APEX STANDARDS

How Advanced Semiconductors are Changing the Face of National Security

National Security Series
Tech Report N4000218
AI-enabled Military Applications
22 April 2023

Military capabilities with cutting-edge technology are now more crucial than ever for national security, as the global landscape evolves at a rapid pace. Major powers such as the United States, China, and Russia are vying for supremacy in artificial intelligence (AI), high-performance computing (HPC), and advanced communications, as these technologies have the potential to redefine the future of armed conflict. The recent conflict in Ukraine has demonstrated the vital role of advanced technologies in shaping the outcome of modern warfare, highlighting the importance of nations developing comprehensive strategies to bolster their domestic production capabilities.

In Europe, the utilization of Western information technology, including AI and autonomous surveillance systems, has had a powerful, albeit less visible, impact on Russian forces in the recent conflict in Ukraine. Commercial vendors have supplied Ukrainian troops with satellites, sensors, unmanned drones, and software, providing reams of battlefield data condensed into apps that help soldiers on the ground target the enemy. Developed by unconventional minds in American tech, such as Elon Musk's SpaceX and Palmer Luckey's Anduril, these technologies function as an "Uber for artillery."

In the Pacific, Huawei, which began as a Chinese telecoms firm, has transformed into a high-tech conglomerate spanning various sectors, including consumer electronics, enterprise software, IoT, new energy, healthcare, and automotive. However, in 2018, the US imposed sanctions on Huawei's access to US technology, citing its ties with the Chinese People's Liberation Army (PLA). This happened at a sensitive moment when Huawei announced the world's first 5G processor, the Kirin 990. The sanctions forced Huawei to divest its smartphone business line due to its inability to access sophisticated semiconductors manufactured by TSMC. In 2018, Huawei was TSMC's second-largest client after Apple, highlighting China's top tech firms' reliance on foreign technology from countries like the US, Taiwan, Japan, and South Korea—so long as these technologies has a US source. Despite facing challenges in the semiconductor sector, Huawei managed to overcome the Oracle's ERP ban by creating its own Enterprise Resource Planning (ERP) system, which allows it to continue to streamline and automate key business operations, from accounting and HR to patenting and supply chain management. While some software bans can be overcome, semiconductor bans continue to pose significant challenges. The Biden administration has sustained the weaponization of semiconductor supply chains, a strategy initiated by the Trump administration, which has impressed US policymakers with its effectiveness. However, the US is not without vulnerabilities in the semiconductor industry. Intel lags behind TSMC and Samsung in the most advanced 7nm/5nm/3nm technology, whose manufacturing facilities are all based on the other side of the Pacific, creating geopolitical tensions. In response to increasing global competition in compute-driven technologies, nations must develop comprehensive strategies to enhance domestic production capabilities, including investing in R&D, fostering public-private partnerships, and securing reliable supply chains for critical components like advanced semiconductor chips. Ultimately, a nation's ability to innovate, adapt, and achieve self-reliance in production may determine its future.

The integration of AI, HPC, and advanced communications technologies in modern military weaponry is revolutionizing warfare as we know it. These technologies, including AI-guided missiles and bombs, autonomous drones, swarm technology, hypersonic weapons, AI-assisted Electronic Warfare (EW) systems, satellite-guided artillery, and AI-enhanced reconnaissance and surveillance, have already been demonstrated in military exercises and conflicts around the world.

One example of AI-guided missiles and bombs is the Joint Direct Attack Munition (JDAM) and the Long Range Anti-Ship Missile (LRASM), which use AI and HPC to process massive amounts of data in real-time, allowing the weapons to adapt their flight paths, avoid obstacles, and evade enemy countermeasures autonomously. These weapons are linked to remote command centers through high-throughput, low-latency communications, enabling the transmission of critical information.

Weapon	Force	Technical Details	Military Applications Enabled by Advanced Chips	Consequences if not used	Industries Involved	Examples of Weapon Models
Missile guidance	Air Force, Navy	High precision, real-time, automatic identification of moving targets	Enables accurate guidance and targeting of missiles	Risk of missile misfires or unintended damage	Defense, Aerospace, Semiconductors, AI Software	USA - Lockheed Martin - AGM-158 JASSM UK - MBDA – ASRAAM Israel - Rafael Advanced Defense Systems – SPICE China - CASIC - DF-21D Russia - KTRV - Iskander-M
Electronic warfare	Air Force, Navy	Advanced signal processing and high-speed communication	Enables detection and jamming of enemy signals	Risk of enemy interference and loss of operational advantage	Defense, Aerospace, Semiconductors, AI Software	USA - Northrop Grumman - AN/ALQ-218 France - Thales - EW Suite Israel - Elbit Systems - ELM-2022A Russia – Krasukha China - LASER-120
Radar systems	Air Force, Navy	High-speed signal processing and low latency communication	Enables accurate detection, tracking of targets in real-time and situational awareness	Risk of missed targets or mistaken identity	Defense, Aerospace, Semiconductors, HPC	USA - Lockheed Martin - AN/TPS-77 Italy - Leonardo - RAT-31DL Israel - IAI - ELM-2084 Russia - Nebo-M
Unmanned systems	Air Force, Navy, Army, Space	High-performance contextual computing and real-time processing	Enables autonomous navigation, control of unmanned systems and better reconnaissance and surveillance remotely	Risk of mission failure or accidents	Defense, Aerospace, Semiconductors, AI Software	USA - General Atomics MQ-9 Reaper Israel - Elbit Systems Hermes 900, China - Caihong (Rainbow) Series UK - BAE Systems MANTIS Turkey - Bayraktar TB2
Surveillance	Air Force, Navy, Army, Space	High-speed, low-latency communication with automated analysis	Enables real-time data processing and analysis for situational awareness and intelligence gathering	Risk of operational failure or loss of intelligence	Defense, Aerospace, Semiconductors, AI Software, HPC	USA - Raytheon Advanced Surveillance Radar USA - Lockheed Martin Watchkeeper France - Thales Ground Master 400 Israel - IAI Eitam Russia - Beriev A-50 China - KJ-500, KJ-2000
Cybersecurity	Strategic Command, Intelligence	Advanced encryption and authentication	Ensures secure communication and protects military networks and information	Risk of intelligence leaks or cyber attacks on military networks	Defense, Cybersecurity, IT, Semiconductors, AI Software, HPC	USA - Intel SGX Israel - CyberArk Privileged Access Security China - Huawei Security Product Taiwan - Winbond Secure Flash South Korea - AhnLab MDS
Navigation	All	High-speed processing and low latency communication	Enables accurate positioning and navigation of military vehicles, aircraft, and ships	Risk of navigation errors or accidents	Defense, Aerospace	USA - Northrop Grumman LN-260 France - Sagem SIGMA 95 UK - BAE Systems INS Israel - Rafael Advanced Defense Litening III China - CHC Navigation Technologies iBase
Sonar systems	Navy, Submarine	High-speed auditory signal analysis and classification of threats	Enables detection and tracking of underwater targets, such as submarines or torpedoes	Risk of missed targets or operational failure	Defense, Aerospace, Marine, Semiconductors, AI Software	USA - Lockheed Martin AN/SQQ-89 France - Thales Sonar 2087 Italy - Leonardo PMS
Space and Satellites	All	High-speed processing and communication	Enables satellite communication, imaging, and navigation for military operations	Risk of mission failure or loss of communication or imaging capabilities	Defense, Aerospace, Satellite, Semiconductors, HPC	USA - Lockheed Martin SBIRS UK - Skynet 5 France – Syracuse Israel – Ofek Russia - Gonets
Weapons guidance	Air Force, Navy, Army	High-performance computing and real-time processing, combined with advanced sensors and guidance systems	Enables accurate and precise targeting of weapons	Risk of missed targets or civilian casualties	Defense, Aerospace, Semiconductors, AI Software	USA - Lockheed Martin AGM-158 JASSM UK - MBDA Brimstone France - MBDA Scalp Israel - Rafael Spice China - CASC KD-20

Advanced semiconductor chips are used in a variety of weapons across Air Force, Navy, Army, Space, and Strategic Command forces. Missile guidance technology is used by several countries such as the USA, UK, China, and Israel to enable high precision, real-time, and automatic identification of moving targets for accurate guidance and targeting of missiles. Electronic warfare capabilities enable detection and jamming of enemy signals by countries such as the USA, France, and Israel to prevent the risk of enemy interference and loss of operational advantage. Similarly, radar systems, unmanned systems, surveillance systems, navigation, sonar systems, cybersecurity, and space and satellite technologies also utilize advanced chiplets to enable better situational awareness, targeting, detection, and protection of military personnel and assets.

Next-generation military drones, such as the MQ-9 Reaper and Baykar Bayraktar TB2, also utilize AI algorithms to perform tasks like surveillance, target acquisition, and precision strikes with minimal human intervention. These drones rely on HPC to process large volumes of sensor data and make real-time decisions based on that data. Advanced communications technologies ensure an uninterrupted link between the drone and remote operators, allowing seamless command and control.

Swarm technology is another AI and HPC-enabled military technology that enables multiple unmanned vehicles to coordinate their actions and work together as a cohesive unit. Each vehicle in the swarm uses AI algorithms to process sensor data, communicate with other vehicles, and make autonomous decisions. HPC ensures that the swarm can process vast amounts of data quickly, while advanced communications technologies enable high data rate, low-latency communication between swarm vehicles and human operators.

Hypersonic weapons, such as Russia's Avangard or China's DF-ZF, use AI and HPC in their guidance and control systems to process vast amounts of sensor data and make real-time adjustments to their trajectory in high speed. Advanced communications technologies ensure continuous synchronization the weapon and remote command centers for in-flight updates and target adjustments.

Directed energy weapons, such as the U.S. Navy's Laser Weapon System (LaWS) and the High Energy Laser Tactical Vehicle Demonstrator (HEL TVD), also rely on AI and HPC to process sensor data and accurately track and engage targets. These systems use advanced communications technologies to maintain a high-speed, low-latency link between the weapon system and remote command centers for real-time targeting updates and status reports.

AI-powered electronic warfare systems, like the U.S. Army's Multi-Function Electronic Warfare (MFEW) system, rely on HPC to handle vast amounts of signals from different sources, such as radar, radio frequency, and electromagnetic signals. These systems utilize AI algorithms to analyze data, identify enemy vulnerabilities, and suggest actions to improve overall situational awareness in a fast-changing environment, therefore maintaining connectivity for in-the-moment updates and adjustments between the electronic warfare system and remote command centers, .

The integration of these advanced technologies in modern military weaponry is reshaping the global military landscape, as demonstrated by recent conflicts such as the one in Ukraine. In this rapidly evolving global landscape, countries will strive to develop strategies to bolster their domestic defense supply chain production to maintain their strategic advantage on the world stage and pave the way for the next generation of military innovations. The ability to innovate and produce domestically is crucial in the high-stakes game of modern warfare, where the relentless march of technology awaits no one.