

MILITARY USE OF EMS FOR INTEGRATED OPERATIONS

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...to understand, manage and control the electromagnetic environment is a vital role in warfare at all levels of intensity. The outcome of future operations will be decided by the protagonist who does this to decisive advantage.

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Abstract

Electromagnetic Spectrum is a critical enabler for operations across all physical domains and the information environment. A comprehensive understanding of the EMS and operations within it is critical to enhancing mission effectiveness and gaining and maintaining the desired degree of control within an integrated battlespace. The critical dependency on the EMS and the spectrum becoming more congested and contested has led to efforts at a more comprehensive exploitation of the EMS – integrated and effective across the full spectrum of operations, systems and domains. The modern ESM operations have evolved to include Electromagnetic spectrum management (ESM), Electronic Warfare (EW) and Signals Intelligence (SIGINT) as part of Information Operations and Communication networks. This would involve a comprehensive review

of the doctrine, organisation and force development and distribution and capability development in terms of technology, procedures and human resource.

Introduction

Technological development has been a key influencer in the evolution of warfare. This has been more evident in the last few decades, wherein an unprecedented rate of technological advancement has led to vast changes in the global security dynamics and the way military operations have been conducted. Electromagnetic Spectrum has been a critical component of military operations for more than a century. It gained prominence during the Bekaa Valley operations of 1982 as Electronic Warfare, whose success prompted a doctrinal shift worldwide in the use and denial of electromagnetic spectrum towards warfighting, to provide an advantage in the operational and tactical arena.

Advances in digital and networking technologies and their applications in the past couple of decades have led to an increasing dependence on the Electromagnetic spectrum (EMS). Also, easy proliferation of technology has led to threats becoming more diversified and unpredictable, resulting in varied types and levels of war the armed forces are expected to fight. As technological revolutions provide the capabilities for armed forces to undertake integrated operations, optimum utilisation of EMS has emerged as a critical capability for shaping the battlespace, enhancing awareness and undertaking sustainment operations, to achieve decisive results. A comprehensive understanding of the EMS and operations within it is critical to enhancing mission effectiveness and gaining and maintaining the desired degree of control within an integrated battlespace.

The EMS is a physical environment, which includes the full range of all possible frequencies of electromagnetic radiation. In the past, the use of the EMS as part of military operations has mainly been considered in a supporting role to achieve tactical outcomes and the focus has been on Electronic Warfare (EW) operations that aim at ensuring use

of the EMS for own forces, while denying the same to the adversary. However, the critical dependencies and the spectrum becoming more congested and contested has led to efforts at a more comprehensive exploitation of the EMS – integrated and effective across the full spectrum of operations, systems and domains. The US in its strategy document on Joint Electromagnetic Spectrum Operations of May 2020 has come up with a new concept called Electromagnetic Spectrum Operations (EMSO) that involves coordinated military actions executed to exploit, attack, protect, and manage the electromagnetic operational environment (EMOE) and resolve electromagnetic interference (EMI) in order to achieve the commander's objectives.² The UK has issued a Joint Doctrine Note (JDN) 1/18, in which it has also identified the convergence of Cyber and EMS Cyber and Electromagnetic Activities (CEMA).³ NATO has recently recognised Electromagnetic Environment (EME) as an “operational environment” and a part of the battlespace where friendly forces manoeuvre in time, location, and spectrum to create electromagnetic effects in support of the commander's objectives.⁴ Russia has displayed its prowess in controlling its EMS operations in Estonia, Georgia and Ukraine and more recently in Syria. China has identified the strategic importance and cross dependencies of electronic warfare, cyberspace operations and space and took a major institutional step in 2015 to create a Strategic Support Force, linking the three. It is investing in advanced EMS dependent military equipment and systems and in training specialist EM warriors and conducting EW operations as part of all its exercises and deployments.⁵

“Future conflicts will not be won simply by using the EM spectrum and cyberspace, they will be won within the EM spectrum and cyberspace. This will require changes to our operating concepts, military systems, and - most importantly - a new way of thinking in our Navy.”

Adm. Jonathan Greenert
former Chief of Naval Operations
US Navy

As technological advancements are enabling synergising of forces, all conventional conflicts of the future, especially among adversaries with near peer capabilities, are expected to involve integrated operations. These integrated battlefields are expected to be defined by high tempo of operations, conducted in compressed time frame, necessitating quick manoeuvre and precise application of concentrated firepower, supported by efficient logistics. Advantage would be gained through multi-domain command and control, a higher degree of situational awareness and exploitation of superior technology. This would require integration of 'processes' across all operational domains of land, air, maritime, cyberspace and aerospace, towards optimisation of effort and enhancing effectiveness.

All these would be enabled through optimum exploitation of EMS, which transcends all physical domains and the information environment, making it critical to integrated operations across the air, land, sea, space and cyberspace domains. Commanders are dependent on EMS for their Command and Control of the battlefield, intelligence gathering and dissemination, communications, manoeuvring and mobility, targeting (kinetic and non-kinetic), coordinated application of firepower, position, navigation and timing (PNT) requirements and combat sustainment operations. This recognized need for military forces' critical reliance on the EMS also creates vulnerabilities and opportunities for exploitation. Hence, the EMS has become a contested arena, where advances in influencing the EMS are regularly countered through measures aimed at denial, disruption and deception.

Efficient use of EMS in Integrated Operations would entail coordinated EMS operations across the whole spectrum of military operations, comprising all synchronized military actions to exploit, attack, protect, and manage the electromagnetic environment (EME) to achieve the commander's objectives.⁶ This aggregation would enable a unified approach to better identify, organize and disseminate concept of operations, user requirements, doctrines, resources, materiel and technologies, enabling Electromagnetic Spectrum Dominance in peace time, crisis and conflicts.⁷ Electromagnetic spectrum management

(ESM), Electronic Warfare (EW), Signals Intelligence (SIGINT) as part of Information Operations and Communication networks are the components of EMS operations. A commander of an integrated force would have to address all four during planning and conduct of operations to attain and maintain EMS superiority during all phases of integrated operations. The freedom of manoeuvre within the EMS that this would provide would be crucial to conduct of all other missions within the operational area.

Spectrum Management. While the EMS is inexhaustible, it is limited in capacity and extends beyond geographical boundaries. An exponential increase in use of Spectrum Dependent Systems (SDS) for security and in the civil and commercial domains is leading to the EMS becoming constrained, congested and contested and requiring coordination not only within the services, but with multiple civil agencies. The dynamic nature of new age equipment is adding to the complexity of EMS environment. Spectrum Management involves planning, coordinating and managing access to the EMS during all phases of military operations so that all equipment and systems can operate without causing or suffering unintentional harmful electromagnetic interference. Harmonising the spectrum usage would involve collation of data, identification of interferences, allocation and deconfliction of frequencies and provision of consistent spectrum interference resolution by trained specialist combatants. The commander would also have to promulgate operational, technical and procedural orders towards unhindered use of the EMS in consultation with these specialists.

Electronic Warfare. Electronic Warfare is conducted to attain the level of superiority required to enable effective friendly forces' use the Electromagnetic Environment, while simultaneously exploiting, preventing or reducing the adversary forces' usage of EMS. It will require centralised planning, fully integrated with other aspects of joint operations, and decentralised execution, to ensure unity of effort while maintaining tactical flexibility. The integrated EW plan of the commander would encompass all its sub-elements. While the peacetime operations would be oriented towards obtaining data and intelligence, as the conflict

escalates, the emphasis would shift to attacks against the enemy's use of EMS. Defensive action would be achieved through adaptable, agile and flexible systems and equipment, with an ability to change their operating modes and characteristics (power, frequency, waveform etc.). Offensive EW action would aim at disruption, deception, degradation, and/or destruction of adversary's EMS dependent systems and would include kinetic and non-kinetic means, including Directed Energy Weapons (DEW). Offensive EW capability provides a non-kinetic option to a commander to influence the battlefield, in addition to the kinetic ones. However, in a modern-day battlespace it would entail a highly dynamic process, requiring near real time domain awareness and the ability of the system to provide instant solutions.

SIGINT. EMS operations cannot be undertaken without developing adequate awareness of the EMS environment in relation to the geographical location and operating parameters of all emitters. This is achieved through sensing, assessing and monitoring to ensure positive identification and tracking of all the emitters and associated platforms and weapons in the area of responsibility. This has to be supplemented by inputs from diverse agencies, processed, catalogued and stored in comprehensive libraries and updated in as near real time as possible. Enabling visualisation of Electromagnetic Order of Battle (EOB) as a subset of the overall ORBAT onto the Common Operational Picture (COP) of the commander would enhance battlespace management, provide decision support and allow synchronisation of kinetic and non-kinetic attacks in support of the broad objectives.

Communications. Effectiveness of all battleplans would be dependent on having a reliable, secure and resilient C4ISR network dependent on wired and wireless media. An ever-increasing demand for intelligence data, in terms of high-resolution video and images, is placing extensive demands on the EMS.

Achieving proficiency in conduct of these operations would require a change of perspectives of commanders and combatants related to integrated operations and the decisive role of EMS. At the

strategic level, this should be followed by a comprehensive review of the doctrine, organisation and force development and distribution and capability development in terms of technology, procedures and human resource.

Doctrine

Most current doctrines treat electronic warfare as merely an operational support function and it finds limited mention in Joint and service specific doctrines. There is a need to highlight the criticality of assured access to frequencies and bands of operations for successful conduct of operations in all other domains. Consequently, the EM environment can be identified as a battlespace, where adversaries would carry out offensive action and manoeuvre to gain control, similar to the primary objectives of operations undertaken in other domains. This would ensure that EMS operations form a fundamental part of the commander's plans in an integrated battlespace. These aspects could be promulgated in a fundamental document on EMS that provides basic principles and guidance for planning, executing, and assessing electromagnetic spectrum operations in an integrated battlespace across the competition continuum.⁸ This in turn would act as a guiding document for coherent action towards relevant organisational changes, dedicated capability building and structured training, all as part of a roadmap with an implementable timebound plan.

Organisation

Based on the doctrinal review, organisational changes may be incorporated at all levels. A shift on emphasis from a services-oriented organisation to an integrated one would allow better engagement among all agencies, including government and non-governmental ones. It would reduce the bureaucratic layers and entities for managing, co-ordinating and developing systems connected with EMS, thereby promoting functional synergies. This would also help optimise the equipment, infrastructure, spectrum and manpower. A specialist directorate with adequate

empowerment and responsibilities would help address the strategic aspects of the EM environment and EMSO missions defined above. It would also draft the strategic and capability enhancement roadmap and ensure standardised EMS related training. At the operational level, the commander would be made responsible for command and control of EMS operations for which he/she would be required to issue EMSO guidance and instructions to achieve EMS superiority towards the overall objectives of integrated battle plans. Assistance for this would be provided by an EM specialist, akin to a component commander, who would also ensure synchronised employment of EMS based capability and more effective coordination of planning and execution. More specialist units need to be established and trained and these should be embedded at the operational and tactical levels for support as well as to undertake EW operations. Specialist officers at various levels would provide guidance for implementation of EW policies and instructions and supervise the conduct of all EMS operations within the AOR.

Capability Development

Capability development should aim at improving equipment and SDS' capability, augmenting spectrum availability and optimising spectrum usage. These efforts would once again gain through an institutionalised approach, especially for strategic and operational usage, as tactical systems cater to domain and service requirements. Efforts should however be made for service specific capabilities to reinforce and complement the integrated capability. Capability development should also aim for judicious use of budgetary allocations.

- There is a need to evolve to an agile, fully integrated EMS infrastructure with all domain capability. Integrated operations would require evolution and modifications of system architectures, both in hardware and software, to enable synergised EMS exploitation at strategic, operational and tactical level. However, initial action should be to build on interoperability of systems, while retaining flexibility to meet service-specific requirements.

- Integrated Operations would require development of a robust and secure integrated C4ISR architecture with sufficient bandwidth to handle data requirements. It should complement existing networks and allow for interfaces at strategic and operational levels.
- All future SDS should be designed to operate in dynamic, contested and congested EM environment. Endeavour should be made to upgrade existing systems so that they can be integrated into the advanced EM environment. Software defined equipment being developed should be modular, programmable, rapidly deployable and reconfigurable to suit mission requirements, while being efficient in its use of the spectrum. This would also address interoperability issues.
- The capability requirements should be defined in the integrated technology roadmap, to enable collaborative R&D efforts by government and non-government entities to provide indigenous solutions. A lot of EMS related innovation is taking place in the commercial domain, which should be studied for security related applications. Standards would have to be defined for all new equipment to enhance and sustain the interoperability between communication and information systems operated by various participants. Emerging and disruptive technologies and applications should be pursued for innovative approach. For example, Cognitive EW that involves use of advanced technologies like Artificial Intelligence (AI) and Machine Learning (ML) will make operations in the EM environment more potent and responsive.
- Traditional methods of EMS management and control are inadequate to address contemporary challenges of a complex and highly dynamic EM environment. It would require development and employment of advanced planning and management tools that in the hands of EMS specialists would allow commanders to better operate in the dense EM environment, deconflict and manage the very congested spectrum, enhance mission effectiveness, reduce planning cycles, coordinate effects and

collaborate with other mission command elements.⁹ The US in its push for a unified approach to joint spectrum operations is investing in development of a comprehensive Electromagnetic Battle Management system. Such a system would have training tools and real-time electromagnetic spectrum monitoring embedded into it.¹⁰

- Unmanned Systems are becoming ubiquitous in the modern battlefield. They have vulnerabilities in terms of their reliance on EMS that could be exploited. At the same time, they could be utilised effectively as EW platforms, standalone, in buddy modes or as part of expendable swarms.
- Technology absorption in the armed forces cannot be effective without an associated review of the related command and control concepts, doctrine, and tactics, techniques, and procedures (TTP).

Human Resource Development

Effective conduct of EMS operations needs educated combatants that understand not just the technical aspects, but also the operational concepts and inter-relationship with the other warfighting domains.¹¹ Officers should undergo structured training in EMS operations. Exercises conducted during relevant in-service courses should include C2 aspects of EMS in support of integrated operations.

It also requires skilled operational crew to manage the EMS efficiently and in a secure manner and optimally handle the equipment to manoeuvre within the EMS. A core team of specialists, including personnel from all three services, should be developed. They should be trained in core capabilities at tactical, operational and strategic levels at designated centres that should be established for the purpose. The training should reflect the most advanced level of adversaries' capabilities and should be in line with technological advances. Their roles in integrated operations have already been discussed above.

All other operating crew, besides training for skill development on

their respective systems, need to be made aware of the fundamentals and protocols of operating through the EMS. Training should emphasise on EMS operations and management in a congested and contested EM environment.

Exercises. All joint and integrated exercises should include all aspects of EMS operations within the plans so as to align the EMS aspects with the overall objectives. These exercises would be utilised to validate concepts, procedures and capabilities. All equipment, procedures, coordination and management of EMS should be tested as realistically as possible, to include operations in congested and degraded EM environment. Besides improving competencies and awareness of participating combatants, lessons learnt from these exercises should contribute to the development and evolution of doctrines, structures, procedures and capability.

EM Ranges provide an ability to test and evaluate equipment and concepts in a secure environment. More EM ranges that cater to integrated operations, rather than service specific ones, should be established with adequate infrastructure to cater to a more expansive EMS environment and missions. Synthetic EMS training systems or EM simulators have become an inescapable necessity to train combatants to operate in a complex EMS environment. These should be able to replicate realistic scenarios and provide software to simulate contingencies. Using EW Ranges and Simulators in concert would help enhance understanding of EMS among all combatants, reduce training periods for honing of skills of operators and more effectively prepare EMS specialists in complex EMS skills and new inductions.

Conclusion

Recent campaigns have highlighted the importance of EMS in conduct of operations at all levels of conflict, spanning all defined domains of military operations. Integrated operations are complex as they require amalgamation of diverse elements within the operational area towards common defined objectives. EMS is a crucial enabler of these

synchronisation and coordination actions and efforts have to be made for assured access to the desired spectrum through technological, policy and coordination initiatives. The increasing dependence of militaries on the EMS for information advantage, decision superiority and operational advantage also makes it a crucial vulnerability to be targeted by the adversary. The Armed Forces must prepare for defensive and offensive actions to ensure availability of maximum spectrum and EMS combat elements and the freedom of manoeuvre and action within the EMS. This would require a review of the doctrines and restructuring of the organisation to give more importance to this critical element of integration and integrated operations. Investments will have to be made on capability building for the armed forces as part of a national plan involving both government and private sector enterprises. Indigenisation is a must for financial and security reasons and would necessitate R&D in contemporary and emerging technologies and applications. Technological advancements notwithstanding, human resource will continue to be the defining factor in any military operation and the armed forces should work in a coordinated fashion to achieve proficiency and awareness in order to achieve dominance in EMS.

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