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VALIDATION OF ARMY SPECTRUM ALLOCATION AND ANALYSIS PROCEDURES.--ETC(U)  
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ARMY CONTRACT/ DAAK21-79-C-0011  
VALIDATION OF ARMY  
SPECTRUM ALLOCATION AND ANALYSIS  
PROCEDURES. VOLUME I.

9 FINAL REPORT.  
VOLUME I

Prepared for:  
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FOREWARD

This two-volume report by Hydrotronics, Inc. presents the results of a study conducted for the Army Spectrum Manager, Office of the Assistant Chief of Staff for Automation and Communications, Department of the Army. The study, entitled "Validation of Army Spectrum Allocation and Analysis Procedures", has the overall purpose of developing recommendations for improving the Army's analysis procedures that are used to: support Army spectrum allocation requirements; evaluate the NATO interoperability of new and existing systems; provide the direct support for research and development efforts to assess the impact of new equipment and systems on available spectrum resources.

Volume I of this report is an executive summary containing the highlights of the study, conclusions and recommendations.

Volume II presents an analysis of the details of each Task of the study, organized under their respective Objectives. Details, themselves, are presented in appendices to Volume II.

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## SECTION I INTRODUCTION

### BACKGROUND

To maintain a viable defensive posture against potential enemies of the United States, and to compensate for probable numerical deficiencies, the U. S. Department of Defense and its components have long pursued a material development pattern of ever increasing sophistication. The associated communications-electronics (C-E) equipments have likewise increased in complexity, sophistication and occupancy of the electromagnetic spectrum. This has occurred simultaneously with an explosion in industrial and consumer communication-electronics technology with its attendant demands on the spectrum resource.

The result is that the communications-electronics equipment experimenter, developer or user is confronted with an increasingly difficult task in obtaining spectrum support for emerging systems and equipment. This is particularly critical when the material is mission essential, and failure or delay may be costly or catastrophic in terms of lost time, material resources, tactical advantages, or even lives.

To minimize such impact, the spectrum allocation to equipment process should facilitate, not hinder, the effort to obtain spectrum support for vital Army C-E equipment. The process should provide for early awareness of new spectrum requirements, for electromagnetic environmental impact assessment, and for frequency supportability determination. The procedures and techniques employed to this end should be efficient, current, comprehensive and time/cost effective. It is the title and intent of the study to accomplish a "validation of Army spectrum allocation and analysis procedures" currently used in the spectrum allocation to equipment process.

## APPROACH

The objectives of this study, briefly stated, are to:

1. Determine the applicability of current procedures;
2. Evaluate the worth of current data base in support of allocation and analyses and identify needed improvements; and
3. Review the basis for evaluation of candidate systems seeking spectrum allocation.

Achievement of the study's objectives is to culminate in recommendations, where and if appropriate, for improving the analysis procedures used to meet the Army's responsibilities in spectrum allocation. These responsibilities fall into the following categories:

1. Support of Army spectrum allocation requirements.
2. NATO interoperability.
3. Support for research and development efforts.

The approach taken in the study has been to address each objective in light of its contribution to meeting the various categories of responsibility in the Army spectrum allocation effort. This mutual supportability is depicted in Figure 1.

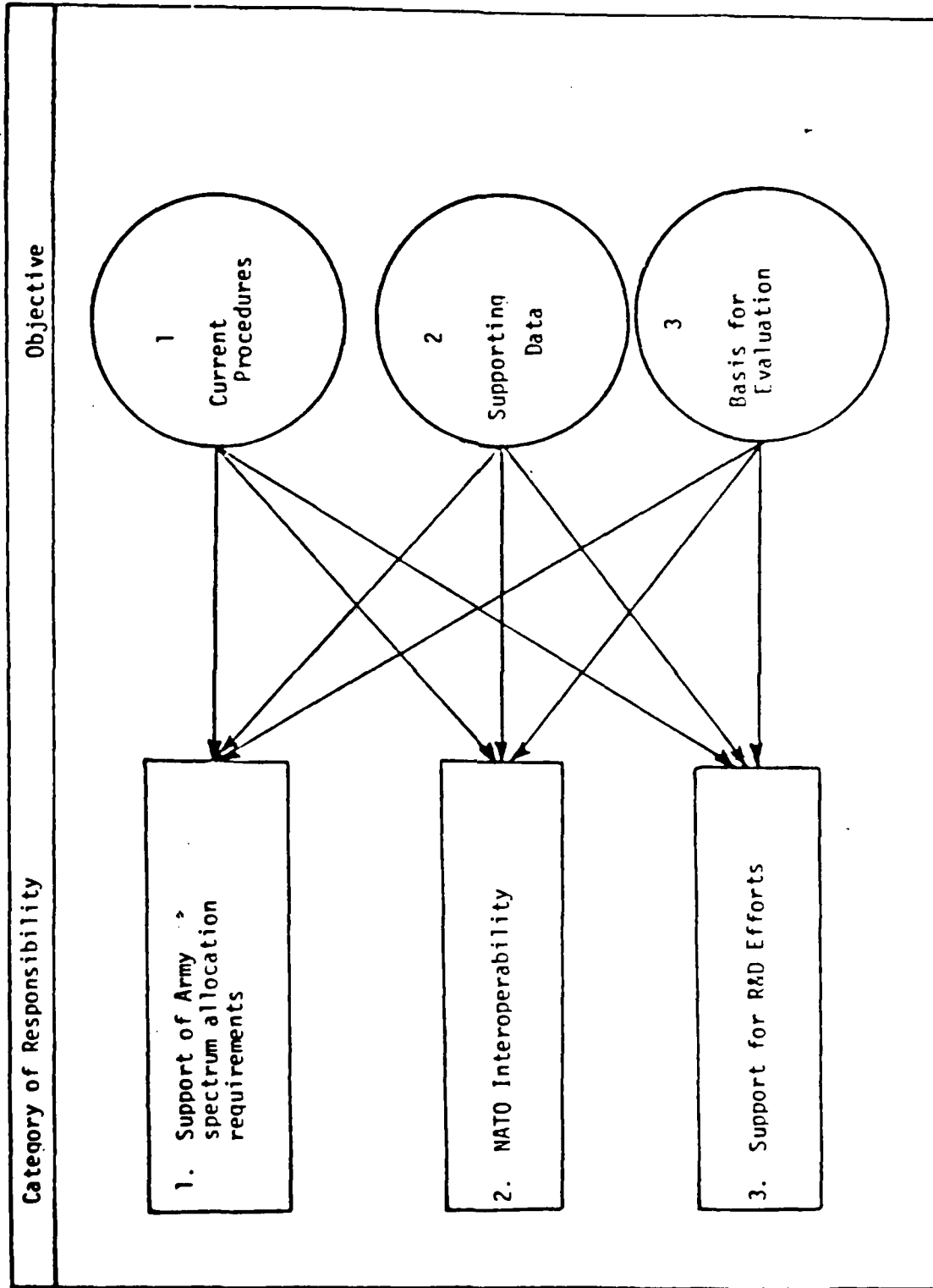


Figure 1. Mutual Supportability of Objectives in Meeting Army Spectrum Allocation Responsibilities

SECTION 2  
HIGHLIGHTS OF STUDY

GENERAL

The spectrum allocation to equipment process, as it currently exists, attempts to do two things: a. Provide a degree of assurance that the new C-E equipment will receive frequency assignment support at the time it becomes operational; b. Determine if the new C-E equipment will or will not function compatibly in its operational environment on its assigned frequencies. This operational environment may be civil or military, peacetime or wartime, or it may transition through any combination of environmental operating conditions.

The process is, in many ways, analogous to the process involved in licensing a new automobile driver.

- The new driver undergoes a development process (drivers education, parental instruction, etc.) to prepare him to operate in the environment - the development stages of the Materiel Acquisition System.

- An independent evaluation agency (Dept. of Motor Vehicles, State Police, etc.) functions to assess the ability of automobile drivers to operate in the environment - The J-12 Working Group, Frequency Panel, USMCEB and the Spectrum Planning Subcommittee of the IRAC.

- At a selected point in time, the evaluation agency conducts an abbreviated review of the candidate driver's ability to function in the environment - The J-12/SPS spectrum allocation to equipment/frequency supportability review.

Just as the driver licensing process serves a useful purpose in screening applicants to ensure some given level of ability to function satisfactorily in the environment, the spectrum allocation to equipment review establishes a level of probability that the equipment will be compatible with its environment. Both processes, as a result of years of experience, are effective in detecting gross inadequacies.

Administratively, each process also serves as a clearing house and office of record as to the size and composition of the respective operating environments, and as a means of identifying new entries into the environment.

Unfortunately, neither process ensures satisfactory, compatible operation in the environment, once entered. That task falls to other agencies. In the case of C-E equipment, operational commands become burdened with trying to absorb the new equipment without causing an imbalance in the electromagnetic environment. Quite often only an extensive, expensive retrofit will provide the solution, during which the affected equipment is not performing its mission.

At present, the spectrum allocation to equipment process errs by attempting to accomplish both technical and administrative functions, with a resulting marginal performance in each, rather than focusing its limited resources on one or the other function and performing it well.

## SPECTRUM ALLOCATION TO EQUIPMENT PROCESS

The Spectrum Allocation to Equipment Process is discussed in detail in SECTION 2, Volume II, of this report. It is generally conceded by those interviewed during the study that some such process is necessary. That is, there is a consensus that a need exists to: (a) screen new equipments for general compliance with spectrum allocation rules and regulations, (b) provide a mechanism which will alert the spectrum management community regarding new equipment and systems entering the environment, and (c) provide an office of record for allocation applications.

The major dissatisfaction with the current process occurs when it attempts to go beyond the screening, alerting and recording role. Considering the quantity of allocation applications (see Army Responsibility, pages 17-18, Volume II) which must be reviewed, and the limited resources available to conduct the reviews, a dilemma is created when the process is confronted with anything other than the simplest of equipments or systems. On the one hand, if the imposed schedule is to be maintained, only a cursory review can be conducted of each application regardless of complexity or sophistication (see Frequency Supportability, pages 32-35, Volume II). To do otherwise would require greatly increased resources, or an unacceptably longer time to gain approval of an allocation application. On the other hand, the process must consider an application in sufficient depth to discharge its mission and responsibilities.

A further weakness of the process revealed during this Study is the lack of a positive feedback mechanism wherein the trends and lessons learned through the processing of the many and varied allocation applications is fed back into the R & D community. A feedback loop such as this could provide considerable guidance and direction to C-E materiel developers embarking on new programs. This is discussed on page 31, Volume II, under EMC Guidance to Developers. The high occurrence of the failure of

Army equipment to meet standard harmonic and spurious attenuation levels in the review process, as discussed under Task F.4.3.2 in SECTION 4, Volume II, is a case in point. Early recognition of this situation by the Army could have generated a concerted effort to: (a) determine whether it was the equipment, or the standard, which was deficient, and (b) take prompt remedial action.

The dissatisfaction and weakness noted above is related to the lack of current, cohesive, comprehensive guidance regarding the spectrum allocation to equipment process. The discussion under Task F.4.1.1 in SECTION 2, Volume II, addresses the realignment of responsibilities within the Army, the cancellation of guidance documents, and the absence of new directives to explain and compensate for these changes. At the joint level, only a memorandum of the USMCEB (MCEB-M 565-78 (V)) is available to provide guidance and direction to a process that purports to regulate (by approval/disapproval authority) the majority of C-E equipment and systems entering the Department of Defence (DoD) inventory. At the national level, a few paragraphs in the NTIA Manual govern the review process for many of the equipments and systems of the Federal Government, including those of the DoD. The paucity of good, current guidance does little to promote understanding and support of the allocation process.

## ANALYSIS PROCEDURES AND TECHNIQUES

A significant finding of the Study is that there is little or no in-depth EMC analysis performed within the spectrum allocation to equipment process, itself. The action taken at the Army, joint and national levels is most appropriately described as a review. True electromagnetic compatibility (EMC) analysis is precluded in the process by the lack of adequate time, data, resources and analysis tools.

However, independent, in-depth and detailed analyses are conducted in accordance with the EMC Program Guide developed for each major project or program. Such analyses are normally conducted in a depth and detail appropriate to the complexity and sophistication of the equipment or system. The key to the value of these separate, full EMC analyses is the alert Project Manager who recognizes and appreciates the role of the EMC analysis in predicting the equipment's performance early in the development cycle.

The major limitations of the Spectrum Allocation to Equipment Review are listed below.

- Time - The current guidance (MCEB-M 565-78 (V)) provides only ten working days for the ECAC J-12 Technical Review. Since most true EMC analysis efforts consume several man months or years of analysis effort over months or years of elapsed time, in no way can such a technical review provide the same level of accuracy and thoroughness.

- Data - The requirement for data originates with the application for joint or national frequency allocation. The joint and national reviews are directed to the data provided by Army on the DD Form 1494 and OT Forms 33, 34, and 35 used for the allocation application. As discussed under Task F.4.2.3, SECTION 3, Volume II, these data are quite often projected, estimated or calculated, particularly in the early application stages.

- Resources - Task F.4.1.1, SECTION 2, Volume II, discusses the level of effort applied to the allocation application review process. When this level is divided by the number of applications reviewed, (approximately 85 per year average) it is readily apparent that the level of effort directed to each application review is best measured in terms of man hours or man days, vice the man months or man years devoted to an EMC analyses conducted in accordance with the Program Guide.

- Analysis tools - The analysis procedures and techniques employed in the Spectrum Allocation to Equipment Process are identified in Task F.4.1.2 and evaluated under Task F.4.1.3. SECTION 2, Volume II contains the discussion of these tasks. An apparent weakness of the review process is the limited availability and employment of automated analysis techniques. This is compounded by the total lack of a realistic, validated environment against which the applicant equipment may be evaluated. No agency in the spectrum allocation to equipment review process possesses a deployment upon which to base an environment, and no Service, joint agency, or other competent authority has validated an environment as a realistic and sound basis for EMC analysis.

Only limited use is made of analysis models within the spectrum allocation to equipment process, and none by the Army agencies involved in the process. Of the models in use, some refinements or improvements are required if newer technology equipments are to be thoroughly analyzed. A more directly beneficial expenditure of resources could be realized, however, if the results of EMC Program Guide analyses were better communicated to the allocation review bodies. Any further computerized application evaluation effort by Army spectrum allocation agencies should examine the use of calculators and plotters as tools with which to perform the calculations and table verifications made in their review process.

## DATA SUPPORT

Four major data bases were considered in this portion of the Study. These are maintained by:

DoD ECAC, Annapolis, MD  
CESD, CORADCOM, Alexandria, VA  
COMM/ADP Lab, CORADCOM, Ft. Monmouth, NJ  
EMETF (Tuscon), USAEPG, Ft Huachuca, AZ

The major findings under this Objective are presented in SECTION 3, Volume II.

Because of the long term working relationship between the data support elements and the analysis community, the identification and definition of data elements (items) required to support analysis efforts is quite complete. All essential data elements are defined in each of the data bases maintained by the agencies listed above. As new technology or evaluation techniques evolve, the data bases evolve in stride.

The accuracy, currency and fill of the data elements in the various data bases is highly questionable, however. None of the agencies maintaining the data bases are originators of the data. Consequently, they are dependent on a variety of sources to provide initial and update data reports. These are supplied in many ways in accordance with varying schedules. Further, the data values may range in accuracy from "estimated" or "calculated", in the case of data extracted from a DD Form 1494 frequency allocation application for an experimental equipment, to the precisely measured data values of a communications satellite frequency assignment.

The interface facility of the data bases to the analysis procedures is examined under Task F.4.2.3. A major finding is that there is no apparent interface or exchange of data between the DoD ECAC and the

## EVALUATION CRITERIA AND GUIDELINES

As stated in GENERAL, above, the spectrum allocation to equipment process attempts to determine if a new C-E equipment will or will not operate compatibly in its intended environment. Because it is neither cost effective nor technically reasonable to develop actual environments in which each allocation applicant may be tested, evaluation criteria and guidelines have been adopted as the accepted approach to determine probable compatibility.

This Objective of the Study undertakes the identification and evaluation of the evaluation criteria and guidelines. A full discussion of the findings is presented in SECTION 4, Volume II, of this report.

Task F.4.3.1 reveals that there are three primary deficiencies in the evaluation criteria and their application in the spectrum allocation to equipment review process. These are shown in Table 1 below.

- No Common Reference. The criteria used during the application review is not necessarily the same as those criteria against which the equipment was developed.
- Questionable Data. The joint and national evaluations are performed using the data reported on DD Form 1494 or OT Forms 33, 34, and 35 which may not accurately reflect the technical characteristics of the applicant equipment.
- Lack Of Appropriate Standards. In several cases there are either no standards, or only standards of questionable validity, against which to evaluate an applicant equipment.

Table 1. Evaluation Criteria Deficiencies

various Army EMC Data Bases. As a result, an Army analysis of ECAC data, or an ECAC analysis of data contained in an Army EMC Data Base, are precluded.

The study explores the techniques of exchanging data bases and of employing a remote computer access system to enhance EMC data availability and to encourage updating of the EMC data bases.

The Study did not uncover analysis guidelines directly applicable to the Army Spectrum Allocation to Equipment Community. As a result, the community has developed its own procedures and techniques to meet its tasking. While this is not inherently bad, it does little to promote understanding of their process and is subject to inconsistencies.

Under Task F.4.3.2, the Study addressed the extent of failure of Army allocation applications to meet the evaluation criteria. Frequency Panel, US Military Communications-Electronics Board (USMCEB) records from 1970 to the present were reviewed. A total of 271 Army allocation applications were found, out of the 603 records reviewed, which failed to meet one or more standards or other evaluation criteria.

Next, the Study examined the number and content of Army letters originated to waive the requirement to meet standards. Because of several organizational changes in recent years, there is no file of Army waiver letters before 1975. Out of the 242 applications on file at ECAC, a total of 50 Army waiver letters were disclosed, all granting waivers for meeting the requirements of MIL-STD-461/461A. An additional two deficient allocation applications were disapproved by Army (Headquarters, Dept. of the Army). No indication of waiver action (Army or otherwise) was found for other cited deficiencies.

The Study found few cases where the values in standards, by which applicant equipments are evaluated, should be relaxed. On the whole, although military standards are more stringent than national standards and provide greater coverage (e.g., receivers), values stated therein are considered attainable with available technology.

There are no directly applicable standards for secondary surveillance radars (SSR's), telemetry (except for that used on Test and Evaluation ranges) and newer systems employing emerging technology (e.g., spread spectrum, frequency agile equipment). Further, there is at times a divergence of opinion among the various spectrum allocation to equipment review agencies regarding the application of standards. That is, when

are which standards (or which portions thereof) to be applied to which categories of applicant equipment? This is further compounded by the DoD encouraged use of "tailoring" of standards. Under the DoD tailoring concept, materiel developments may attain the essential level of performance, reliability, ruggedness, etc., without being burdened with the requirement to meet idealistic specifications. That is, only those specific standards, or portions of standards, that are essential are called out in the development contract. The overall specifications are thus "tailored" to the specific needs of the materiel requirement. Review agencies, generally unaware of the extent of tailoring of standards in a development, are prone to apply all apparently applicable provisions of a standard.

### SECTION 3 CONCLUSIONS

Analysis of the findings of the various Tasks of the Study lead directly to certain conclusions. For convenience, these are presented below in groupings related to the Objectives of the Study. Additionally, a general group is included to provide for those general conclusions drawn from the overall findings of the Study.

It is concluded that:

A. In general,

1. Some process is necessary and warranted to screen allocation applications, alert the spectrum management community to new equipment entering the environment, and serve as a clearing house or office of record for allocation applications which have been processed.
2. The performance of the present process, in providing the essential service described in the above conclusion, is marginal.
3. There is a lack of current, cohesive, comprehensive guidance regarding the spectrum allocation to equipment process.
4. There is a need for central direction of the spectrum allocation to equipment process from the Army Spectrum Manager to the various commands and agencies representing the Army in the allocation process. This direction should be in the form of a statement of the Army Spectrum Manager's policies as to what the spectrum allocation to equipment process is/is not, what it can/cannot do, what it should/should not be.

B. In the area of applicability of the development and analytical procedures currently employed in the spectrum allocation process,

1. No analysis procedure guidelines exist for the spectrum allocation to equipment review agencies.
2. Available time, data, resources and tools preclude the conduct of true EMC analyses in the routine application review process.
3. Analysis models used to evaluate candidate C-E equipment during the application review process are not current with the emerging technology of the equipment being evaluated (e.g., spread spectrum, satellite communications).
4. The use of programmable calculators and plotters would enhance the performance standard calculations and table verifications now performed manually within the spectrum allocation process.
5. There is a minimum of beneficial feedback from the results of the spectrum allocation to equipment application review process.
6. Communication and coordination of information within the Army spectrum allocation community regarding the findings of EMC tests and analyses are weak or totally lacking.
7. Secondary Surveillance Radars are not being evaluated under national (RSEC) nor DoD (MIL-STD 469) criteria.
8. NATO interoperability is not positively determined by the spectrum allocation to equipment process. The extent, if any, of NATO interoperability is currently determined by EMC analyses performed under a developing equipment or system's EMC Program Guide and evaluated during Operational or Developmental

Tests (OT or DT). ASARC, DSARC and In Progress Reviews are the control points for assessing interoperability, not the spectrum allocation to equipment process.

C. In the area of spectrum allocation and analysis data and data interface,

1. Adequate data elements have been defined, and exist in appropriate data bases, to support the spectrum allocation to equipment process.

2. Although adequate data elements have been defined and provided for, the data content is questionable with regards to accuracy, currency and fill. Inadequate data validation, outdated data, and missing data, limit the effectiveness of the files.

3. The present practice of manual reference to tabular data such as the spectrum allocation tables is more efficient and cost effective than computer assisted reference.

4. Library searches for analysis and test reports related to a candidate equipment undergoing spectrum allocation review are difficult and time consuming. This is due to a lack of categorization of the reference documents in a manner which facilitates retrieval. The use of a working list of pertinent reports would facilitate retrieval and reference during allocation review.

5. There are neither standards nor guidelines for developing an environment against which a candidate equipment will be evaluated. Internal Army analysis environments are synthesized, restricted in scope, but quite detailed. Joint and national environments are subsets of actual joint and national data bases selected by the reviewing engineer.

Consequently, they are subject to varying degrees of experience and operational knowledge and result in a lack of uniformity in evaluation criteria. This conclusion was also drawn under Objective 1.

6. There are no identifiable data interfaces between the ECAC data base and Army analysis agencies, nor between Army analysis data bases and ECAC analysis efforts.

7. The development and use of a remote computer access capability, between the ECAC data base and Army EMC analysis agencies, may promote data interface and offer significant improvements in the areas of content, quality and currency of the data used for analyses by both Army and ECAC.

D. In the area of criteria and design guidelines used as a basis for evaluation of Army C-E equipment from the standpoint of spectrum allocation,

1. Current evaluation criteria are deficient with regards to: (a) common reference points for standards, (b) content and quality of data considered in allocation application reviews, and (c) lack of appropriate standards for all systems.

2. On the whole, the requirements of Military Standards are more stringent than those of national, or other, standards, particularly with regards to receiver performance.

3. Except in a few instances, there is no justifiable reason to relax present guidelines regarding the standards against which candidate C-E equipment, nor should the full MIL-STD-469 or RSEC be applied to a short duration, radar guided artillery round.

4. There is no standard for telemetry, other than when it is to be operated on Test and Evaluation ranges. Nor are there adequate standards for equipment employing advanced technology (e.g., spread spectrum, satellite communications, etc.).

5. The entire area of standards application is disorganized. As shown in Conclusion 4, above, clear guidance does not always exist as to what standards apply, nor when. Also, the entire area of "TAILORING" standards, as encouraged by DoD, is not officially recognized during joint and national reviews.

6. No concerted program exists to determine the extent of, evaluate, or take remedial action on, the deficiencies cited in Army spectrum allocation to equipment reviews.

## SECTION 4 RECOMMENDATIONS

A review of the Conclusions of this Study reveals no need for broad, sweeping changes or revisions to the spectrum allocation and analysis process or organization within the Army. Instead, the institution of a number of relatively minor, but related, measures, all pursuing a singular goal, will serve to update, refine and optimize a process which is currently functioning at an apparently marginal level. Accordingly, a concerted action on the recommendations presented herein is considered the best approach to follow in upgrading the Army spectrum allocation to equipment process with a minimum expenditure of resources.

It is therefore recommended that:

A. In general,

1. A statement of policy, such as that suggested in Appendix J, be issued by the Army Spectrum Manager to clarify Army policy and provide central direction regarding the spectrum allocation to equipment process as a whole.
2. Resources be identified and action be initiated to update and revise that Army documentation (Army Regulations and other publications cited in Task F.4.1.1 as being in need of revision) which provides spectrum allocation and EMC guidance to the Army.
3. The Army R & D Spectrum Engineering Support effort be modified to provide for on-site assistance at program manager, development agency and other appropriate locations. This on-site assistance would be rendered in any area required to ensure the maximum understanding and probability of success of a spectrum allocation to equipment application.

B. In the area of applicability of the development and analytical procedures currently employed in the spectrum allocation process,

1. Army adopt the position in the joint arena (Frequency Panel and J-12 Working Group) that the joint review process should be upgraded by:

a. providing improved analysis procedure guidelines relative to standards and evaluation criteria, and

b. seeking the development of improved, advanced analysis models by ECAC for use in the review process.

2. The Army allocation application review effort explore the application of programmable calculators and plotters to perform their review checks and verifications.

3. Internal Army communication and coordination of information, resulting from EMC tests and analyses and the allocation application review process, be officially organized and sanctioned by DA. Applicable test/analysis information should accompany applications whenever possible. Pertinent allocation review data (both Army and other Service) should be gleaned from the process and disseminated widely within the Army EMC, R & D and frequency management communities. The use of a monthly or quarterly "newsletter" format is suggested.

C. In the area of spectrum allocation data and data interface,

1. A library search be commissioned to identify and categorize representative EMC analysis and test reports into a working list. This working list would facilitate the review of a candidate system which may relate to a given analysis or test report by being similar, or by being a potential interferer or victim.

2. Army adopt the position internally and in the joint arena that environments against which candidate equipments are evaluated must be representative, accurate, current and, hence, validated if there are to be uniform standards of evaluation.

3. Remote computer access between the ECAC data base and Army EMC analysis agencies (e.g., EMETF, COMM/ADP LABS, etc.) be examined and, if feasible, pursued as the most promising means of promoting data interface where required, and for offering significant improvements in the areas of data content, quality and currency.

D. In the area of criteria and design guidelines used as a basis for evaluation of Army C-E equipment from the standpoint of spectrum allocation,

1. A concerted effort be made by Army to update and upgrade appropriate military standards through joint action or by development and publication of an "ARMY NOTICE". Particular emphasis should be placed on:

a. a general use telemetry standard,

b. special exemptions or reduced requirements for special applications now considered under general standards (e.g., radar guided artillery rounds, rockets, etc.).

c. advanced technology systems.

2. The use and consideration of "tailoring" of standards be researched and resolved in the joint arena.

3. Emphasis be placed on requiring Army spectrum allocation applicants to include more current, accurate and complete data with their DD Form 1494 applications. This emphasis could be via the "newsletter" suggested in recommendation B.3., by responsibility assignment in revised Army Regulations as

recommended in A.2., above, by on-site assistance as recommended in A.3., above, or by any combination of these measures.

4. A periodic statistical review be conducted of the number and causes of failures of Army allocation applications. The analysis conducted under Task F.4.3.2 of this Study is representative of the qualitative and quantitative information available, and the performance trend of new equipment being introduced into the Army C-E inventory.