

Managing the Electromagnetic Battlespace

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"The next trade war will be on Spectrum and the next World War for Water"

Davinder Kumar 1995

The world is witnessing a revolution in military affairs (RMA) as a result of rapid technological progress. This has led to a paradigm shift in planning and conduct of military operations from legacy platform centric systems to network centric systems. This transformation at strategic level is critically dependent on assured availability, survivability and efficiency of communication-electronic information infrastructure. However, the entire gamut of communication-electronic equipment is affected by and affects the overall electromagnetic operational environment. These interactions in the electromagnetic domain lead to problems of electromagnetic interference and incompatibility.

As density of emitters and receivers was less, resolution of such problems was limited to management of the frequency spectrum, emission control, long term spectrum planning and electronic warfare measures. The problem, though serious, was not considered critical because of the nature of battle. However, the erstwhile battlefield has evolved into an intense, mobile, dynamic and dense battlespace. The allocation of the frequency bands for the Defence Forces is also shrinking as commercial demand for this critical natural resource increases. New technical management procedures are required to manage this situation.

Concept of Electromagnetic Battlespace

Electromagnetic waves, like all other waves are characterized by their frequency and intensity. The electromagnetic spectrum consists of electromagnetic waves of all possible frequencies. This spectrum extends from the very low frequency range used by submarines to millimetric waves used by advanced radars. In

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fact, it is practically defined till about 3000 GigaHertz. The United Nations (UN) defines the spectrum as a sovereign natural resource of any nation state. Electromagnetic waves interact with the physical environment and each other. These interactions have long been exploited by the Communicators community for planning radio communications. Affect of distance and time on electromagnetic waves has also been studied and researched by users and academia. These have been traditionally used to manage the spectrum.

The subset of the overall battlespace in which all electromagnetic systems operate is the electromagnetic Battlespace. It is interplay of three dimensions. These are :

- (a) The frequency spectrum or spectral dimension,
- (b) Geographic location or spatial dimension and
- (c) Real time or temporal dimension.

Characteristics of Electromagnetic Battlespace

This space is all pervasive and affects all communication-electronic equipment. It is not possible to model the entire spectrum technically using a single theoretical rule. It is silent, not directly perceivable by humans and hence very difficult to visualise. Thus, affect of mismanagement, though critical, is not obvious immediately. As emissions are scarce during peacetime, the effects of all emitters will only be felt during wartime, when there will be little time to correct the situation.

Electromagnetic propagation does not respect manmade boundaries. Consequently, the electromagnetic battlespace is shared by all agencies, present in the space. The enemy is also part of this battlespace and in future conflicts, operations for control of the electromagnetic battlespace are likely to be the rule rather than an exception.

Like real-estate, all parts of the spectrum do not have the same value. Legacy systems of the Army were based on bands of the Spectrum having best propagation characteristics. Thus, they were immune to adverse effects of minor antenna mismatch, short term fading etc. However, the civil sector has leveraged this information to force military systems out of these so-called "beach-

front property" bands. Due to rapid technological growth, the Spectrum has assumed greater commercial value than even before.

The electromagnetic spectrum can be easily polluted. Sources of pollution being natural noise, unintentional electromagnetic emissions from activities like heavy machinery, vehicles and intentional pollution in terms of jamming and electromagnetic pulse.

There is a limitation on range of equipment due to emitter power, path attenuation and receiver sensitivity. The propagation is also affected by terrain, atmospheric and solar conditions. Therefore, it is possible to judiciously re-use spectral resources with respect to geographic locations.

In today's dynamic battlefield conditions, there is an increased reliance on 'mobility'. This coupled with a high communication-electronic equipment density make the electromagnetic battlespace extremely dynamic. Thus, time is the third dimension of the electromagnetic battlespace. The electromagnetic spectrum is not depleted with time. However, in case it is not used at the present moment, the resource is lost forever. As equipment cost decreases and Spectrum cost increases, plans must be made to optimally utilise the entire available Spectrum at all times.

Like real estate, occupation of the spectrum is on a first come first serve basis. Due to commonality of the electromagnetic battlespace between opposing forces, the force which maximises usage of spectrum *ab-initio* and incorporates efficient protection mechanisms, will have an upper edge.

It is possible to share spectral resources in time. This is commonly called spectral scheduling.

As per some experts, the Gross Domestic Product (GDP) of a country is directly linked to the telephone density. The spectrum is critical not only for the Defence Forces, but also for overall national growth. Due to increased reliance and ubiquity of cellular communications, the spectral space is becoming increasingly crowded. As spectrum demand of civil industry increases, spectral needs of Defence Forces are likely to be sidelined in a market driven economy. Thus, as the spectral slice shrinks for Defence Forces, its management becomes critical.

DIFFICULTIES IN MANAGING THE ELECTROMAGNETIC BATTLESPACE

Lack of Management Models

Readymade models are not available for outright purchase or emulation. The processes take time to develop and mature. This needs national effort and top-down approach.

Non Tangible Nature

The electromagnetic battlespace is not tangible. Hence, its loss or mismanagement is not directly perceivable. This leads to mis-perception. In fact it is difficult to attribute failures to mismanagement till the time effective technical visualisation tools are in place.

Complex Technical Problem

Managing this space is not a trivial technical problem. Solutions are not readily available and most developed nations are vastly protective of their expertise in this area. Since most of the solutions are empirical in nature, direct application is not easy.

Real Time Solution

The management requires real time or near real time granularity. Thus use of automated systems is a necessity. The data to be processed is so large, that this application may have to be run on super computers for real time management.

National Effort

The electromagnetic battlespace cannot be managed in a piece meal manner. It is an all or none proposition. With plethora of agencies being part of the electromagnetic battlespace, coordination and commonality of approach between all constituents of the battlespace is necessary.

Requirement of Specialised Technical Tools

Specialised tools are required for efficient management of the electromagnetic battlespace. These include wideband monitoring receivers with direction finding capability and software for electromagnetic de-confliction. Comprehensive geo-spectral databases containing technical information about all emitters and

receivers in the battlespace and a responsive interference reporting mechanism are essential.

Enforcement Measures

Management of this technically challenging space requires enforcement of spectral discipline. This role can be played by the Joint Communication Electronic Staff under Headquarters Integrated Defence Staff. However, a new generation of techno savvy legal staff is needed for the purpose. The overall legal process needs to be dovetailed with the national legal setup and support the Defence Forces in arbitration of spectrum matters.

Procedural Measures

The procedural measures which accrue out of the legal framework can be divided into long and short term management processes. These are as follows:-

- (a) Long management measures include planning and electromagnetic compatibility (EMC) assurance process through equipment certification, testing of equipment for their electromagnetic characteristics and simulation of electromagnetic affect of projected equipment inductions on present battlespace components. Implicit in this process is the maintenance of a database of technical characteristics of the entire communication-electronic equipment inventory. Service Headquarters shall carry out long-term planning and forecast. They shall also be tasking the technical support facilities.
- (b) Short term management measures include software systems for automation of demand and assignment, creation and updation of geo-spectral databases and real time interference detection and resolution mechanism. Short term management shall be coordinated at the Command level by the Command Communications Electronics Coordination Committee (CCECC). Being geographically static, CCECC is visualised to be the overall assignment authority at theatre level.

Technical Support Measures

The technical support measures include infrastructure for development and maintenance of databases, support software,

equipment testing facilities, and monitoring networks. It also includes consultancy mechanisms to provide technical basis for framing of rules and regulations. The relevant organisations in the defence services will have to interface with national level facilities to achieve the required synergy.

Model Implementation

Being a Tri-Services model, this model is likely to take a long time to implement. Hence as an interim measure, the Army through the Corps of Signals, is modifying its existing resources. These include the following:-

- (a) Development of appropriate software to automate management functions. This software shall be based on a Geographical Information System (GIS) platform and help assignment authorities grant-interference free resource of user units.
- (b) Procure automated monitoring stations as means of interference resolution and aid enforcement.
- (c) Modify test procedures to capture equipment characteristics data for populating appropriate databases.
- (d) Carry out anticipatory training of selected Officers to act as electromagnetic battlespace managers.

Conclusion

Electromagnetic battlespace management is a rapidly advancing technical field. Due to the criticality of managing the Electromagnetic Battlespace and its ever-changing nature, it is pertinent that robust management processes are put in place. This shall ensure own dominance and control of the electromagnetic battlespace and thus go a long way in ensuring success in future military or economic conflicts.