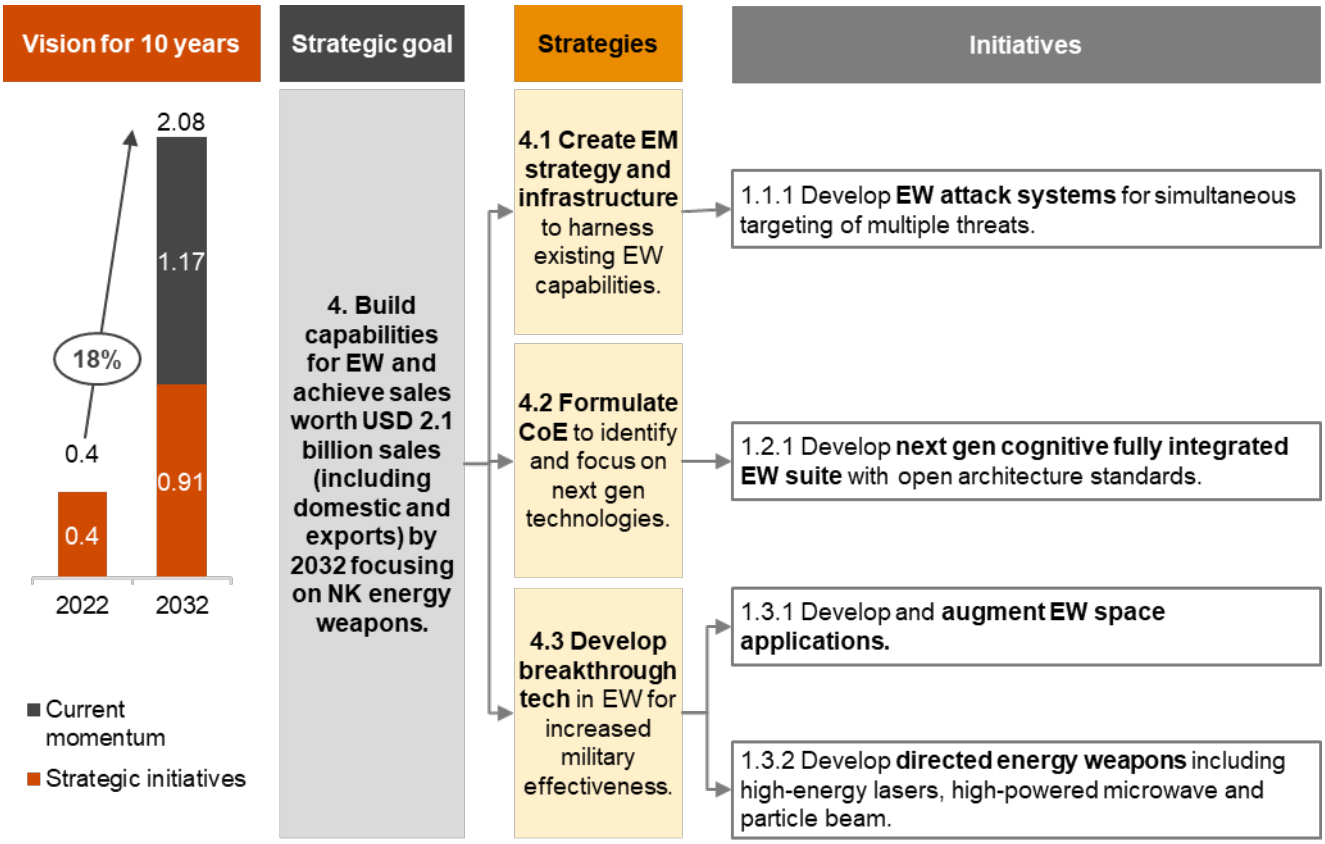
Source: PwC analysis



3.1.4 Build capabilities for EW

India can build capabilities for EW to earn USD 2.1 billion in revenue (domestic and international) from this domain by 2032.

Figure 15: EW strategy and initiatives



Source: PwC analysis

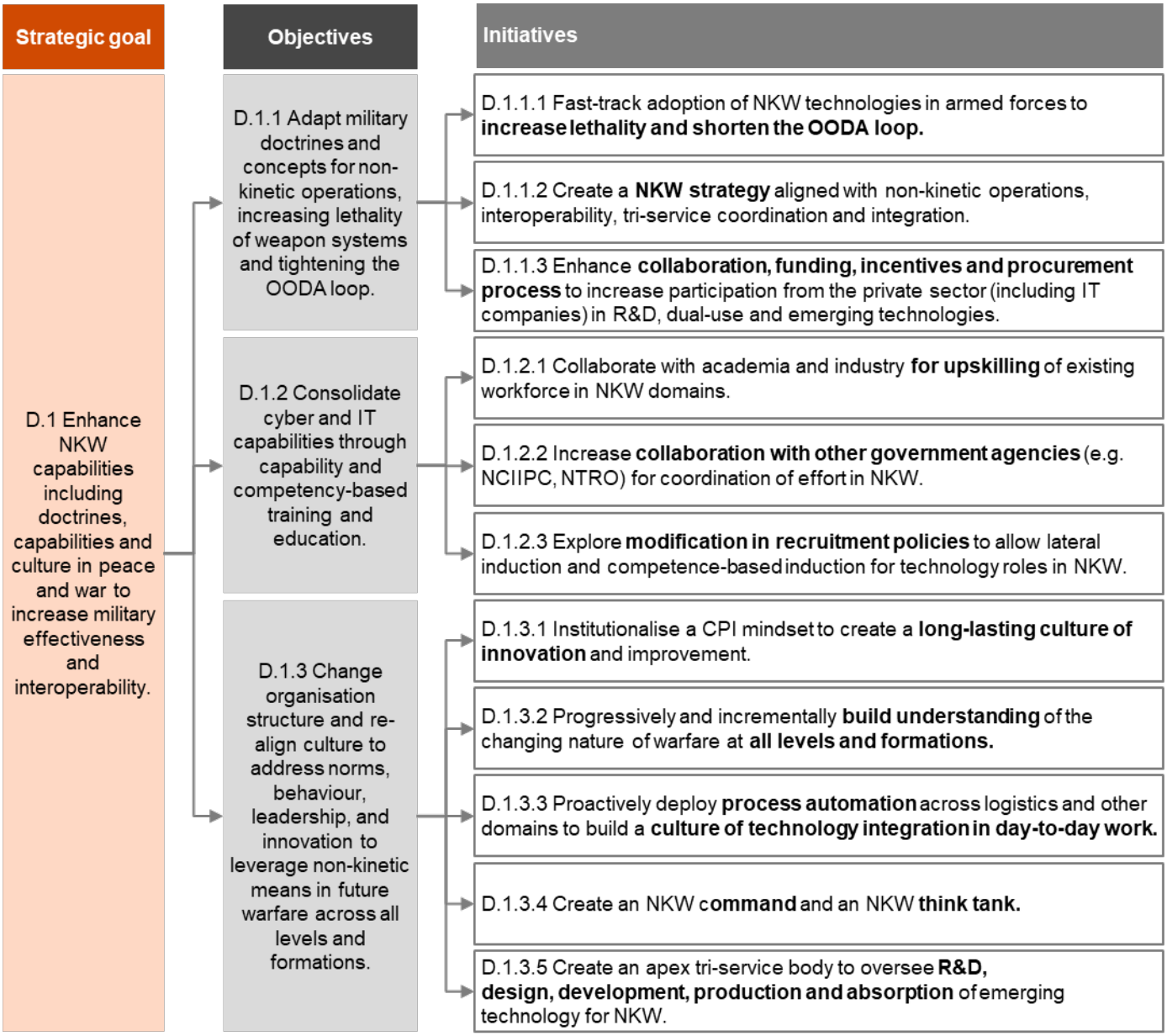
3.2 Strategic capabilities

3.2.1 Military doctrines and concepts

To realise the vision of becoming a leading supplier of NKW solutions by 2032, India must revisit its doctrines, consolidate capabilities, and re-align organisational culture. The key steps for implementing doctrine-level reforms are as follows:

1. Adapt military doctrines and concepts for non-kinetic operations, increasing lethality of weapon systems and tightening the OODA loop.
2. Consolidate cyber and IT capabilities through capability and competency-based training and education.
3. Change organisation structure and re-align culture to address norms, behaviour, leadership, and innovation to leverage non-kinetic means in future warfare across all levels and formations.

Figure 16: Military capabilities



Source: PwC analysis

3.2.2 Talent

Existence of high-calibre talent is critical for India to become a leader across NKW domains. Key approaches to enable this include:

1. attracting high-calibre talent in emerging tech from home and overseas to enhance NKW
2. creating specific trainings and niche capability building in the technical institutions of India for NKW.

3.2.3 R&D

India needs to build an R&D strategy and revise R&D institution structures to make them more dynamic and efficient, supported by mixed funding models for increasing investments in start-ups, academia and CoEs.

3.2.4 Production

India needs to accelerate its transmission technology and semiconductor production capabilities while developing capabilities for systems-of-systems integration. The key objective of enhancing India's defence manufacturing capabilities is to develop manufacturing capabilities for advanced sensors, transducers, etc.

This, along with the development of systems-of-systems integration capacity, would play a vital role in achieving the goal of indigenisation in NKW.

3.2.5 Alliances

India must re-align its national organisational culture and transform based on evolving needs. It is imperative to collaborate with friendly nations for knowledge sharing, joint R&D, military exercises in NKW and manpower skilling.

3.2.6 Infrastructure

Infrastructure development is critical to provide the private and civil sectors access to advanced computing resources and tech platforms. The key approaches for the same include:

1. Provide shared infrastructure for training, simulation and testing.
2. Develop dual-use 5G/6G test facilities and cybersecurity frameworks for networks.
3. Provide advanced computing resources for shared usage by public, private, academia and start-ups to develop dual-use tech.

Figure 17: Summary of strategic capabilities

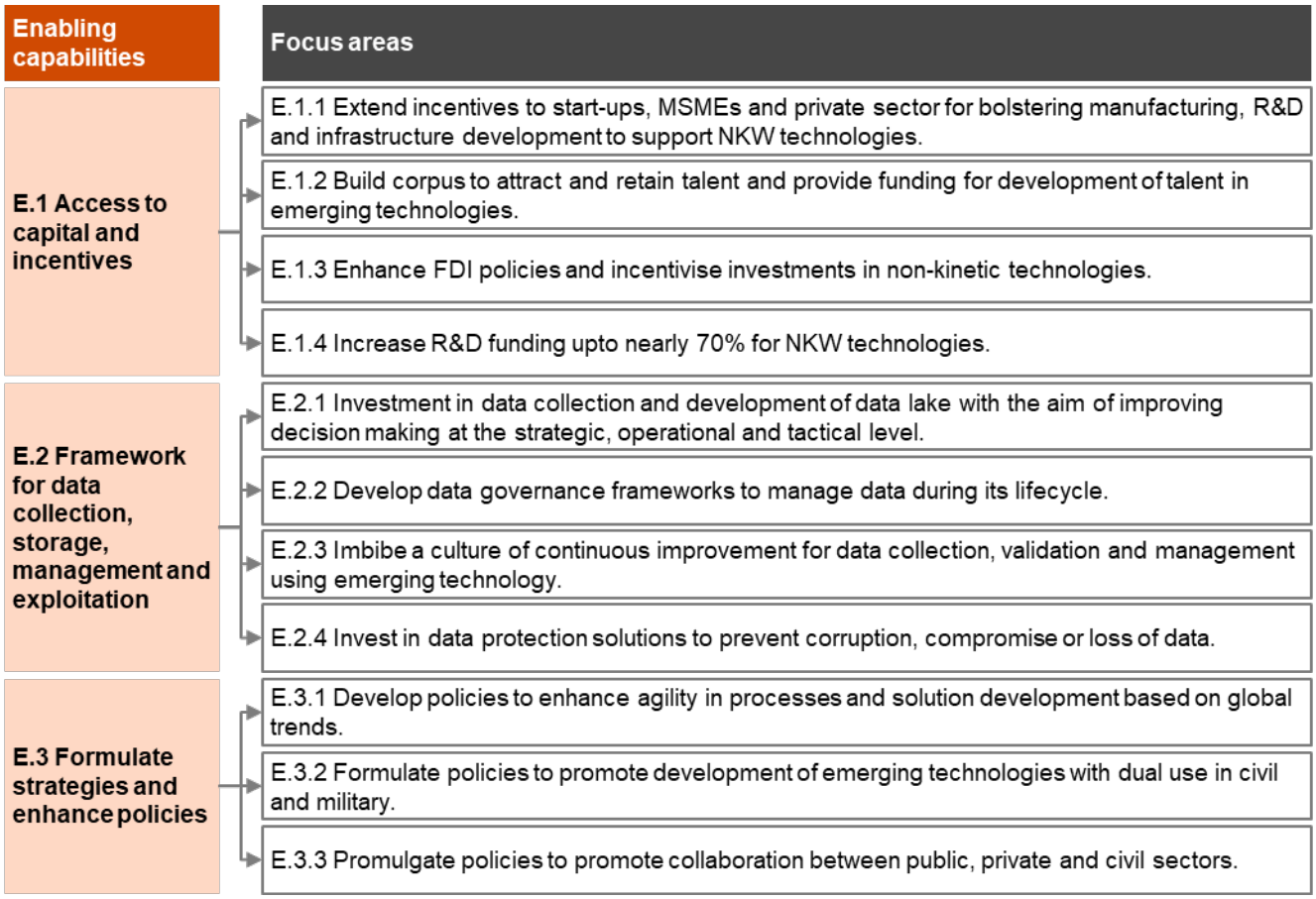
Strategic capabilities	Focus areas
S.1 Production	S.1.1 Forge local knowledge to promote manufacturing capabilities in technical and supporting infrastructure.
	S.1.2 Develop system of system integration capabilities to offer NKW solutions.
S.2 R&D	S.2.1 Formulate R&D plans for integrating military modernisation with future technologies.
	S.2.2 Re-organise R&D Institution structure to achieve dynamic, efficient and effective output.
	S.2.3 Deploy R&D funding mechanisms with participation from all stakeholders with ~70% R&D for NKW.
S.3 Talent	S.3.1 Attract Indian-origin talent from abroad.
	S.3.2 Develop and retain domestic talent to promote early innovation and nourish domestic ecosystem.
	S.3.3 Collaborate with academia to train talent and shift focus of R&D to innovation in military technology.
	S.3.4 Reform military education with focus on emerging technology.
S.4 Infrastructure	S.4.1 Build shared resources like labs, simulation facilities, test beds, test ranges and advanced computing systems through big-ticket military complex.
	S.4.2 Build enabling infrastructure and advance computing facilities for use by public, private, academia and start-ups.

Source: PwC analysis

3.3 Enabling capabilities

To achieve the 10-year vision, the key enabling initiatives that are expected to facilitate this are funding and incentivisation, data management and protection, and policy intervention.

Figure 18: Enabling capabilities



Source: PwC analysis

04 Investments and strategic roadmap

India requires investments worth approximately USD 23 billion in core capability development and implementation. The development of these core capabilities in the short term would aid:

1. Faster adoption of emerging technologies in the aerospace and defence sector
2. Joint capability establishment across the defence and civil sectors as well as accelerated development of dual-use technology goals across different industries.

4.1 Investments

Investments amounting to around USD 19.4 billion are required across four strategic capabilities – R&D, production, talent and infrastructure. The highest share of investments would be required by R&D, owing to the rapid pace of evolution across technology buckets. Government or sovereign investments have been estimated at around USD 14 billion, with the highest share in R&D and infrastructure. Industry is expected to contribute around USD 5 billion, with the highest share in production and talent.

Table 1: Cumulative strategic capability investments (till 2027)

Sr. no.	Strategic capability	Investment (in USD billion)	Share of government (in USD billion)	Share of industry (in USD billion)
1	Research and development	12.40	10.92 (88%)	1.48 (12%)
2	Production	1.23	0.37 (30%)	0.86 (70%)
3	Talent	2.90	0.87 (30%)	2.03 (70%)
4	Infrastructure	2.87	2.01 (70%)	0.86 (30%)
	Total	**19.40**	**14.17**	**5.23**

Source: PwC analysis

Each strategic capability and its components have been examined in greater detail below.

R&D investments

India currently invests around 3% of its defence budget on R&D through the DRDO. Key technologies requiring sovereign investments include quantum sensing and computing, DEW, 5G/6G and cyber. Developed countries tend to spend around 10–13% of their defence budget on R&D. It is hence proposed that the defence R&D spend be increased to around 5% of the defence budget by 2027 and around 7% by 2032 to achieve the strategic goals. It is proposed to invest around 70% of the defence R&D budget in NKW technologies as against the current estimated spend of around 25–30%.[10] Industry is expected to contribute approximately 12% to the country's defence R&D spend to realise the market potential. Additional investments include individual CoEs for AI, cyber, cloud and advanced sensors. The capabilities developed through these investments may have both civil and defence applications.

[10] Industry inputs, SME inputs and PwC analysis

Figure 19: Technology focus areas for defence R&D in India

Source: PwC analysis

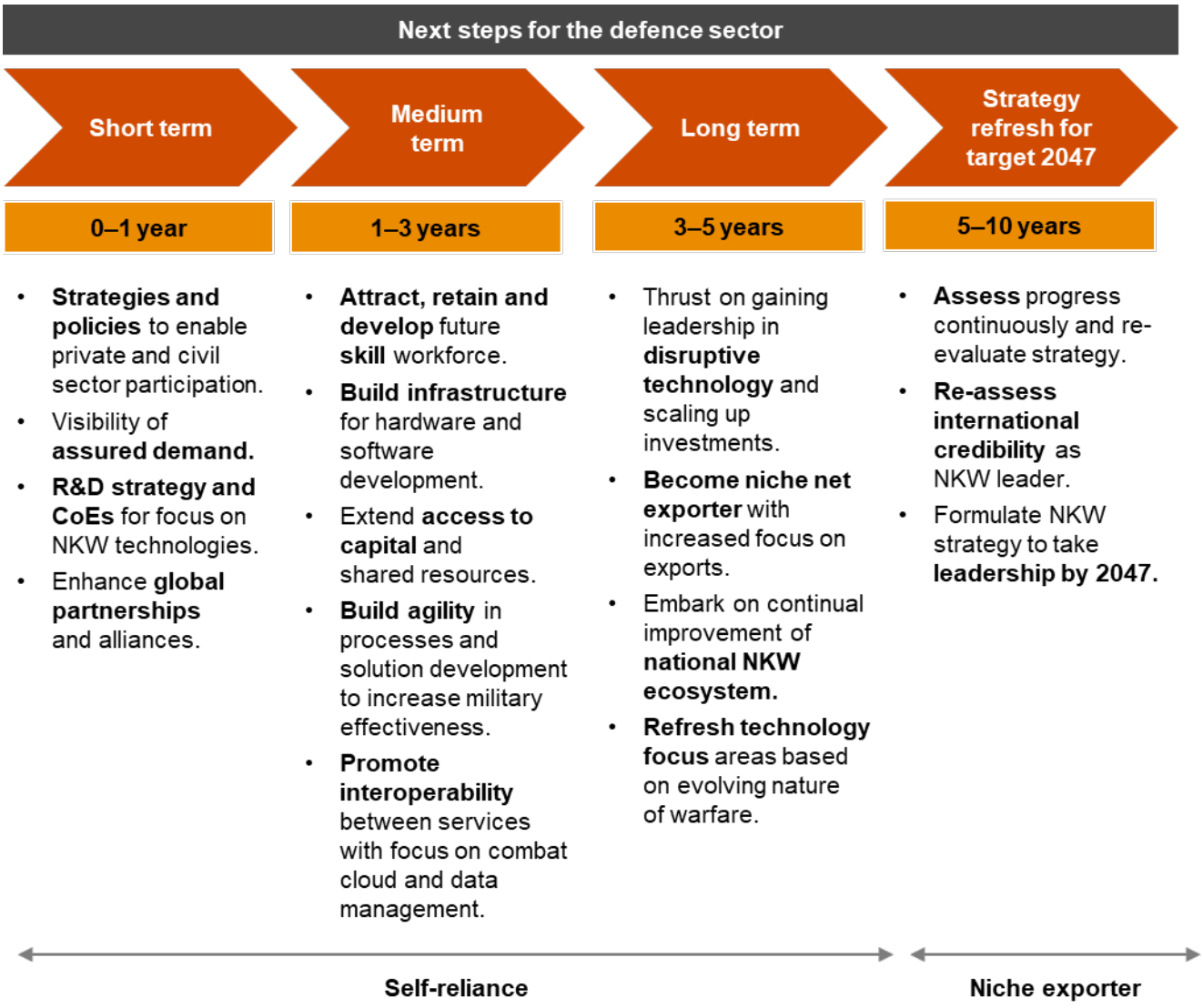
Investments in AI, cyber, cloud and connectivity, and advanced sensor technologies are expected to contribute to solution development for all NKW domains. Given the high involvement of multiple technology areas in NCW and CW, investment requirements for these two domains are high.

4.2 Strategic roadmap

The technology initiatives and ecosystem development approach, as formulated in this report, could pave the way for India to become a leading manufacturer of NKW solutions by 2047. These initiatives could lay the foundation for the growth of the defence sector and redefine India's military prowess based on advancements in technology capabilities.

Figure 20 presents a broad ten-year roadmap for India to implement this strategy. Strategic capabilities would have to be built by 2027, with consistent investments as proposed. Further, the technology initiatives would have to be implemented by 2027 to provide industry with the required start. Continuous assessment and re-evaluation of the strategy will be important to ensure that India is on track to realise its vision by 2047.

Figure 20: Strategic roadmap for India

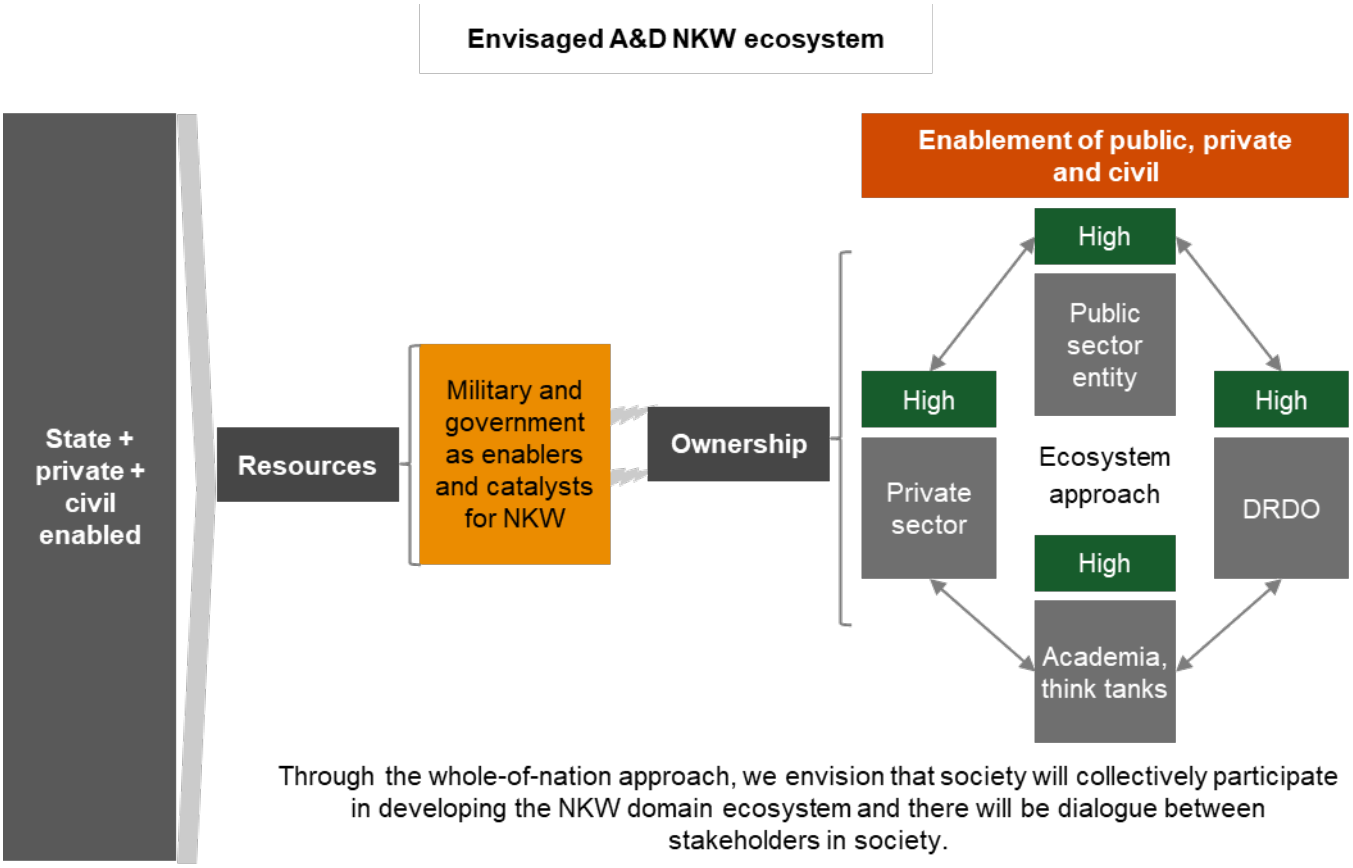


Source: PwC analysis

4.3 Whole-of-nation approach

Strategising the development of a non-kinetic ecosystem in India by fusing military and civil capabilities has emerged as a key theme of the proposed strategy. This approach seeks to leverage technological capabilities of the civilian sector for achieving military effectiveness. This has been termed as a 'whole-of-nation' approach. Figure 21 illustrates the roles of the military and the Government in driving implementation. The key stakeholders – i.e. the public sector, private sector, academia and research organisations – must collaborate with the military and Government to build an NKW ecosystem.

Figure 21: Whole-of-nation approach



Source: PwC analysis

Glossary

Sr. no.	Acronym	Full form
1	AI	Artificial intelligence
2	AR	Augmented reality
3	AS	Autonomous systems
4	ASAT	Anti-satellite
5	A&D	Aerospace and defence
6	C2	Command and control
7	C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
8	CERT-In	Computer Emergency Response Team, India
9	CIS	Communication and information systems
10	CoE	Centre of excellence
11	CPI	Continuous process improvement
12	CW	Cyber warfare
13	DEW	Directed energy weapon
14	DIO	Defence Innovation Organisation
15	DPSU	Defence public sector undertaking
16	DRDO	Defence Research and Development Organisation
17	DTIS	Defence Testing Infrastructure Scheme
18	EM	Electromagnetic
19	EMS	Electromagnetic spectrum

Sr. no.	Acronym	Full form
20	EO/IR	Electro-optical/Infrared
21	EW	Electronic warfare
22	FDI	Foreign direct investment
23	GDP	Gross domestic product
24	HRI	Human–robot interaction
25	ICT	Information and communications technology
26	iDEX	Innovations for defence excellence
27	IED	Improvised explosive device
28	IIT	India Institute of Technology
29	IoMT	Internet of military things
30	IOR	Indian Ocean region
31	IoT	Internet of things
32	IP	Internet protocol
33	ISR	Intelligence, Surveillance and Reconnaissance
34	ISRO	Indian Space Research Organisation
35	IT	Information technology
36	ITeS	Information technology enabled services
37	JATP	Joint Advanced Technology Program
38	KoDi	Korea Digital Development programme
39	KRIT	Korea Research Institute for Defense Technology Planning and Advancement
40	MCF	Military–civil fusion

Sr. no.	Acronym	Full form
41	ML	Machine learning
42	MSME	Micro, small and medium enterprise
43	MOD	Ministry of Defence
44	NCIIP	National Critical Information Infrastructure Protection Centre
45	NCW	Net-centric warfare
46	NKW	Non-kinetic warfare
47	NTRO	National Technical Research Organisation
48	OEM	Original equipment manufacturer
49	OODA	Observe–orient–decide–act
50	OS	Operating system
51	PG	Post-graduate/graduation
52	PSS	Persistence surveillance system
53	QKD	Quantum key distribution
54	QUAD	Quadrilateral Security Dialogue
55	R&D	Research and development
56	RF	Radio frequency
57	ROK	Republic of Korea
58	SCADA	Supervisory control and data acquisition
59	SEZ	Special economic zone
60	SIGINT	Signals intelligence
61	SMB	Small and medium-size businesses

Sr. no.	Acronym	Full form
62	SOP	Standard operating procedure
63	SQUID	Superconducting quantum interference device
64	STEM	Science, technology, engineering and mathematics
65	SWOT	Strengths, weaknesses, opportunities and threats
66	UAV	Unmanned aerial vehicle
67	UGV	Unmanned ground vehicle
68	UK	United Kingdom
69	UMV	Unmanned vehicle
70	US	United States of America
71	UUV	Unmanned underwater vehicle
72	VR	Virtual reality

Table of figures

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