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TANTRA: RE-ENGINEERING LAND POWER FOR THE ALGORITHMIC AGE

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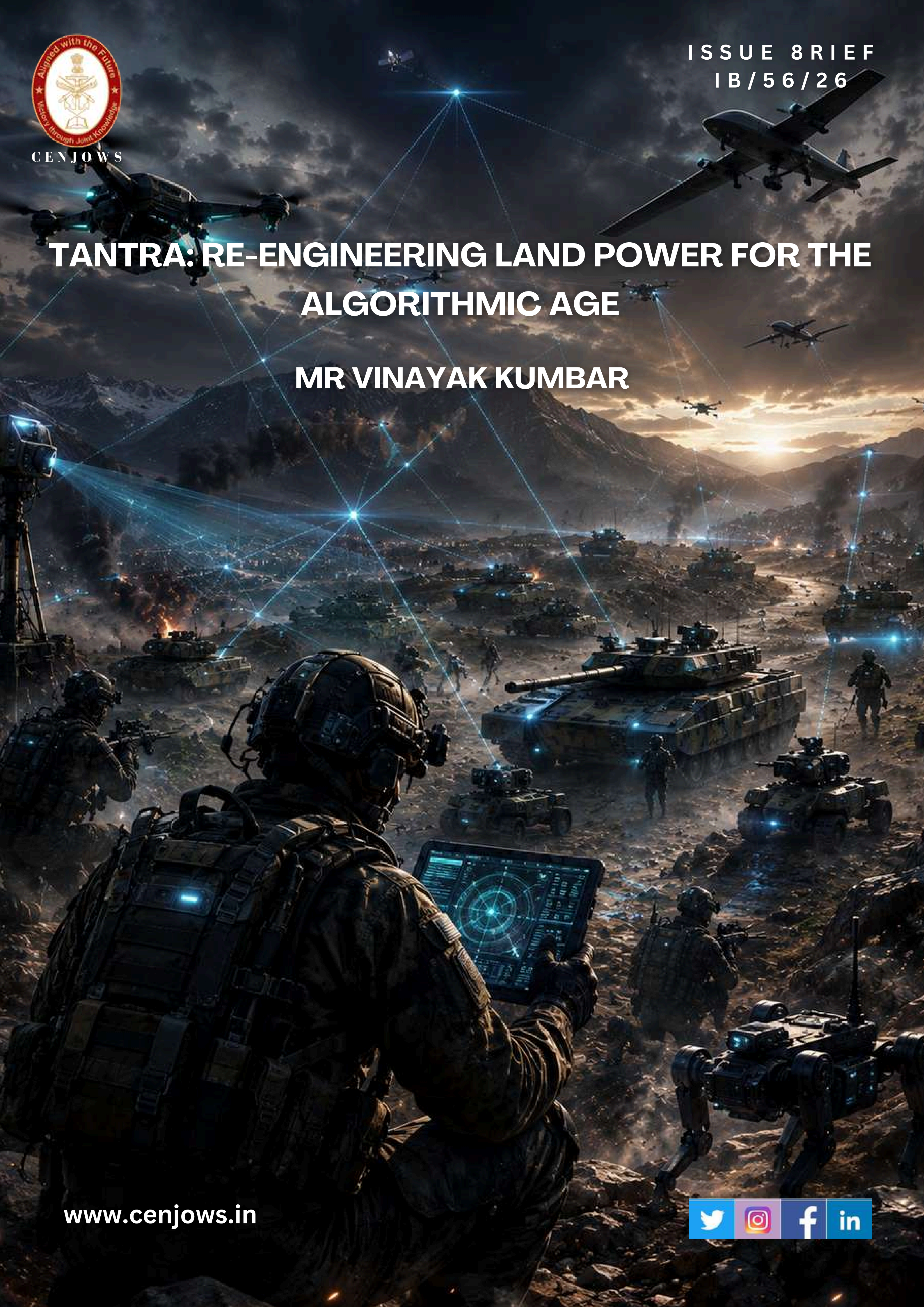

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TANTRA: Re-engineering Land Power for The Algorithmic Age

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Introduction

For a very long time, land warfare has derived its strength from the concentration of forces and firepower mass, for asserting territorial sovereignty. But the proliferation of a persistent surveillance system, Artificial Intelligence (AI), Precision-Guided Munitions (PGMs), autonomous platforms, and sensing technologies has brought in a fundamental alteration to this equation.

The contemporary battlefield is becoming increasingly transparent. Here, large formations are readily detectable, and static positions are often vulnerable to precision engagement. In such an environment, achieving survivability is no longer just dependent on armour alone, nor can battlefield success solely rely upon numerical superiority. Rather, a military advantage will increasingly belong to the force that can see first, decide quicker, manoeuvre faster, deceive effectively and remain hidden more efficiently.

The modern land force is therefore witnessing an evolution from a collection of platforms into a distributed combat ecosystem (DisCS). Algorithms are now effectively complementing command decisions, and sensors are being pushed down to the level of the individual soldier. Autonomous systems are reshaping logistics and manoeuvre, and electromagnetic dominance is becoming as important as control of physical terrain. In parallel to this, advances in Signature Management (SiGma), battlefield deception, Neuromorphic Computing (NC), and Active Protection Systems are redefining the relationship between detection, survivability, and combat effectiveness. This results in a force that is no longer organised around mass but around information, connectivity, and decision superiority.

In the Indian context, these developments carry a particular significance. The vast expanses of the Line of Actual Control (LAC); the challenges of high-altitude warfare; the increasing presence of unmanned systems; and the growing integration of space, cyber, and electromagnetic capabilities are demanding a fundamental recalibration of the land operations. The future battlefield will require forces that are capable of dispersing without compromising the cohesion, remaining concealed without sacrificing awareness, and delivering concentrated effects without physically concentrating themselves.

This paper attempts to examine this re-engineering of land power within the multi-domain operations framework through the lenses of algorithmic manoeuvre (AM), multi-spectral signature management (M2S2), cognitive augmentation, autonomous logistics, man-unmanned teaming (MUM-T), electromagnetic manoeuvre warfare (EMMW), NC, deception architectures, and APS. Together, these technologies signal the emergence of a new model of land warfare. One, in which every soldier, vehicle, sensor, and autonomous platform function as part of a larger intelligent network. If the maritime domain serves as the connective tissue of the battlefield vertical, the land domain remains a decisive anchor. Here the information is translated into physical control, and sovereignty is ultimately secured.

Algorithms and the Decision Dominance

It is a well-known fact that traditional land warfare has been reliant on the physical massing of armour and infantry in order to punch through static defensive lines.

However, when it comes to the modern-day battlefield, this ‘mass’ has somewhat turned into a liability. It is well established that the high-altitude long-endurance (HALE) drones and the never-blinking, i.e., the persistent satellite constellations, have brought in a transparency to the ground. Algorithmic Manoeuvre (AM) is one strong strategic response to this transparency. It can be defined as the ‘art of using Artificial Intelligence (AI) to coordinate hundreds and thousands of dispersed, small units that can be both manned and unmanned in order to achieve a singular objective without ever having to concentrate into a targetable mass.’[1] One can visualise this as a cloud of independent combat nodes. Instead of a line of tanks, which converge only at the moment of impact and then disperse immediately after. This ‘manoeuvre’ is not just physical movement across terrain anymore but rather a rapid shifting of data, priorities, and fires within the Observe Orient Decide Act (OODA) loop. This paper argues that one who possesses a superior algorithm will win the encounter even before the first shot could be fired. One who can efficiently process the terrain data, enemy heat signatures, and electromagnetic emissions in real-time could employ an effective AI-driven command system to identify ‘pathways of least resistance’ that a human eye would miss.

In the Indian context, especially in the high-altitude regions of the Line of Actual Control (LAC), an effective AM can allow a virtual massing of fire from different locations. One can imagine artillery in one valley and loitering munitions in another, all striking a single target with microsecond sync. This significantly reduces the logistics tail and keeps soldiers out of the target zone of the enemy’s precision-guided munitions (PGMs). The algorithm thus becomes a new high ground that could provide a cognitive advantage. This in turn would offset the traditional challenges of difficult geography and inferiority in number.

Mastering the Invisibility in the Battlefield

If one can call the algorithm the ‘sword’ of modern land power, then the Multi-Spectral Signature Management (MSSM) would become the ‘shield’. In a world capable of hyper-sensing, being invisible to just the human eye is no longer enough. It is well known that a modern battle tank or infantry squad emits a spectral thumbprint across multiple bands which include visual, thermal (Infrared - IR), acoustic, and electromagnetic.[2] MSSM is an integrated approach to suppress or spoof all these signatures simultaneously. In times to come, the use of Adaptive Camouflage i.e., using materials that can change their temperature to match that of the surrounding[3] rocks or soil, can make the thermal sensors less effective. Also, the radio silence is often augmented by Low Probability of Intercept (LPI)[4] communication, which effectively mimics the natural background radiation of the atmosphere.

India needs to work around how to deploy these cloaking technologies for its indigenous platforms like the Arjun Mk-1A or the Future Ready Combat Vehicle (FRCV). MSSM is not merely about hiding. It is about Identity Deception (ID). An infantry unit can use Signature Emulators (SEs) to make a small element appear as a full armoured company on the enemy radar. This will force them to draw out their heavy reserves into an ambush. In the multi-domain operations (MDO) architecture, the land domain must master the art of being a ghost in the machine. 'If one cannot be seen across the spectrum, they cannot be targeted, and if they cannot be targeted, the enemy's expensive surveillance assets are in a way neutralised.' Invisibility, one can say, could become the ultimate force multiplier. It can turn a standard infantry unit into an undetectable apex predator on the cognitive battlefield.

Connected Combatant: A Networked War Fighter

The re-engineering of land power stretches all the way down to an individual soldier. The transparent soldier can be equipped with an Integrated Combat System (ICS) which functions as a personal node in the MDO network. This system runs on Neuromorphic Edge Computing (NEC). It is the process in which the chips can process data locally on the soldier's helmet or vest, instead of sending it back to the vulnerable central cloud.[5] This in turn allows for near real-time Target Recognition and Threat Prioritisation (TATP). E.g., a soldier's augmented reality (AR) visor can automatically highlight a camouflaged sniper or a hidden IED by analysing the smallest spectral anomalies in the environment which the human brain would often ignore.[6] This cognitive augmentation can ensure that the soldier's reaction time is much faster than the enemy's even in the most mosaic scenarios. Also, this individual soldier can become a sensor node for the entire vertical. The data which is collected by a soldier's thermal optics on the LAC can be fed directly back to a cislunar satellite or a surface LUSV. This could provide a bottom-up intelligence flow. Tactical Edge AI algorithms can run on low-power devices to provide language translation, ballistic calculations, and medical diagnostics in the field.[7]

This technology can become the key to maintaining a high tempo of operation. The soldier now becomes more than just a rifleman. They turn into a data manager who can call upon the full weight of the MDO architecture with a single voice command. This kind of democratisation of intelligence ensures that even the smallest unit on the ground has the situational awareness of higher levels.

The Versatile Autonomous-Human-Assisted Navigation Architecture

Logistics is often termed the 'Achilles' heel' of land power. There is a requirement of a massive, visible trail of fuel, food, and ammunition for a moving army. AM can solve this through Autonomous Combat Logistics (ACL). Leading armies around the world are testing 'Mule Swarms.[8] These are small, four-legged autonomous robots that are capable of navigating the challenging, treacherous vertical terrain say, of the Himalayas. These can help deliver the supplies to forward posts. These robots do not need roads or GPS. They use visual 'Simultaneous Localisation and Mapping' (v-SLAM)[9] to follow their human counterparts through such terrains. The logistics of the vertical could effectively eliminate the need for vulnerable logistic convoys which are often the primary targets for the enemy's aerial or swarm assets. Hydrogen fuel cells can be used for silent, long-range operations.[10] This, combined with an AI-driven predictive maintenance that is capable of alerting the base before a robot's motor fails, can significantly enhance the operational performance.

It is safe to say that the logistics algorithm is just as important as the combat algorithm. When an army is capable of automating the Last Mile of Delivery (LoD), it can remain dispersed and stay invisible for longer periods. Logistics can be called the silent enabler of the MDO network. Once the land domain becomes capable of sustaining itself through autonomous, multi-spectral hidden supply lines, it can easily maintain its persistent presence indefinitely. This shall force the adversary into a costly war of attrition, one which they prepared for or cannot win. This robotic revolution could ensure that the land power of contemporary times is leaner, faster, and far more resilient than its predecessor.

The Coordinated Human-Autonomous Kinetic Response Architecture

The final pillar of this paper is the integration of heterogeneous swarms into the ground manoeuvre. Manned-Unmanned Teaming (MUM - T) generally involves a single human-crewed tank or Infantry Combat Vehicle (ICV). They act as a mothership for a swarm of, say, 20 to 30 small, autonomous ground and air drones. These act as the tentacles of the unit that scout ahead, jam enemy communications and even act as 'Kamikaze' interceptors against an incoming anti-tank missile. The technical challenge lies in the Human Machine Interface (HMI). The answer to how a tank commander manages a swarm while also driving and shooting lies in task-based autonomy. Here the human gives a broad command, and the swarm autonomously divides the labour among the drones accordingly.

One of the most visible swarm intelligence algorithms can be seen in the ant colonies.[11] Taking these as inspiration, the drones can be programmed to coordinate without a central kill switch node. For leading armies like that of India, MUM-T can be an effective solution to the high-intensity, low-density conflict model. It would allow a small number of top-quality troops to hold vast areas of territory against a force superior in numbers. The swarm could provide a buffering layer that could take the initial casualties, which will ensure the preservation of the highly trained human soldiers for the decisive manoeuvre. By integrating these swarms into the MDO grid, the ground forces can act as a multi-layered fortress. Here the outer wall is composed of expendable silicon, and the inner core is the irreplaceable human strategic intent. This synergy can be seen as the ultimate expression of re-engineered land power.

The Tactical, Adaptive Radio and Networked Ground Architecture

It is now a well-established notation that a battlefield is no longer just composed of soil and steel. It has become this dense forest of Electromagnetic Waves (EMW). Electromagnetic Manoeuvre Warfare (EMMW) is the mastery of controlling this invisible forest. We know that every radio, radar, and sensor emits a signal.[12] EMMW involves the spectrum management that is needed to ensure that our signals are heard, whereas that of the enemies are depleted or drowned out. In contemporary times, the frontline soldier can carry an AI-driven device that can effectively sense an incoming enemy drone's control frequency and then hijack it in mid-air. This spectrum supremacy is the prerequisite for all other manoeuvres. If one loses the EMMW battle, their drones can fall from the sky, their orbit links are cut, and eventually, their AM can go blind.

Software-Defined Radio (SDR) and Frequency Hopping (FH) at microsecond intervals can help move from blasting a single frequency with noise, i.e., a static EW, to precision surgical strikes against specific enemy data packets, i.e., a precision EW. These highlight the invisible vertical layer of the battlefield that exists between the ground and the atmosphere. EMMW can ensure that a connected battlefield remains connected for the user and a black hole for their adversaries. When one is capable of mastering the spectrum at the tactical edge, they can in turn neutralise the technological advantages of the adversary. They can turn their high-tech sensors against the adversary through spoofing or digital ghosting, effectively winning the war before the first engine is even started.

The Multi-Domain-Adaptive Neuromorphic Assistance System

As one moves towards cognitive warfare (CogW), the hardware which powers the artificial algorithms becomes equally critical as the armour that protects the crew. Conventional silicon chips are often energy-intensive and slow when it comes to processing the massive data sets in a battlefield. Neuromorphic Computing (NC) chips that are designed to mimic the neural structure of the human brain are a major breakthrough of the recent times.[13] These chips can process information on-demand rather than in a constant cycle. This effectively allows a multi-fold increase in energy efficiency. This in turn allows for a small, battery-powered ground sensor or soldier helmet to run deep learning algorithms that previously required a room full of servers.

When it comes to signature management, these chips become vital, as they produce a near ‘nil’ thermal signature. A traditional AI processor that gets hot can become a beacon for enemy infrared sensors. On the other hand, a neuromorphic chip stays cool,[14] which allows the digital brain of the unit to remain hidden in the abyss of the electromagnetic background. India’s semiconductor mission can pivot toward these next-gen architectures for defence applications. Neuromorphic computing is undoubtedly the cognitive engine of the MDO network. It allows every tank, drone, and soldier to act as a smart node that can learn and adapt to the enemy’s tactics in real-time.

The Mirage of the Modern Battlefield

In order to complement the suppression of signatures, modern land power relies on the creation of ‘False Signatures’ (FalSi). The ghost army of the contemporary times is composed of inflatable, robotic, and electronic decoys that are capable of perfectly mimicking the thermal, acoustic, and radar profile of an armoured division. These decoys are not like a static balloon but are active emulators that can move, can talk on the radio, and can even emit the specific heat profile of a running diesel engine. In an era of AM, the goal is to overload the enemy’s algorithm. If the enemy’s AI-driven targeting system sees, let’s say, 1000 potential targets but only has 100 attack assets, the system might hesitate, which can provide the forces with the window of opportunity to strike. The use of ‘Plasma Stealth’ generators[15] on decoys can create false radar blips and acoustic synthesisers that are capable of mimicking the sound of a tank column from miles away. Say a satellite in orbit detects a massing of forces that are actually decoys it triggers the enemy to move their assets in air and on land to intercept this phantom threat.

This strategic deception is the modern-day version of the 'Trojan Horse' that aims to prove that, in the cognitive battlefield, the most powerful weapon is not the one that kills but the one that deceives. By mastering the art of this deception, one can project power far beyond its actual hull count. This helps create a deterrence of ambiguity that prevents conflict before it might begin.

The Last Line of Defence

Anti-tank missiles (ATGMs) and loitering munitions are becoming faster and more intelligent. This is making the passive armour insufficient to save an asset. The Active Protection System (APS) is that hard-kill shield which is capable of creating a 360^0 protective bubble around a ground node. Using a millimetric-wave radar (MMWR), the APS can detect an incoming projectile in milliseconds[16] and launch a suitable counter-munition, i.e., a burst of high-velocity fragments, in order to destroy the threat before it hits the target. In modern times there is a visible shift to "Directed Energy APS", where a localised high-power microwave burst fries the electronics of an incoming kamikaze drone, which ensures that it crashes harmlessly. An APS event on one tank is instantly shared as a threat alert to every other unit in the grid, which allows the AM to automatically adjust the unit's path to avoid the ambush zone. This combined shielding can turn a dispersed unit into a mobile fortress. The APS can be seen as a kinetic insurance policy of the land domain which ensures that even when the signature management fails and the invisible army is seen through, the soldier remains protected.

Conclusion

Re-engineering of the land power is not just about replacing the soldier with a robot but is about, in fact, an augmentation of the human with an invisible architecture of algorithms, decoys, and shields. The ground domain remains as a decisive anchor of the MDO framework, as it is the only domain where territory is truly held and sovereignty is physically manifested. By mastering AM and Multi Spectral Signature Management (M2S2), one can ensure that its land forces are no longer targets in a trench but are nodes in a network. The transition from the abyss of the ocean to the mud of the ground shows a consistent theme, i.e., the vertical is about the seamless flow of data and intent across every layer of the planet.

The battlefield vertical is a singular organism, and land power is the most adaptable limb. Securing this through cognitive and spectral mastery is the way ahead to ensure that the strategic high ground of space to come in subsequent chapters remains a useful tool rather than a distant, disconnected eye.

Declaration

I declare that this manuscript is being submitted exclusively to CENJOWS for publication consideration, is original, and has not been published or submitted elsewhere. I further certify that it contains no classified, restricted, or sensitive information and is based entirely on open-source material suitable for publication in the public domain.

ENDNOTES

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