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**CONSIDERATIONS ON SPECTRUM MANAGEMENT
IN MILITARY OPERATIONS**

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Abstract:

With the progress of technology encountered over the past decades, the importance of radio frequency spectrum has become more and more visible and recognized. Effective spectrum management in today's modern battlefield is an important prerequisite to allow commanders at each level to conduct their mission successfully. This includes availability of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) capabilities. Spectrum management is an all-embracing activity conducted by the military throughout the battlespace, at all levels of command. The process, which enables this activity, relies heavily on the exchange of information amongst the different levels of command and entities that use the spectrum, to include non-military users. Access to this information is essential to provide friendly forces with usable spectrum in a timely and reliable manner so that they can successfully accomplish their mission. This paper highlights few aspects concerning the management of the radio spectrum resource in military operations.

Radio Frequency Spectrum, Spectrum Resource, Spectrum Management, Combined Joint Task Force, Theatre Frequency Management Cell, Electromagnetic Battlespace, Host Nation

1. Introduction

The Italian inventor Marconi produced the very first wireless transmission in 1895, in an unutilized "clean" spectrum. Since that event, more than one hundred years ago, advances in technology have led to many discoveries and new use of the spectrum.

Today's modern life has become inconceivable without the increasingly number of systems and services that use radio waves¹ to convey information. Household appliances, private or commercial telecommunications, aeronautical and maritime communications, different sensors, meteorological or other types of radars, safety and security communications are just few of them. From remote controlled toys or common mobile phones, up to the most sophisticated military system, all these need access to the radio frequency spectrum to operate.

Rules for using the spectrum vary in parts of the globe and on a smaller scale, vary from nation to nation. The use of the spectrum can easily be described by saying there are frequency bands that are exclusively reserved for military use, some for civil use and many bands that are shared resources, so that to be used by both military and civil. This is just a simple description; things are getting more complicated when enter into details.

¹ The *radio waves* are electromagnetic waves of frequencies lower than 3000 GHz (gigahertz) which propagate in space without artificial guide.

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2. Radio Frequency Spectrum as a Resource

Radio frequency spectrum is a natural resource to be managed by all individual nations. What makes it “special” from other resources? There are both economic and technical considerations when speaking about the spectrum. Its particularities from the economic perspective make this resource a bit unusual due to the fact that spectrum is inexhaustible and not storable. Although is limited and the large range of entities that use it makes it becoming increasingly congested, the spectrum itself will never run out like oil or water, for instance. And it cannot be stored for later use. That gives it a real high value, from its availability and usefulness to the technological progress and society evolution that contributes to.

From the technical perspective, the radio frequency spectrum is just a portion of the entire electromagnetic spectrum that carries radio waves, besides other parts of it, such as the infrared radiation, ultraviolet light, X-rays, visible light, etc. The physical features of the spectrum impact on the range of applications that can be provided in relation with the specific frequency bands. The propagation characteristics of the radio waves are also a key element to be considered. For instance, signals on higher frequencies can transport a larger amount of information, but on shorter distances.

Reality has shown there are heavy interests throughout the spectrum by both military and civil sides. With the end of the Cold War and subsequent military reductions in most of the European countries, the civilian sector is putting more pressure to shift some of the military usage to commercial services, such as digital broadcasting and especially mobile telecommunications services, since spectrum is an important source of money. On the other hand, the military try to defend their interest in maintaining free access to their “traditional” radio frequency bands for operating the equipment and systems in use in order to accomplish the missions.

3. Spectrum Management and Its Role

Spectrum management is concerned with all aspects of the planning, coordination, and management of the use of radio frequency spectrum through operational, engineering, and administrative procedures. Its objective is to enable spectrum-dependent systems to operate in the intended environment without experiencing harmful interferences.

In military operations the main goal of spectrum management is to control the radio frequency spectrum so that it serves the needs of friendly forces while denying use to the enemy so that he is unable to command, control, or otherwise employ his forces effectively.

Activities start prior to deployment of forces, and depending on the phase of the operation, they range from identifying the spectrum requirements for the force, obtaining equipment parameters from coalition and other friendly forces, producing the spectrum strategy for the operation, or liaison with the host nation for the access to the radio frequency spectrum, up to providing coordinated frequency assignments and allotments to military users, and resolving interferences.

When deploying into theater of operations, forces need to know (at best in advance) on what frequencies can operate their equipment. These are normally authorized and assigned for a specific timeframe, location and unit, according to the type of equipment, its technical characteristics and the spectrum resources that are available.

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4. Responsibilities for Spectrum Management in Military Operations

The Combined Joint Task Force (CJTF) commander is responsible for authorizing and controlling the use of the spectrum resources within his AOR for the military forces under his command. It is his responsibility to establish the policy on how the spectrum is used in the AOR, obtain clearance/approval from the host nation for using the spectrum (usually based on agreements), and ensure that assigned military forces are authorized sufficient use of the spectrum to execute their designated missions.

The CJTF commander will establish a Theatre Frequency Management Cell (TFMC), typically under CJ6 (CIS) organization, to support joint planning, coordination, and control of assigned forces. This will be the single focal point concerning spectrum related issues for all applicable units that require and use frequencies in the AOR, although depending on the type of operation and command and control organization certain tasks may be delegated to lower levels of command (e.g. frequency managers at regional or component commands). It's the CJTF commander to retain the ultimate authority for resolving spectrum use conflicts in his area of responsibility.

The core responsibilities of any functional TFMC are listed below:

- Host Nation Coordination/Liaison
- Allot and Assign Frequencies
- Establish/Maintain Databases
- Develop/Distribute Spectrum Use Plans
- Develop Joint Restricted Frequency List
- Resolve Interference
- Provide Technical Support

Additional tasks and requirements will inevitably be dictated by mission specific requirements.

The basic function of any TFMC is the processing of frequency requests to include the key aspects of determining standard formats, handling and nominating procedures, methods of interference analysis, assignment, and database maintenance. On today's modern battlefield most of these functions are performed on automated systems; however it is important that the procedures be established early in advance, and adhered to, ensuring efficient and effective administration of the TFMC. Before these things can be done, some important questions must be answered:

- What is the overall mission?
- What are the geographical characteristics and boundaries?
- Which nations are involved?
- Are there non-NATO nations involved?
- Who are the host nation frequency authorities?
- What is the host nation's table of frequency allocation?

As in all other human endeavors, the success of a TFMC depends on the quality of the people who staff the cell. The staff of the TFMC must possess an adequate level of language proficiency to be able to communicate with all components of the CJTF and host nations' authorities. This includes a thorough understanding of national customs and norms. Without adequate language skills and cultural awareness, effective operations within the TFMC will be difficult to achieve. Likewise, host nation coordination may become impossible.

The nature of the mission dictates the exact skill requirements and technical knowledge for each CJTF mission:

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- Air Operations - Radar, TACAN, Airfields, Beacons
- Land Operations - Combat Net Radio (VHF FM), R/R
- Special Forces - Tactical Satellite, HF
- Naval Forces - a whole lot of everything

Experience from past of current real world operations has showed that finding personnel having all the required skills is usually not an easy task. Assembling a group of individuals who possess the right combination of skills is the key, instead of searching for a pool of experts who can do it all individually. Besides that, a nation who bid for a post has to ensure it can provide personnel not just for one tour of duty, but covering at least few rotations of personnel, so that avoiding gaps in filling the posts. Continuity in providing qualified personnel to fill the TFMC is “a must” at least from the permanent contacts and coordination that has to be conducted with the host nation authorities.

5. The Electromagnetic Battlespace

The electromagnetic battlespace (EMB) can be understood as the geographical area consisting of land, air, maritime and space in which a spectrum manager has to manage the spectrum resources to enable friendly forces operating their equipment in order to accomplish their mission.

The large number of emitters operating in a limited geographical area makes a very high risk of interference between the different users - e.g. military, governmental, non-governmental or civil radio systems operating within an Area of Responsibility (AOR). This can cause severe interruptions concerning communications, resulting in damage or loss of equipment or even human lives in the worst case.

Figure 1 shows a typical scenario in operations. The radio frequency spectrum unfortunately can't be seen although it is there for transporting information wirelessly.

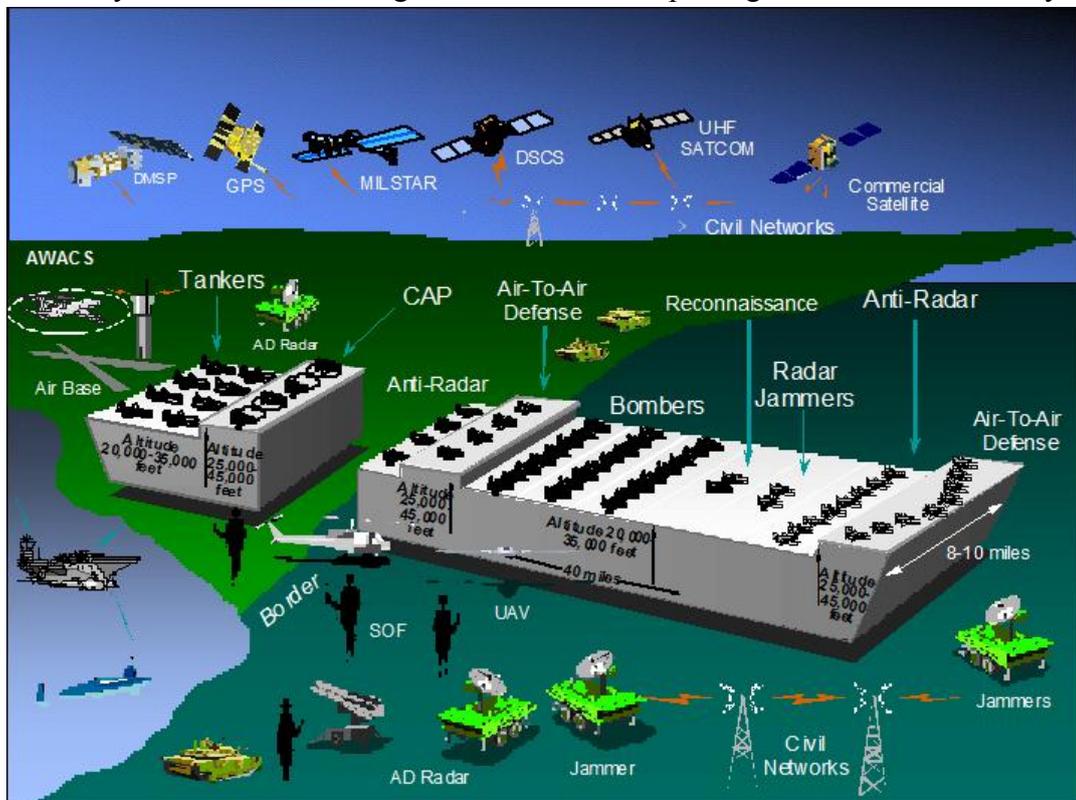


Fig.1 The Electromagnetic Battlespace

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While the CJTF commander needs to know the battlefield characteristics that affect operations, such as mountains, climate, civilian population centers, as well as friendly, hostile, and neutral troop formations, the TFMC/ CJTF spectrum manager needs to know the particular characteristics of the EMB.

Defining the EMB is beyond creating a database of frequency assignments. The EMB is defined by the environmental parameters (i.e. ground type, refractivity, humidity, man-made noise, etc.), terrain elevation, and spectrum-use information, to include all spectrum-dependent systems as shown in Figure 2.

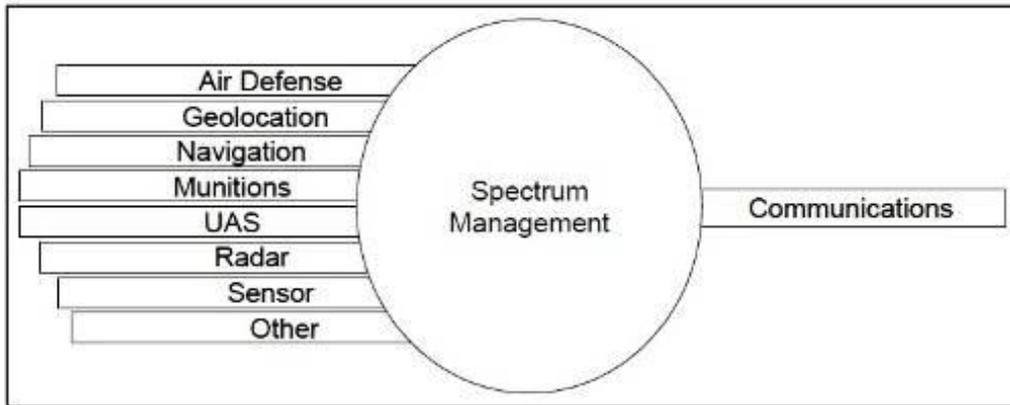


Fig.2 The Spectrum-Dependent Systems

Joint military operations require the most current, accurate, complete, and authoritative spectrum-use information available. If information on a spectrum-dependent system is not in the frequency assignment database, there is no way of ensuring it will not interfere with other systems or that its capabilities would not be degraded by other emitters.

From the spectrum management perspective, joint military operations require a common, single, authoritative source for spectrum-use information for all friendly, enemy (to the extent available), neutral, and civil spectrum-dependent systems to achieve and manage successfully the use of this important resource. At the level of theater of operations, it's the TFMC to built and manage efficiently this common source of spectrum-use information.

6. The Spectrum Management Requirements in Operations

The spectrum management requirements normally differ according to the type of operations that are conducted. For instance, in case of humanitarian relief operations, the military forces may be deployed to provide aid to the civil administration in a mix of civil and military disaster relief organizations (agencies). The civil administration (if one exists) should provide a spectrum management framework for the deployed military force. Where an administration does not exist, the responsibility will be taken by the lead military force/CJTF Commander, so that the TFMC will finally have to act as the controlling authority for all spectrum used by both the military and civil community until a legal national authority is established.

In case of peacekeeping or peace enforcement operations, deployment of forces will normally be unopposed, so that spectrum management process is the same as above. Where an administration does not exist at the beginning of the operation, then the

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restoration of the administration including a civil frequency management capability will be an aim of the operation.

The defense of the national territory would most likely be conducted within the context of an alliance, involving the mixed forces of several nations over a wide area. The achievement of information superiority is likely to be essential to the defense of national territory and military spectrum management would be conducted in conjunction with the host nation's civil and military authorities.

7. Conclusion

By their very nature joint operations are complex and difficult to manage from a spectrum perspective. The primary responsibility to conduct host nation coordination and negotiations with the civil spectrum management authorities will often be delegated to the CJ6 of the CJTF/Chief of the TFMC once basic guidelines for frequency coordination have been detailed in the SOFA, technical agreements, and/or results from other agreements or arrangements.

The nature of host nation support, which includes all civil and military assistance rendered by a nation to CJTF forces within its territory during peacetime, crisis, or war situations based upon mutual agreement, will be dictated by the mission. For instance, one would expect that a considerable amount of assistance would be provided for humanitarian relief operations, and absolutely none for an operation conducted under Article 5. Host nation relationships are extremely important, since the CJTF has no inherent authority to employ spectrum-dependent equipment in sovereign nations for Non-Article 5 operations without mutual agreement.

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