

**STRATEGY
RESEARCH
PROJECT**

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**CONTROL OF THE SPECTRUM VIA DOMINANT SPECTRUM
KNOWLEDGE ENABLES INFORMATION SUPERIORITY**

BY

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USAWC STRATEGY RESEARCH PROJECT

**Control of the Spectrum
Via
Dominant Spectrum Knowledge
Enables
Information Superiority**

by

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ABSTRACT

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Joint Vision 2010 relies on the principle of Information Superiority to enable its tenets of Dominant Maneuver, Precision Engagement, Focused Logistics and Full-Dimensional Protection and gain Full Spectrum Dominance. Information Superiority relies on the uninterrupted flow of information from source to destination, more often than not via the electromagnetic spectrum. The current spectrum strategy and the one currently in draft focus primarily on what Arthur F. Lykke, Jr. would describe as the means and the end, but neglecting the key component of the ways - those concepts which tie the means together, focusing them to accomplish the end. This paper proposes the two concepts of: 1) Dominant Spectrum Knowledge; to focus the automation efforts of the services and joint community, and 2) Spectrum Rules of Engagement; to focus the tactics, techniques and procedures of the services and joint community to control, as opposed to just manage, the spectrum battlespace.

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JOINT VISION 2010 AND SPECTRUM STRATEGY

Joint Vision 2010 (JV2010) is the armed forces' concept for the military as a smaller, more lethal fighting force, able to meet a myriad of demands placed upon it. The concept is appropriately based around solid men and women trained and motivated to provide selfless service to the nation. The mechanism by which they will fulfill the missions given to them is the equipment placed into their capable hands within the framework of doctrine, organizations and training. The key enabler of this "new military force," able to be successful across the full spectrum of conflict, is information superiority, which is defined as:

The capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same.¹

Information superiority relies on the uninterrupted flow of information from a source to a destination. This transfer must occur via means such as courier or some other medium such as the electromagnetic spectrum. The electromagnetic (EM) spectrum is defined as:

The entire range of wavelengths, extending from shortest to longest or vice versa, that can be generated physically. This range of electro-magnetic wavelengths extends almost from zero to infinity and includes the visible portion of the spectrum known as light.²

The complexity of the electromagnetic spectrum environment is nearly overwhelming and is increasing. Nearly every piece of equipment (commercial and military) used by the armed forces uses or is affected by the spectrum in some manner. Even systems that do not transmit or receive can be affected by electromagnetic interference (EMI) or Electromagnetic Environmental Effects (E3). Newer technologies are changing the ways that decision-makers desire the type, amount and methods of information presented to them. These changes are pushing innovative developments in technology to sense the battlespace and fuse source data between numerous sensors to get the information to the decision-maker. The EM spectrum available to transfer that data for the military is being reduced by spectrum auctions within CONUS and OCONUS and by greater restrictions on spectrum use by civil authorities, both here and abroad. It is crucial that for this information age we achieve superiority in controlling the EM spectrum lest we compromise our goal of information superiority. Achieving that superiority requires a sound vision and an executable strategy to achieve it.

HELP US BUILD A STRATEGY . . . PLEASE!³

Arthur F. Lykke, Jr. presents an approach to understanding how to frame executable strategies. His model is depicted as a three-legged stool, the legs of which are the military

objectives, the military concepts and the military resources.⁴ These are synonymously referred to as the ends, ways and means. Without a well-defined end state, or the means to achieve that end state, the strategy will fail. Concurrently, without a conceptual framework to determine which resources to obtain and how to use them to reach the overall goal, the strategy will also fail.⁵ In the formulation of the present draft spectrum strategy, the conceptual framework "leg" of the stool is too short and puts the overall goal of spectrum supremacy at risk.

The major finding of a recent (October 1998) Department of Defense Inspector General Audit Report was the alarming inability of the military to perform the function of spectrum management. The report stated that the ability of the military to support two major theaters of war in the spectrum management functions was "hampered" and "impaired."⁶ It is apparent from this report that given the increasing reliance on sophisticated technologies which rely on unrestricted access to the spectrum, the vision of JV2010 may never be realized unless the identified shortcomings are addressed now. Indeed, the current draft Joint Spectrum Vision 2010 acknowledges the severity of the problem. It states that " . . . current spectrum management practices, software, and procedures are not prepared to embrace and support the adaptive, agile, emerging systems without constraining their timely fielding and overall performance."⁷ The Department of

Defense (DOD) and Joint Chiefs of Staff are circulating drafts of a spectrum strategy and the aforementioned vision document for comment now (spring, 1999), in an attempt to resolve the issues.

Since limitations of spectrum in JV2010's future battlespace will negatively impact sophisticated systems, a concentration of effort should be focused on identifying where the limitations are and how to work around them. To effectively control the spectral battlespace in 2010, and present the warfighter a status of the capabilities of his warfighting systems given any particular scenario, his planners must know the spectrum battlespace, and be able to adapt operationally to that battlespace. To take full advantage of the knowledge of those limitations, they must be able to plan for and train to operations given the parameters of that spectral battlespace.

What follows is a conceptual approach to assist the Commander in Chief (CINC) or Joint Task Force (JTF) commander gain superiority of the electromagnetic spectrum. Dominant spectrum knowledge, as the capstone integrating mechanism for all the spectrum management database and application tools, will enable the commander to understand the limitations and capabilities of his weapon systems within the parameters of any given operational environment. With that knowledge, the commander may then exercise control over friendly use of the

spectral battlespace and minimize spectrum fratricide and interference through the use of spectrum rules of engagement throughout the range of conflict.

THE SPECTRUM ENVIRONMENT

Tactical decision-makers are demanding greater knowledge about the environment in order to make more precise and accurate decisions -- and they are demanding that knowledge faster.⁸ They are increasingly using visual media (video teleconferencing, imagery, etc.) to analyze information. The Army's Task Force XXI Advanced Warfighting Experiment (AWE) held at the National Training Center (NTC) focused an effort on providing situational awareness down to each platform level. By putting computer "applique'" in each vehicle and linking them via networks to the most up-to-date intelligence, each vehicle was able to "see" via their on-board monitors where they were, where their friends were, and where the enemies were. The Army's follow-on effort of the Division AWE, held at Fort Hood, Texas proved the value of video teleconferencing to the brigade and equivalent headquarters levels. These two initiatives have enormously increased the demands for bandwidth at the Army's primary warfighting level (42 percent increase over normal for the NTC rotation and only approved for that one time event).⁹

This demand for battlespace awareness is not limited to the Army. Each service desires that near-real-time situational awareness be distributed across the entire battlespace to enable a common operational picture, increasing an already high demand for communications bandwidth. More sophisticated sensors, platforms, and emergent technologies that increase our forces' capability to "see" the battlespace are generally only fully effective with much greater bandwidth usage.¹⁰ They are causing much more spectrum to be used to gather the requested data.

We use Host Nation Support agreements to gain use of spectrum. Obtaining frequency use is becoming increasingly difficult given the bandwidth requirements of our sophisticated systems. Early negotiations for spectrum use with host nations, allied nations, and cooperative nations are critical. The difficulty of obtaining frequency resources is exacerbated by short-notice contingency operations, which limits any time available to negotiate.¹¹ The supported CINC's spectrum manager must be able to solidify spectrum requirements from the forces prior to entering negotiations. These negotiations must be based on sound data, especially when operating in congested environments, in order to gain the highest effective use of whatever frequencies are made available.

Current means for a commander to manage spectrum use are limited to: 1) those procedures that outline which frequencies

to use (communications annexes to operations orders, signal operating instructions, etc.); 2) those documents mandating which frequencies not to use (restricted frequency lists), and; 3) some database and frequency management applications tailored for use by professional spectrum managers. These tools mix like oil and vinegar - intense effort is required to achieve only temporary satisfactory results. Additionally, minimal training on spectrum interference is available for other than spectrum managers.¹² Infantrymen, intelligence analysts, logisticians, and all others who operate those systems that emit electromagnetic energy do not appreciate the far-reaching effects of frequency propagation.

Frequency management is performed at all levels by assigned spectrum managers. Those individual operators, who will operate a system whether or not there is an authorized frequency, perform frequency control.¹³ There is no immediate impact to those operators who violate their assignments by "bootlegging" or "dialing a frequency." A mechanism for both training individuals other than professional spectrum managers, and enforcing frequency-use restrictions is necessary for effective control. It is recognized that although unimpeded access to the total spectrum cannot be achieved, "key portions must be commanded most of the time."¹⁴ Command implies knowledge, decision-making and control. The commander of 2010 needs to not

only just manage spectrum use, but also control it for true information superiority. Control requires a true fusion of tools and capabilities, not the effort-intensive, transitory capability of today.

PROBLEM 1 - LOTS OF DATA, LITTLE KNOWLEDGE

Know the enemy and know yourself; in a hundred battles you will never be in peril.

Sun Tzu¹⁵

The current draft spectrum strategy calls for the DOD to " . . . develop and maintain a comprehensive, integrated, coordinated, consistent, and up-to-date RF spectrum usage requirements database."¹⁶ The detailed explanation of the tasking focuses primarily on keeping a robust database on friendly emitters (military, non-military and host nation). This required database would improve support to operational planning, frequency allocations and assignments, interference resolution, impact assessments and policy formulation, and systems acquisition support. Included would be international regulations and host country information.¹⁷ However, to ensure the desired capabilities (esp. operational planning and impact assessment) are provided, precise information about adversary systems' use of the spectrum must also be fully incorporated into the database system. While this need for enemy information is recognized in joint publications¹⁸, and limited enemy data is

maintained in some classified systems, it has not been addressed in the DOD Spectrum Strategy document in any comprehensive fashion.

There are several sources available to formulate a picture of the spectrum environment. The International Telecommunications Union (ITU) maintains a database of internationally registered users of the spectrum (a very small percentage of users). Some information can be gathered from host nations via bilateral agreements. Yet, there are countries which are not sophisticated enough to have such centralized knowledge, as in the case of Saudi Arabia during Desert Shield/Storm.¹⁹ The Joint Spectrum Center (JSC), the DOD focal point for electromagnetic spectrum management matters also maintains a library of area and country studies focusing on the spectrum environment.²⁰ The services and CINCs also maintain data for their specific areas of interest. Unfortunately, not all of these databases are compatible, and none contain a complete picture of the spectrum battlespace. Most of the military databases are woefully out of date.²¹

Currently, it is the responsibility of the CINC or JTF spectrum manager for determining frequency requirements for any force structure and operational plan included in JOPES. Since there are no automated interfaces between the automated tools available to the spectrum manager and the JOPES, that

requirement determination is a manual process, which is virtually an impossible task. When initiating the spectrum planning for initial Army forces (ultimately, just over a division size element) to enter Bosnia for OPERATION PROVIDE PROMISE, the United States Army - Europe (USAREUR) frequency management office had no idea of the proposed force structure because it was in rapid transition. So the exasperated Army frequency manager forwarded the entire V Corps Central Region Signal Operating Instructions (SOI) to the CINC United States European Command (USEUCOM) frequency manager to coordinate with the United Nations and Croatian frequency authorities in Zagreb. Of course, this did not include any of the hundreds of emitters requiring frequencies other than the single channel radios.²² This situation may have been mitigated if the USAREUR and CINC frequency managers could pull force-planning data coupled with frequency requirements off some centralized automated system. The ability to fuse operational parameters within a complex spectrum environment, and be able to advise the JTF commander on courses of action in the electromagnetic battlespace of Joint Vision 2010, is a responsibility of the spectrum manager. Yet he does not have the ability to perform that essential task.

There are several automated tools and databases to assist in the management of frequencies, such as the Frequency Resources Record System (FRRS), the Joint Spectrum Management

System (JSMS), and the Revised Battlefield Communications-Electronics Operating Instruction (CEOI) System (RBECS), as well as numerous service specific tools. Yet, none encompass the entire spectrum, consider all of its different uses,²³ nor are compatible with each other.²⁴ Nor are they interoperable with operational databases and applications such as those included in the Joint Operational Planning and Execution System (JOPES).

RECOMMENDATION: DOMINANT SPECTRUM KNOWLEDGE

The above capabilities and those enhanced capabilities envisioned by the DOD strategy focus on acquiring the necessary data to make decisions. Yet dominance requires knowledge, not just data, which necessitates getting the fusion of the spectrum environment and the concept of operations together in a timely manner to affect decisions. That fusion must exist at the warfighter level. This fusion involves primarily a three step process: 1) Establish as a Priority Intelligence Requirement (PIR) knowledge of the electromagnetic battlespace, 2) Integrate spectrum requirements into JOPES automated systems, and 3) Advance the modeling and simulation capabilities to enable simulation of the spectrum environment through the course of an operational scenario.

Step 1: Implement Spectrum PIR

Understanding the electromagnetic battlespace (EMB) is crucial to the overall success of any spectrum management and control strategy. The EMB consists of not only the background noise, but also friendly, coalition, host nation and hostile force electronic order of battle (EOB).²⁵ While the JTF J-2 may be tasked to provide spectrum use information on the enemy, his priority of focus of collection assets is determined by the commander's PIR.

CINCs and JTF commanders should establish, as a priority intelligence requirement, information about other-than-friendly emitters and receivers, which will focus limited national and other intelligence assets to that end. Information about military systems of the US and those of coalition partners is normally readily available. (Albeit not in any single, centralized, integrated source - but the current draft strategy is addressing that deficiency). Some information can be made available on enemy systems, but only if the priority is high enough to capture limited time on limited collection assets, which is determined through the PIR.

Step 2: Integrate Spectrum Requirements in JOPES Databases

JOPES databases and feeder application systems need to be expanded to include spectrum bandwidth requirements in much the

same way logistics requirements are. Data on emitters and receivers across the battlespace is valuable only if correlated with operational plans. For example; the sequencing of units during a deployment leads to an increasing presence in an area of operations. This logically would increase bandwidth requirements. However, the increase is not necessarily directly proportional. Different weapons systems requirements for spectrum may allow for some frequency sharing or may mandate exclusive use. Additionally, those "extra" systems which aren't normally recognized as part of a force package in a deployment list (wireless LANs, hand-held radios, cell phones, RF tags, etc.) need to be supported. JOPES is the only mechanism to capture this as force structures are developed and operations are planned.

Step 3: Advance the Art of Modeling and Simulation

The ability to model the spectral battlespace and couple that with simulating operational scenarios needs to be a priority effort within DOD. The myriad databases identified for improvement in the DOD IG report, as well as the numerous application tools available don't go far enough to ensure dominant knowledge of the electromagnetic battlespace. The ability for a spectrum manager to answer the commander's questions can only be answered if the automation can support a

simulation. For example, "What is going to happen to our radios, sensors and weapons systems on our deep attack through this corridor? From a spectrum interference viewpoint, is there a better avenue of approach?" Current state-of-the-art systems are allowing pilots to fly their routes and deliver their ordnance in a virtual environment prior to actually performing the mission using data from satellite imagery and intelligence sources. The same capability must be developed to virtually rehearse the information battle in the electromagnetic environment.

This dominant spectrum knowledge could enable CINC staff spectrum managers to determine what the total bandwidth requirement for a course of action would be, and what limitations the electromagnetic environment would put on that requirement. With that knowledge, the commander could decide on possible renegotiations of host nation agreements, reassignment of operational frequencies, a reduction in capabilities of friendly systems, changing an operational concept or, if necessary, disregarding the restrictions and operating on prohibited frequencies. If the spectral awareness was complete, then the impact of each option could be weighed and a fully informed decision could be made.

**PROBLEM 2 - SIMPLE, SLOW, BLUNT CONTROLS IN A COMPLEX, RAPID
PRECISE WORLD**

To control many is the same as to control few. This is a matter of formations and signals.

Sun Tzu²⁶

The ultimate reason for any spectrum policies, plans, strategies or visions is to enable the warfighter to prosecute the mission successfully. This mission may be in a hostile or benign environment or in peacekeeping, humanitarian relief or conflict. Basically, in accordance with our National Security Strategy, military missions may be in one or more of the categories of Shape, Respond or Prepare.²⁷ Warfighters prepare for any and all missions by setting priorities, evaluating options, pursuing alternatives, establishing plans, and training their forces. Forces must be able to perform their assigned missions anywhere on the planet.

More and more, US forces will be operating as members of coalitions. More and more, forces are being asked to operate in relatively benign environments where the mission does not involve destruction of an enemy, but more of quelling a crisis, or relieving hardship by bringing order to societies wrought by disaster. As our technologically advanced forces are deployed around the world, using increasing amounts of spectrum, the likelihood is increasing that our systems will interfere with

(or suffer interference from) each other, with coalition, and with host nation systems. These spectrum conflicts can affect the operational capabilities of all three entities. The most damaging can be the host nation system because of the legal and political ramifications.²⁸

The electromagnetic spectrum is considered the sovereign property within the boundary of any country in which that spectrum is used. This has been recognized by the nearly two hundred signatory countries of the United Nations. Regulations propagated out of the International Telecommunications Union (ITU), the UN's specialized agency which handles spectrum regulation, hold the equivalent of treaty status within the United States.²⁹ The myriad bands of the electromagnetic spectrum are under the jurisdiction of the ITU for 1) international designation of uses and, 2) for resolving any cross-border interference disputes. Within individual nations, however, the spectrum is controlled by that nation itself.³⁰

With the emergence of the concept of information warfare comes the idea of information as a weapon. Therefore, discussion is warranted on the issue of whether electronic attack (non-physical or non-lethal) constitutes use of force, and thus is a hostile act under the provisions of the UN charter.³¹

The services and DOD have deployed numerous systems worldwide without obtaining host nation approval to operate those systems. As a result they " . . . {risk} damage to host-nation relations and degraded performance for U.S. or host-nation equipment."³² The systems include such critical weapons platforms as: the PATRIOT missile system, which can only be operated on a temporary basis in Korea; Navy shipboard SPS-40 and SPS-49 radar systems which cannot be operated within 50 miles of Bahrain; and in Europe, neither the PREDATOR Unmanned Aerial Vehicle nor the Joint Surveillance and Target Attack Radar System (JSTARS) have clearance to operate (with a one-time exception granted for the PREDATOR in Bosnia due to an agreement reached at the Dayton Accords). "At least eighty-nine telecommunications systems, including the spectrum dependent components of other major systems, have been deployed within the European, Pacific and Southwest Asian theaters without the proper frequency certification and host nation approval."³³ Each geographic CINC has been affected by illegal operations of spectrum dependent equipment within other nations.³⁴ The commanders are unable to use this equipment for training, exercises, or actual contingencies because of the risk of damaged relations or unacceptable frequency fratricide. Fully functional materiel, fielded without spectrum clearance, sits idle while its useful life expires.³⁵

There are several means available to control frequency use. There are *positive control measures*, those which indicate what frequencies to operate on, such as the Air Tasking Order (ATO), the Joint Communications Electronics Operating Instructions (JCEOI) - sometimes referred to as the Joint Signal Operating Instructions (JSOI), and the Communications Annex to CINC OPLANS. *Negative control measures*, the most common one being the Joint Restricted Frequency List (JRFL), are those which indicate those frequencies which are prohibited. These could be considered by some as adequate. However, those published documents generally apply only to communications emitters, not non-communications emitters such as radars or sensors, nor commercial-off-the-shelf (COTS) products such as pagers, cell phones and wireless local area networks (LANs).

A deficiency of these control measures is their rigidity and inability to adapt to real-time changes in the spectral battlespace, especially when both the positive and negative control measures are so complex and detailed. Col. Dickson, Vice Director of the Joint Electronic Warfare Center during OPERATION DESERT STORM, spoke of the inadequacy of the JRFL.

Because a good spectrum management system within the joint arena - as well as in the coalition warfare arena - is lacking, developing the list [the JRFL] is difficult . . . commanders basically do not have a good idea of who is operating on which frequency at a specific time. . . . the

joint restricted frequency list during the Gulf conflict got out of hand at times. . . leading to many cases of frequency fratricide. This lack of control over spectrum management remains a serious electronic warfare problem.³⁶

The JRFL is the only published document that specifically outlines those frequencies that are to be protected from jamming interference. Three categories of protection are utilized; TABOO, PROTECTED and GUARDED. TABOO is the most restrictive category and is reserved for the most urgent of command channels and safety uses. No one is allowed to communicate or jam on those frequencies without prior specific approval. PROTECTED frequencies are those critical friendly frequencies that are not to be jammed by electronic warfare (EW) assets. GUARDED frequencies are those enemy frequencies subject to exploitation that are not to be jammed. The JRFL thus is primarily a document that protects communicators and intelligence gatherers from electronic attack.³⁷ In the world of Joint Vision 2010, the possibility of electronic fratricide from entities other than jammers and to other than military targets is increasingly likely. This is especially true when including the proliferation of commercially based communications and sensor technologies being use by the military.³⁸

Additionally, the JRFL addresses only time and frequency - and not function nor geography. The function that may need

protection is the command nets of the unit, yet the command frequencies may change often or even be on a frequency-agile or spread spectrum system. Publication and dissemination of a JRFL to all concerned on a timely basis would be impossible in a case where the frequencies change often. For a geographic example, the unit may be out of range of a potential source of interference, in which case the frequency could effectively be wasted if on a blanket, area-wide JRFL. Another deficiency is that the document usually does not address non-military entities. Therefore a more powerful tool than the current JRFL is warranted; one which considers functions, geography, and all emitters and operators.

RECOMMENDATION: SPECTRUM ROE

The method by which any commander can effectively control forces is through training and enforcement. The spectrum can only be controlled through the discipline of the operators on the "trigger" - those personnel using the systems that radiate. This can be achieved through 1) Defining the spectrum as property and protecting it via ROE, 2) Training personnel on spectrum ROE, and 3) Expanding the JRFL to include all emitters (not just jammers) to give the operators a tool to implement the ROE.

Step 1: Define Spectrum as Property under ROE

Chairman of the Joint Chiefs of Staff Instruction 3121.01

Ch-1 (22 December 1994) "Standing Rules of Engagement for US Forces" states:

Participation in multinational operations may be complicated by varying national obligations derived from international agreements; i.e., other members in a coalition may not be signatories to treaties that bind the United States, or they may be bound by treaties to which the United States is not a party. *US forces still remain bound by US treaty obligations even if the other members in a coalition are not signatories to a treaty and need not adhere to its terms.*³⁹ (Emphasis added.)

Rules of Engagement are designed to prevent damage to non-belligerent entities and protect friendly forces. They outline in simplistic terms " . . . the means by which the NCA and operational commanders direct the use of armed force in the context of applicable political and military policy, and domestic and international law."⁴⁰ As our national strategy has forces engaged in many Operations Other Than War (OOTW) and that an emerging focus is on information operations, it will become more critical that the spectrum be considered a host nation resource not to be interfered with in accordance with international law. Indeed, all ROE will be more stringent, detailed and very sensitive to political concerns, more so than in actual warfare.⁴¹ The current commander of the Joint Spectrum

Center notes that sophisticated military systems may be more restricted during OOTW than in wartime as they must share the spectrum with non-military systems.

Spectrum access during operations other than war may be every bit as stressing to the systems as a major regional conflict. This is because civilian and commercial systems are normally fully functional during these operations, and compatible operation with these systems must be achieved.⁴²

The spectrum is being recognized as an economic resource to be protected, as it has increasing value.⁴³ Financial institutions and the banking industry would not be able to conduct transactions without the communications connectivity enabled by the spectrum. All space-based systems that are essential to worldwide commerce are absolutely reliant on unimpeded access to the spectrum. Emergency services, such as medical evacuation, fire fighting and other first responders depend on instantaneous communications as does aviation with approach radars and other avionics systems. All of these systems, as well as other civilian and commercial examples would be operational during OOTW. Interfering with these systems by encroaching on their spectrum use could be detrimental to those activities that they support.⁴⁴ If the definition of hostile act is expanded by the UN to include electronic attack, the possibility of inadvertent interference on some potentially belligerent nation's system by one of our non-EW assets could be

misinterpreted and cause severe political repercussions. Thus, the spectrum as property is a reality that should be acknowledged by warfighting commanders, and protected as required.

The definition of property under the provisions of the ROE should include host nation frequencies that are critical to the infrastructure of that country. Candidates for protection from electronic interference would be quite similar to functions, such as those listed above, that would be protected from kinetic attack.

The idea of protecting property is not unprecedented in recent conflicts. The ROE for DESERT SHIELD had as one of its rules: "You may not seize property of others to accomplish your mission in peacetime."⁴⁵ For the Somalia Relief Operation, one rule stated a similar restriction; "You may not seize the property of others to accomplish your mission."⁴⁶ For OPERATION URGENT FURY, the 1983 invasion of Grenada; "Minimize disruptive influence of military operations on the local economy commensurate with mission accomplishment."⁴⁷ These rules mandate that host nation property (in peacetime) was not to be seized or taken. For the Grenada conflict, the commander attempted to minimize impact on the indigenous population through the ROE. These rules focused on the owners of the property not being denied its use. Within the context of the ITU regulations and

the treaty status of those regulations, US forces interfering with local users of the spectrum without host nation approval are thus denying the citizen or business use of their spectrum "property." They would be violating the ROE for those engagements.

Step 2: Train Personnel on Spectrum ROE

A key aspect of the success of any operation is the discipline of the force. This discipline comes in large part from the knowledge gained through training. A major part of the preparation for any operation, especially operations other than war is training the Rules of Engagement. Military personnel can generally understand kinetic weapon effects because they can be seen. It is much more difficult with electromagnetic energy. Electromagnetic effects training within a scenario can be the most realistic training to test both the ROE and the personnel who implement them.⁴⁸

Incorporating spectrum ROE into the Joint Warfighting Center's catalog of items for senior joint warfighters to be trained on is essential. Senior leaders must know of any political or social impact of electromagnetic encroachment upon civil and commercial systems with regards to possible legal and/or economic ramifications. Indeed, with the possibility of information as a weapon, then the possibility of frequency

interference being viewed as a military attack needs to be considered by the commander as well.

Step 3: Expand the Role and Scope of the JRFL

To properly implement spectrum ROE requires proper tactics, techniques and procedures. The role and scope of the JRFL must be expanded to include all emitters (civil, military and all others), geographic area of operations, priority of functions, and all operators (not just electronic attack assets). The current definitions of the protective categories of the JRFL do not allow for civil or commercial entities to be protected from interference. The protection would only be from deliberate electronic attack. With the proliferation of high bandwidth systems in the JV 2010 battlespace, host nation systems would need to be protected from other than EW assets as well. The JRFL is only designed for operators of electronic attack assets to refer in order to avoid spectrum fratricide. There is no other negative control measure for operators of other emitters to refer for them to avoid spectrum fratricide. Remembering the absolute probability of spectrum interference within the complex environment of Joint Vision 2010, the emphasis must be that the operators of all emitters know the authoritative bounds of their operations. They have their "fingers on the trigger."

ROE is not to be a substitute for tactics, techniques or procedures (TTP), doctrine or restating the law of war, but is to govern the proper use of force.⁴⁹ Alone, however, the concept of spectrum ROE cannot be implemented without the supporting means of the above TTP. The Joint Restricted Frequency List as amended, together with the current positive control measures, would suffice as the means to provide that operational guidance to the force.

SUMMARY

The idea of spectrum supremacy is not new, at least within the Army. Several published documents have advanced the idea and the necessity, yet the difficulty has been in translating it into an executable strategy. TRADOC, in its Force XXI Operations concept, speaks of spectrum supremacy as the key element of information operations.⁵⁰ Army Field Manual 100-6, Information Operations mentions it as the lynchpin for information dominance.⁵¹ The Army Enterprise Strategy has Maintaining Spectrum Supremacy as one of the ten principles of assuring information superiority for the warfighter.⁵² This document has attempted to show that achieving spectrum supremacy (ends) requires advanced knowledge of the electromagnetic environment, and control of that environment as the concepts

(ways) that leverage the tools (means) that are present (JRFL, SOI, etc.) and those being considered (robust databases, etc.).

Amassing large quantities of data in interoperable databases cannot attain Dominant Spectrum Knowledge. That data is absolutely essential, but is only the means to the end. The spectrum data must be coupled with the operational forces' data, and manipulated in a virtual environment to proactively set the stage for military operations. The aggressive data collection envisioned in the DOD draft spectrum strategy, fed into JOPES and coupled with an advanced modeling and simulation capability for the warfighting spectrum manager will fulfill the concept (the ways) of Dominant Spectrum Knowledge.

In a complex operational environment, the ability to simplify tasks will be valued. Using spectrum ROE in conjunction with the JRFL and publishing positive control measures based on dominant spectrum knowledge will severely reduce the current workload of spectrum managers and greatly enhance the protection of spectrum users. Control of the electromagnetic spectrum is an essential component to information superiority.

Now we know that we must consider the spectrum as the property of individual nations, and may add spectrum limitations to the rule of engagement as a control measure. We also know that a key to spectrum dominance is the ability to know the spectral battlespace and be able to predict it and use it to our

best advantage. Now what is needed is warfighter internalization of those concepts. The best method for that is sophisticated training at the strategic/ operational level of warfare - the CINC/JTF command level.

With Dominant Spectrum Knowledge and its inherent advanced simulation capability, we will be able to train commanders on the spectrum aspects of Information Operations similar to the way we can now train on logistics. With that ability to predict the outcome of courses of action, the commander can more effectively control frequency use through the discipline and training inherent in Spectrum Rules of Engagement training and implementation. These two concepts are the ways that allow the means envisioned in the spectrum strategy to fulfill the goal of that strategy, dominance of the electromagnetic spectrum. By accomplishing this, we are that much closer to achieving Information Superiority for 2010.

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ENDNOTES

¹ Joint Chiefs of Staff, "Joint Vision 2010," in U.S. Army War College, Selected Readings, Academic Year 1999, Course 1, "Strategic Leadership, Volume II", (Carlisle, PA: U.S. Army War College, 1998), 340.

² Martin H. Weik, Communications Standard Dictionary, (New York: Van Nostrand Reinhold Company, Inc., 1983), 298.

³ Jack Woodward, LtGen, USAF, J6 of the Joint Staff in a speech to a group of joint spectrum managers, December 1998.

⁴ Arthur F. Lykke, Jr. "Toward An Understanding of Military Strategy," in U.S. Army War College Selected Readings, Academic Year 1999, Course 2 "War, National Policy & Strategy Volume I" (Carlisle, PA: U.S. Army War College, 1998), 179.

⁵ Ibid., 176-177.

⁶ Inspector General, Department of Defense, Audit Report: Coordination of Electronic Frequency Spectrum and International Telecommunications Agreements (Arlington, VA: Department of Defense, 9 October 1998), i.

⁷ Department of Defense, "Joint Spectrum Vision 2010," (undated draft), 5.

⁸ Ibid.

⁹ General Accounting Office, DEFENSE COMMUNICATIONS Federal Frequency Spectrum Sale Could Impair Military Operations, Report to Congressional Committees (Washington, D.C.: U.S. Government Accounting Office, 17 June 1997), 10.

¹⁰ Department of Defense, "Spectrum Strategy," (Washington, D.C.: Department of Defense, 22 December 1998, draft), 10. While it is true that increased ability to detect higher levels of detail requires much greater bandwidth (different frequency bands yield different detection capabilities), technology also holds the promise of increasing spectrum efficiency. So, not only is technology the cause, but is also a solution to spectrum congestion. But in the years to 2010, the efficiencies will not have caught up to the demand for detail.

¹¹ John J. Hamre, Information Systems: Y2K & Frequency Spectrum Reallocation, Statement before Senate Armed Services Committee, 4 June 98: Available from <http://www.defenselink.mil/news/Jun1998/to6051998_t604sasc.html>; Internet; accessed 24 Sept 1998.

¹² Current frequency management training is only available at the Interservice Radio Frequency Management School (IRFMS) at Keesler Air Force Base, MS, and the Battlefield Spectrum Management Course at Fort Gordon, GA. The high level of mathematics competence to understand propagation limits the classes to professional spectrum managers. Awareness training is being planned for and designed as a result of the DOD IG report and is included in the draft spectrum strategy document.

¹³ Earl S. Takeguchi and William J. Wooley, "Spectrum Management," in The First Information War, ed. Alan D. Campbell (Fairfax, VA: AFCEA International Press, October 1992), 159.

¹⁴ Training and Doctrine Command, Force XXI Operations, TRADOC Pamphlet 525-5 (Ft. Monroe, VA; U.S. Army Training and Doctrine Command; 1 August 1994), 3-6.

¹⁵ Samuel B. Griffith, Sun Tzu: The Art of War (New York; Oxford University Press, 1963), 84.

¹⁶ Department of Defense, "Spectrum Strategy," (22 December 1998, draft), 12.

¹⁷ Ibid., 13.

¹⁸ Joint Staff, Joint Operations in the Electromagnetic Battlespace, Chairman of the Joint Chiefs of Staff Manual 3220.01 (Washington, D.C.: Joint Staff, 10 October 1997), 2-2.

¹⁹ Department of Defense, Conduct of the Persian Gulf War: Final Report to Congress (Washington, D.C.: U.S. Department of Defense, April 1992), 571.

²⁰ Director for Command, Control, Communications and Computer Systems, Joint C4 Systems Descriptions, J-6 Guide 6111.01 (Washington, D.C.: Joint Staff, December 1997), 347.

²¹ Department of Defense, IG Report, 19-21.

²² This observation is based on the author's personal experience as USEUCOM frequency manager and primary frequency planner and coordinator for the Bosnia operation from 1992-1993. The Signal Operating Instructions (SOI), or as sometimes referred to as the Communications-Electronics Operating Instructions (CEOI), are those positive control measures which dictate what frequency or hopset to use during what particular time period for individual radio nets. Also included may be call signs, visual signals such as colored smoke, flares or panels, and challenge and password. Not included are the thousands of other electromagnetic frequency users which the spectrum manager must worry about such as radars, sensors, multi-channel line-of-sight systems, multi-channel satellite systems, hand-held radios, wireless LANs, etc.

²³ Different uses of the spectrum allow for different management techniques. Propagation techniques also may allow for differences. For example, an FAA radar beacon requires frequency protection for safety of navigation, whereas a frequency hopping radio being used for training may allow for sharing of individual frequencies in its hopset.

²⁴ Howard Pace, Jr. and Phillip E. Pace, "Frequency Management for the 21st Century," Journal of Electronic Defense, January 1998, 47.

²⁵ Joint Staff, CJCSM 3220.01, 3-4.

²⁶ Griffith, 90.

²⁷ President, A National Security Strategy for a New Century (Washington, D.C.: Office of the President of the United States, October 1998), 8-35.

²⁸ Inspector General, 5.

²⁹ Department of Defense, Spectrum Requirements: Report to Congress (Information pamphlet, n.p., n.d.), 17.

³⁰ Inspector General, 3.

³¹ Glenn Bowens, "Legal Issues in Peace Operations," Parameters (Winter 1998-99): 62.

³² Inspector General, 5.

³³ Ibid.

³⁴ Ibid., 6-7.

³⁵ Ibid., 11.

³⁶ Takeguchi, 159.

³⁷ Joint Staff, CJCSM 3220.01, E-1.

³⁸ Charles J. Dunlap, Jr, Technology and the 21st Century: Recomplicating Moral Life For the Statesman and Soldier (Carlisle, PA: Strategic Studies Institute, U.S. Army War College, January 15, 1999), 10.

³⁹ Chairman of the Joint Chiefs of Staff, "Standing Rules of Engagement for US Forces," CJCSI 3121.01, 1 October 1994, in U.S. Army War College Selected Readings, Academic Year 1999, Course 4 "Implementing National Military Strategy Volume III", (Carlisle, PA: U.S. Army War College, 1998), 20-70.

⁴⁰ "Rules of Engagement," Joint Task Force Commander's Handbook for Peace Operations, in U.S. Army War College Selected Readings, Academic Year 1999, Course 4 "Implementing National Military Strategy Volume III" (Carlisle, PA: U.S. Army War College, 1998), 20-1.

⁴¹ Operational Law Handbook, JA 422, 1995, "Rules of Engagement," in U.S. Army War College Selected Readings, Academic Year 1999, Course 4 "Implementing National Military Strategy Volume III" (Carlisle, PA: U.S. Army War College, 1998), 20-36.

⁴² Rusty Yeiser; quoted in Clarence A. Robinson, Jr., "Computing Advances Spark Spectrum Management Tools," Signal, February 1997, 58.

⁴³ Department of Defense, Joint Spectrum Vision 2010, 7.

⁴⁴ Inspector General, 11.

⁴⁵ Ibid., 20-39.

⁴⁶ Ibid., 20-5.

⁴⁷ Brad C. Hayes, A Rand Note N-2963-CC, "Naval Rules of Engagement: Management Tools for Crisis," in U.S. Army War College Selected Readings, Academic Year 1999, Course 4 "Implementing National Military Strategy Volume III" (Carlisle, PA: U.S. Army War College, 1998), 20-80.

⁴⁸ Hayes, 20-106.

⁴⁹ Operational Law Handbook, 20-37.

⁵⁰ TRADOC, 3-6.

⁵¹ Department of the Army, Information Operations, Army Field Manual 100-6 (Washington, D.C.: U.S. Department of the Army, August 1996), 2-8 and 5-12.

⁵² Director of Information Systems for Command, Control, Communications, and Computers (C4), The Army Enterprise Strategy, The Vision (Washington, D.C.: Office of the Secretary of the Army, 20 July 1993), 26-27.

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