NAVAL SPECTRUM USE MANAGEMENT AUTOMATION

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ABSTRACT

The U.S. Navy makes heavy usage of all segments of the electromagnetic spectrum for such diverse applications as communications, control (positioning) of ships and aircraft, target identification, and passive and active electronic warfare. The density of emitters results in a severe electromagnetic interference (EMI) environment in even a moderate size Battle Force. This environment can preclude usage of spectrum resources unless sophisticated spectrum engineering is performed to alleviate the EMI problems and assure system performance. The Navy's ability to perform this engineering function in the planning stage of a deployment is historically limited by a lack of data, engineering tools, procedures, and trained personnel with sufficient insight into the problem to perform the needed analyses. Similarly, the ability of the afloat spectrum user to re-engineer the spectrum allocation in the face of changing requirements cannot be accomplished during the operational phase of the mission because of the lack of time, experience, and engineering tools.

Recent advances in the development of automated spectrum management tools, methodology, and data management have resulted in the fielding of several automated systems which solve parts of the overall spectrum management problem. The lessons learned from these fielded models, in turn, have led to the development of a set of validated operational requirements and architectures and a subsequent system design for an overall Navy spectrum management system. The architecture is based upon a division of functional responsibilities between ashore support activities performing area-wide management (ashore and afloat), and afloat users managing the actual assigned spectrum with a Battle Group. The SUMS system will have the ability to optimally and efficiently solve large sets of EMI, system performance, and spectrum use engineering problems. The prototype of the system will be fielded during 1982-83 for both ashore area-wide and afloat elements.

1.0 BACKGROUND

The U.S. Navy makes heavy usage of all segments of the electromagnetic spectrum for a variety of communications, telemetry, and sensing purposes. The overall spectrum user community within the Navy is finding increased difficulty in getting spectral allocations for new uses because of pressures (such as Worldwide Administrative Radio Conference (WARC)), and crowding of more and more emitters into a limited resource. Therefore, optimum spectrum usage is becoming mandatory, demanding sophisticated spectrum engineering techniques. This development, in turn, requires an extremely large amount of information on equipment-related electromagnetic compatibility (EMC) characteristics, propagation factors, spectrum asset status, and spectral occupancy.

As with other members of the spectrum user community, the U.S. Navy, in order to achieve the goals of its varied missions, must use more efficiently the available electromagnetic spectrum to support increasing requirements in the areas of radar, navigation aids, communications, and electronic warfare (EW) systems.

Historically, electromagnetic spectrum use has evolved from crude communications capabilities to sophisticated systems. For instance, radar is used to sense the presence or absence of moving objects. More sophisticated navigation systems are evolving to present precise positional information for a variety of users. Usages for communications are becoming more demanding and complicated. As this trend continues, the number of individual emitters increases also, further raising demand for electromagnetic spectrum. With this increase, a concurrent increase in the amount of electromagnetic interference (EMI) is unavoidable. To minimize an increase in interference, improved spectrum management using more sophisticated analysis techniques is needed.

Unlike terrestrial systems, however, the management problem associated with Navy platforms is compounded by the close proximity of other platforms and their emitters, and the physical limitations in spatial segregation for a given interfering systems pair. The situation is further aggravated by the fact that, unlike terrestrial emitters, the emitters aboard Naval platforms move great distances and travel into many differing electromagnetic environments. Spurious emissions caused by signals re-radiating from the metallic body of the platform add to the problem.

Several recent developments in spectrum management automation particularly tailored to the needs of restricted segments of the Navy spectrum user community have evolved. From these, the Navy has learned both the positive and negative impacts of automation on the management of the spectrum. With these preliminary findings, the Navy has embarked upon the development of an overall Spectrum Use Management System (SUMS). The evolution which led to the design of SUMS and the approach being taken in its development are described in this paper.

2.0 NAVAL USAGE OF THE SPECTRUM

Like their counterparts in the civilian community, the Navy relies heavily on the electromagnetic spectrum in fulfilling its designated missions. Communications between ships in a Battle Group and from ships to the ashore support community are vital to command and control of afloat forces. Radar and other sensing devices are used not only to control the movements of our own aircraft and ships but also to detect the presence of possible hostile platforms. Navigation systems are used to determine with ever increasing accuracy the positions of units controlled. Fire control systems are used to control guns and missiles. All these resources are vital to the deployment of a modern Battle Group.

The exact deployment of these capabilities, however, depends upon a variety of factors. The composition of the Battle Group first determines the population of emitters which will be present. The objective or mission of each element of the Battle Group will then determine the nature of use of each emitter as well as the relative locations of the ships deployed. The particular threat situation, in terms of hostile platforms, determines the minute-by-minute specific mission of each emitter. Each of these factors should be encompassed in the optimal overall development of emission contingency plans and decisions within the Fleet.

Due to the scale of the planning and decision making processes necessary to support a modern Battle Group, however, a division of responsibilities has evolved in both the planning and operational decision making methodologies currently employed by the Fleet. This methodology normally charges the staff element responsible for the specific usage of a given equipment with the responsibility for planning its use and for making the operational decisions on how specifically to use it in any given situation. The weakness in this management scheme is that without lengthy and detailed coordination between the staff elements, plans for each emission set are developed separately. The result precludes accounting for mutual interference between sets of emissions.

In some cases, the frequency set available for application to a given emission set is restricted either by equipment design or by the set of authorized frequencies available for the particular application. Other emission sets, however, are highly flexible, both in tuning range and in the set of authorized frequencies. Normally, the latter groups of frequencies are controlled by higher authority than the Battle Group and must first be scheduled for usage with the higher authority. This coordination is usually fraught with problems, mainly stemming from the inability of the requiring Battle Group to supply information in the requisite detail on the nature of the mission to the higher authority. Decisions are consequently made in light of these deficiencies which do not optimally meet the specific needs of the Fleet. Further, in making the decisions, the planner does not have the engineering tools with respect to EMI and propagation analysis necessary to optimize the frequency schedule to be employed. He also, in most cases, does not have a clear picture of the external electromagnetic environment into which the Battle Group will be deploying.

3.0 RECENT DEVELOPMENTS IN SPECTRUM MANAGEMENT AUTOMATION

Recently, advances in both the capacity for analyzing EMI and propagation effects and supportive automated data processing have allowed development of tools for real time spectrum management. Computer capabilities accounting for the effects of adjacent channel separation, harmonic and intermodulation interference, and propagation throughout the spectrum have evolved. Using real environmental characteristics, these capabilities allow the user to analyze a variety of emission environmental problems rapidly and as a consequence to make rapid decisions as to corrective actions required when interference is encountered or when signal propagation cannot be achieved over the required path. These capabilities have been applied in limited capabilities to analyze the problems inherent in shipboard interference among communications emitters, shipboard interference of fire control emitters, and high frequency radio transmission propagation.

In parallel with these advances, man/machine compatible support computer codes tailored to the use of the spectrum manager have evolved. With the overall advances occurring in data base management capabilities, this has allowed the development of simple but effective automated data processing tools which utilize the EMI and propagation analysis capabilities in support of operational needs. This technology has enabled the fielding of relatively sophisticated tools into the fleet with a minimum of training and maintenance impacts.

Both these areas are continuing to evolve. Research into the basic physical description of other interference and propagation anomalies is continuing. Development of integrated capabilities encompassing more and more of the overall analysis requirement, in terms of both algorithms employed and strategy of employment, is being pursued at a variety of levels. In parallel, the development of artificial intelligence methods and more sophisticated data storage and retrieval processes is making possible the compilation and management of a data base which historically could not have been managed.

The result of this trend is a new generation of tools which will allow the Navy to better pursue the basic goal. With these tools, properly engineered plans can be developed which will insure the deployment of an emission set which will have minimum interference while meeting signal coverage and propagation requirements. These will be implemented in a manner suited to human beings not sophisticated in the usage of data processing equipment. The potential of inadvertent entry of erroneous information will be minimized.

4.0 THE POTENTIAL FOR AN OVERALL NAVY SOLUTION

With its complex usage of the spectrum, the resultant management problem in the Navy becomes likewise complex. With the technology described in the last section, segments of the overall management problem have been solved and preliminary tools developed to implement the solutions. The Navy is now embarked on integrating these capabilities into an overall spectrum management capability which will solve the next level of management problem. The Spectrum Use Management System (SUMS) is attempting to integrate the state-of-the-art in interference and propagation analysis capabilities and methodologies into the required composite ship and shore based system. The envisioned capability will manage all levels of user hierarchy, from the individual unit, to complex Battle Groups, to extensive regional management. This will be done by deployment of two subsystems: the Tactical SUMS, which will be fielded aboard afloat combatants and will manage the spectrum within a restricted area of responsibility; and a Fleet SUMS, which will be fielded regionally to manage all the Naval emitters in a given area.

The system will integrate the technologies described to include a complete and adequate mathematical description of all characteristics of all emitters in the Naval inventory, the ability to describe in a timely fashion the requirements for use of these as a function of operational situation, the ability to achieve an optimal frequency assignment for all deployed emitters given the constraints of the environment in which they are deployed, and the ability to rapidly and accurately modify these emitters as required to meet changes in environment or situation. Using electronic data transfer techniques, this will be accomplished in such a way as to allow all required echelons of spectrum user to achieve the required knowledge to make optimal spectrum decisions at their respective levels in a timely manner consistent with the most current available information. The prototype will be fielded in 1982-83.

5.0 SUMMARY

The Navy has historically used the spectrum for a variety of missions. In recent years, both the density of spectrum use and the sophistication of the equipments using the spectrum have increased. Similarly, the competition for usage of the spectrum by non-Navy users has increased. These, among other factors, have made management of the limited resource complex but vital to the effective accomplishment of the Navy’s mission.

Recent advances in analysis tools in such problems as EMI and propagation analysis have allowed development of a set of automated data processing tools to alleviate segments of the overall management problem. In parallel with these, data processing and data management techniques have allowed the growth of management capabilities which in turn allow the data bases and man/machine interfaces necessary to make a comprehensive system deployable for Fleet use to be developed. Using these as the technological basis, the Navy is embarked on development of a comprehensive Spectrum Use Management System (SUMS) which will satisfy the requirements of all classes of emission and all levels of command. Using the technology, this system will steamline the Navy's management of the spectrum while insuring optimal use of the limited spectrum resource.