REPORT OF THE

DEFENSE SCIENCE BOARD
TASK FORCE

ON

DoD Frequency Spectrum Issues

"Coping with Change: Managing RF Spectrum to Meet DoD Needs"

November 2000

OFFICE OF THE UNDER SECRETARY OF DEFENSE
FOR ACQUISITION AND TECHNOLOGY
WASHINGTON, D.C. 20301-3140

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MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION, TECHNOLOGY & LOGISTICS)

SUBJECT: Final Report of the Defense Science Board (DSB) Task Force on the RF Frequency Spectrum

I am pleased to forward the final report of the DSB Task Force on DoD Frequency Spectrum Issues. This effort, chaired by Mr. William G. Howard, was formed to determine the competing interests in and access to the RF frequency spectrum and its impact on military readiness in the 21st century. The final report represents the collective view of the Task Force members on this important topic.

In summary, the Task Force members firmly believe that increasing competition for RF frequency spectrum and the complexities of the current process for international frequency allocations threaten U.S. military readiness. Therefore, the Task Force recommends that the Department push for a national level spectrum policy and that it adapt its own spectrum policy, strategy, tactics and organization to meet this challenge.

I endorse all the Task Force recommendations and propose you review the Task Force Chairman's letter and report.

Dr. Craig I. Fields
DSB Chairman

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29 NOV 2000

Dr. Craig I. Fields
Chairman DSB, OUSD(AT&L)
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Dear Dr. Fields:

Attached is *Coping with Change: Managing RF Spectrum to Meet DoD Needs*, the report of the Defense Science Board Task Force on RF Spectrum. The Terms of Reference for this study requested the Task Force to assess the adequacy of the Department of Defense's vision and strategy for frequency spectrum, to determine the adequacy of the Department's forecasted spectrum requirements for JV2010 and its processes for spectrum management. Further, the Terms of Reference specified that the Task Force determine the impacts of national policy / statutory requirements on DoD spectrum.

Using the Terms of Reference as a guide, the Task Force conducted a broad-sweeping study of spectrum management within DoD and of external pressures that bear on the Department's ability to gain access to RF spectrum needed to carry out its missions, both in the US and abroad. Spectrum managers, defense spectrum users, and equipment developers addressed the Task Force, as did representatives of the Federal Communications Commission, the State Department, the National Telecommunications and Information Administration (Department of Commerce), commercial spectrum managers and the National Security Council.

The Task Force was impressed with the impact of spectrum considerations on the operational effectiveness of US forces, as demonstrated most recently in Kosovo.

The United States lacks a national spectrum policy / strategy. The multiplicity of organizations charged, by the Communications Act of 1934, with spectrum management responsibilities in the US each have different goals, objectives and constituencies. There is no effective mechanism to resolve conflicts, such as those that arise from pressures for spectrum for burgeoning civilian wireless services and military necessity. US delegations' ability to negotiate at international spectrum allocation meetings is hampered by lack of consistent attention to international spectrum matters. DoD must push for a single, national authority to rationalize the nation's approach to allocating the limited spectrum resource.

The Task Force concludes that the DoD's spectrum management policies are out of step with changes underway in spectrum use. These changes, driven by modern communications system concepts and new RF hardware and software developments, are rendering the time-honored

concept of "allocation ownership" obsolete. The Task Force concludes that the Department of Defense must develop capabilities-based spectrum policy and strategies and must organize to manage spectrums based on identified and forecasted requirements rather than simply defending existing Defense spectrum allocations. The current defensive nature of DoD's spectrum policy and its reluctance to consider alternative spectrum concepts, including sharing with non defense users, leaves the military vulnerable to losing mission-critical spectrum access.

DoD's qualification procedures for new and upgraded equipment, although covered in existing acquisition regulations, are inadequate to assure usability of new systems abroad and in the United States and do not protect against RF energy hazards. This shortcoming seriously complicates the spectrum considerations accompanying US forces' deployment abroad. DoD must rigorously enforce its qualification requirements and inject spectrum considerations at every step in system development.

New system, hardware and software technology makes possible radio, radar, sensor and other concepts unimaginable even ten years ago. Since many of these concepts have unique military applications, DoD must conduct research and development into new spectrum concepts to assure that their use results in reliable, secure communications and sensing.

Finally, DoD has specialized needs that must be attended to in spectrum allocation and use at test, evaluation and training facilities and in assuring adequate expertise to manage spectrums within the Department and the Services.

Each of the above issues is treated in detail in the attached report, with represents the unanimous position of the Task Force.

I would like to express my sincerest appreciation to the Task Force members and to the government advisors for their spectrum management knowledge and insight. Without their hard work, dedication and enthusiasm, this report would not have been possible. I would also like to thank all the breeders who took time to prepare and deliver their views to the Task Force.

All of us on the task Force hope that our study's sponsors will find the information contained in this report useful and that the specific recommendations we made actionable.

Sincerely,

William G. Howard, Jr.
Chair, DSB Task Force on
DoD Frequency Spectrum Issues

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Foreword

Imagine trying to win an overseas air war where target intelligence can be gathered only part of the day, where aerial refueling is hampered by inability to fly in close formation under prevailing weather conditions, and where many newly developed radio systems for air, sea, and land forces don't work the way they did back in the U.S. Sound unlikely? It isn't - these constraints limited the U.S. forces' ability to operate to maximum efficiency during the Kosovo campaign. These restrictions on U.S. military equipment did not arise from sabotage, maintenance failures, or enemy countermeasures - they resulted from the Department of Defense (DoD) acquisition system's failure to insist on qualifying spectrum allocations for new systems that depend on access to the radio frequency spectrum. Without such qualification, systems that function well in the U.S. may not be usable abroad. Unless new systems' use of radio frequencies is qualified, they may interfere with other military users or with critical civilian users of the radio spectrum, even at home.

Imagine the commander of an Airborne Warning and Control System (AWACS) aircraft operating over the Gulf of Mexico being brought before the FCC on charges that his radio signals interfered with reception of the Super Bowl game in Miami.

Imagine U.S. service men and women denied use of their Commercial Off The Shelf (COTS)-sourced radios because they interfere with civilian users who have higher priority for spectrum access.

Finally, imagine a future in which computer-controlled radios, capable of operating flexibly across a wide range of spectrum from 2MHz to 2GHz, with user-defined modulation waveforms, are restricted to fixed channel operation (in the same manner as older, hardware-defined radios) because of the failure to develop spectrum assignment techniques consistent with new radio technologies.

In the United States, some military equipment designed to operate in the UHF band can no longer be used because its spectrum was auctioned off to raise funds to reduce the national budget deficit and promote the growth of the digital cellular telephone industry.

All of these instances involve spectrum policy and management, the work of ensuring access to radio frequency spectrum need by U.S. forces, wherever they operate. It is a complicated, exacting process to ensure that military communications, radar, geo-positioning, and intelligence systems operate effectively.

Coping with Change examines management of the radio frequency spectrum as it applies to DoD. The study examines international, national and Departmental facets of the spectrum management process; DoD's spectrum management organization and special issues related to system qualification; new spectrum technologies; test, evaluation, and training; and skilled spectrum management personnel. The study Task Force concludes that spectrum practices that have served the nation and the Department well over the last 66 years must be updated to handle the needs of increased Operational Tempo (OPTEMPO), frequency-agile radios, and digital and spread-spectrum signals. DoD must be better prepared than it is to manage in the context of future, new technology systems.

DoD Spectrum Management - An Overview

Frequency spectrum is an essential enabling resource for modern military operations. Wireless communications, radar, EW, and intelligence systems all depend on access to this limited resource. Until recently, DoD has had little difficulty meeting its spectrum needs; however, its ability is lessening as competing military and commercial demands for spectrum access grow rapidly. DoD's mastery at managing its spectrum, both within the Department and at national and international levels, is weakening due to changes in geopolitics, the perceived reduced primacy of defense needs, and increasing pressure for spectrum access by economically important new Radio Frequency (RF) systems.

The Communications Act of 1934 established the framework for dealing with spectrum allocation in the United States; it has changed little since. Yet new digital and RF technologies have made possible system concepts unimaginable even 20 years ago. Demands for spectrum reassignments are arising, driven by new communications applications, economic forces, and political pressures. Additionally, international spectrum allocations, essential considerations in Outside of the continental U.S. (OCONUS) deployment of U.S. forces, differ substantially from U.S. assignments. These important changes are not well understood by DoD's leadership. Further, lack of an overall national spectrum policy mechanism imperils consistent management of this critical commodity and the U.S. position in international spectrum governing bodies. Bad allocation choices can be difficult, if not impossible, to reverse.

In its study, the Defense Science Board Task Force on Spectrum Management addressed the rapidly changing spectrum environment, taking into account national, international, technical, and economic considerations. The Task Force concentrated on the following areas:

The Notion of Spectrum

Advancements in technology and practice are changing the notion of "spectrum." What in 1934 was a static, one-dimensional property is becoming a dynamic, multifaceted commodity. The original framework is based on the idea of "ownership" of spectrum assets for an assigned purpose. The recent onset of software-programmable radios and radars, spread-spectrum waveforms, digital signals, spectrum-sharing technology and dynamically allocated frequency assignments challenges the established spectrum management framework. Multiple users now share common spectrum, separated by frequency, location, time and waveform under the control of supervisory systems. Such changes are occurring in both military and commercial domains. The notion of spectrum "ownership" is shifting in response to the rise of systems that manage bands of frequencies for multiple, dispersed, diverse users.

DoD must adapt to new spectrum notions. It must plan, assign, and use spectrum consistent with characteristics of future systems. This demands a defense policy for ensuring access to spectrum resources needed to accomplish DoD objectives, taking into account the possibility that some systems may not be operated strictly as military systems. Further, the change in spectrum notion

requires development of a management framework that incorporates new considerations into spectrum decisions.

The International Spectrum Environment

The international spectrum environment is complex and getting more so. Spectrum management is a sovereign right of nations. Allocations abroad do not match those in effect in the United States. The Cold War hegemony that governed international military allocations for 40 years is gone. Developing nations are building wireless communications capabilities to supplement meager native wired communications networks and developed countries have discovered the economic benefits of ubiquitous wireless communications; the RF spectrum is getting crowded everywhere. The operational tempo (OPTEMPO) of U.S. forces in future OCONUS deployments leaves little time for international spectrum coordination.

The U.S. has only a single vote in the International Telecommunications Union (ITU) and the World Radiocommunication Conference (WRC) that, by treaty, governs international spectrum allocations. In order to prevail, the United States must conduct detailed bilateral negotiations with other nations to garner their support of U.S. positions. Despite the complexity of these negotiations, the position of chief of the U.S. delegation at the World Radio Conference is an ad hoc appointment, changing with each new WRC meeting.

U.S. National Spectrum Policy

The United States is unique in the world in that it lacks a mechanism to formulate a national spectrum policy that balances traditional national security and new commercial uses of frequency spectrum. The national security argument no longer suffices to mandate allocations to meet DoD needs at the national level; national and global communications spectrum needs are expected to grow by several times over the next decade. Our current national governance structure, consisting of the Department of Commerce's NTIA (charged with government allocations), the Congressionally established, independent FCC (administering non-government uses), and the State Department (responsible for international spectrum allocation negotiations) cannot consider all demands for spectrum and determine which allocations are in the best overall national interest.

DoD must promote a mechanism within the U.S. government that can develop and administer a national spectrum policy that comprehends the full scope of U.S. spectrum needs in the domestic and international contexts. DoD should, within the Administration and with allied organizations in both the military and commercial worlds (e.g., AFCEA, EIA), work for the reestablishment of a White House-level Office of Information Resources Policy, modeled on the former Office of Telecommunications Policy, to develop a national spectrum policy covering both government and commercial users. The head of this office should also be the head of the WRC delegation, much as the Special Trade Representative is in the United States Trade Representative (USTR), to provide consistent leadership to the United State's negotiations within the ITU and WRC.

Defense Spectrum Policy, Strategy, and Tactics

DoD's spectrum policy lacks flexibility in that it is focused on defending existing Defense allocations against non-DoD incursions. Both national and international demands for spectrum for commercial uses are strong and getting stronger. While no single U.S. commercial organization seeks to undermine access of U.S. forces to wireless communications and other spectrum-enabled capabilities, the impact of conceding to aggregate commercial demands for current DoD spectrum would seriously impair the national defense. National security is no longer the trump card in spectrum allocation negotiations; commercial users are insistent on spectrum they need to field new communications products. DoD may eventually have to open part of its current spectrum to nonmilitary users. The Department must develop a spectrum policy that rigorously defends spectrum needed for unique physics reasons (such as propagation or foliage penetration), justifies spectrum needed for military operations, and anticipates spectrum sharing to achieve the best use of spectrum to meet both commercial and military needs. (DoD already uses private sector spectrum as a purchaser of commercial satcom and cellular services.) DoD can either get ahead of this problem or become the victim of it.

DoD must examine its spectrum policy in light of other, compelling demands for spectrum access to develop a more flexible approach. A complete assessment of current and future DoD spectrum needs must drive this examination and assessment of the costs associated with reallocation of DoD users. The policy should seek sensible ways of sharing spectrum with non-DoD users.

DoD's Spectrum Management Organization

The DoD Spectrum Management Organization, established in 1997 by Defense Reform Initiative Directive 31 (DRID 31), is generally working well, although adjustments are needed to bring the organization in line with new spectrum management needs. The present organization is broadly split into policy, strategy, and frequency management portions.

In line with the importance of spectrum in achieving the information dominance called for in JV2020, DoD must raise leadership consciousness of spectrum policy issues and its ability to negotiate for needed spectrum resources on both national and international levels. The Spectrum Management Directorate in Assistant Secretary of Defense for Command, Control, Computers, and Intelligence (ASD/C3I) acts as DoD's spectrum management focal point and authority for national and international (ITU and NATO) policy, planning, and oversight. The Directorate oversees the DoD Electromagnetic Compatibility Program (EMCP), develops policy to support DoD spectrum requirements, provides spectrum management policy guidance to the Office of Spectrum Analysis and Management (OSAM), the Services, and the Joint Spectrum Center (JSC), and communicates and coordinates with OSAM, Services Spectrum Management Offices (SMO), the Joint Staff, and the JSC on national and international spectrum matters. The current position of the Directorate in the DoD hierarchy is lower than the importance of the spectrum issue merits. The Directorate should be raised one level in the organization to report directly to the ASD/C3I. Additionally, it must be adequately staffed to deal with overall policy, international negotiations, resources, and acquisition.

The OSAM and the JSC are the two elements of DoD's spectrum management strategy organization. These organizations maintain essential information and technical tools required to manage DoD's spectrum needs, both nationally and internationally, and are charged with understanding and coordinating current and future spectrum needs throughout the Department. Effective strategy is essential to manage inherently joint aspects of spectrum and to plan future spectrum needs and uses. Currently, the spectrum strategy organization resides in Defense Information Systems Agency (DISA), an organization principally concerned with management of telecommunications and information systems.

Spectrum is a critical element of military operational electronic architecture. Spectrum considerations must be integral parts of the overall battle space communications, intelligence, and sensing architecture. As such, management of spectrum needs assessment, strategy, and operational support should be assigned to the focus of the overall operational information architecture. It is unclear to the Task Force where responsibility for the operational architecture now resides. Ultimately, serious information warfare will require an Information Operations Commander in Chief (CINC), with responsibility for overall operational system architecture as well as war fighter support. The 1999 assignment of the Joint Task Force for Computer Network Defense to U.S. Space Command (USSPACECOM) and the recommendation of the Defense Science Board Task Force on Tactical Battlefield Communications that responsibility for the architecture of the future battlefield information system be assigned to U.S. Space Command, are strong indications that U.S. Space Command is evolving into DoD's Information Operations Command. If the Uniform Command Plan continues in this direction, United States Space Command will evolve into "United States Information Command (USINFOCOM)" – the logical home for spectrum strategy and responsibility for both OSAM and the Joint Spectrum Center.

Co-location of the leadership of the three Service Spectrum Management Offices and OSAM is critical in resolving important joint frequency management issues between these organizations. This practice should continue.

The three Service Spectrum Management Offices appear to be effective in coordinating and assigning spectrum to meet Service operational needs.

New System Certification

New systems require spectrum to operate and must be qualified before they can be deployed. Current DoD 5000 series regulations call for coordination of spectrum during the development of new systems however, this important step occurs late in the system development process and are often skipped. Enforcement of these regulations is nonexistent. As a result, some new systems have been unusable, particularly in international deployments such as Kosovo (e.g., E-TCAS and Global Hawk). Additionally, the advent of software programmable radios and radars, such as Joint Tactical Radio System (JTRS) and the F-22 radar, does not fit established qualification procedures, in that both operating frequencies and waveforms are programmable by the operator or an automatic system. They also pose major international deployment problems. The electromagnetic environmental effects (E^3) implications of such systems are not yet well understood.

DoD must rigorously enforce existing spectrum coordination regulations for systems being developed and modified. Spectrum coordination should start early in the system development process and continue through to operational test and evaluation. Both U.S. and international coordination must be undertaken. The Defense Acquisition Board (DAB) should include spectrum coordination in its development oversight checklist, and test and evaluation should not begin until coordination is complete.

The qualification process must be reexamined to adapt to the needs of frequency/waveform-agile equipment.

Spectrum-Related Research and Development

Research and development of spectrum usage technology underway in the commercial sector is tightly focused on commercial product needs. The DoD must take the lead in developing and evaluating new techniques for efficient spectrum use such as spectrum-sharing, dynamic allocation, spectrum-smart, cognitive radios, and spectrum "sniffing."

Test and Evaluation

Test and evaluation and training facilities present special problems in spectrum management. Both test and evaluation and training require war-like access to spectrum

under the "train as you fight" and "test as you use" doctrines. Currently, the spectrum available for telemetry and instrumentation is inadequate to support the pace of activities in crowded areas such as the southern California, Arizona, and Nevada test and training complex.

DoD should accelerate technology development to reduce bandwidth needed for control and instrumentation of test and evaluation. Additionally, the DoD should seek spectrum consistent with increased instrumentation and test complexity for test and evaluation and training facilities.

Spectrum Management Expertise

Spectrum management is, by its very nature, an arcane undertaking. The community of DoD spectrum and frequency managers is small (roughly 150 government employees and military worldwide supplemented by a larger force of contract personnel). However, the small numbers of participants, and the behind-the-scenes nature of the activity, belie its importance to the success of DoD operations.

DoD should examine its spectrum professional training capability to ensure that adequate, competent personnel are available to manage and carry out this essential activity. Further, training of acquisition personnel likely to become engaged in system acquisition should include mandatory "spectrum literacy" exposure during training courses such as those offered by Industrial College of the Armed Forces (ICAF).

The following sections of this report develop, in detail, the Task Force's findings and recommendations for each of the considerations summarized above. *Coping with Change* is presented in the form of an annotated briefing, with presentation charts facing supporting text. Following a background section (slides 2-14), the Task Force's findings, conclusions, and recommendations are grouped into six sections: National Spectrum Policy (slides 15-19), DoD Policy, Strategy, and Tactics (slides 20-28), DoD Spectrum Organization (slides 29-33), Spectrum and System Development (slides 34-38), Spectrum Research and Development (slides 39-40), and DoD Special Needs (slides 41-46). A brief summary concludes this report.

Information dominance is key to the success of U.S. military operations of all kinds; spectrum access is indispensable in achieving that dominance. Demands for spectrum to handle the rapidly increasing information demands of modern, joint, dispersed forces are escalating rapidly. Access to the spectrum resources needed to achieve the goals of JV2020 is endangered by pressures for reassignments to other nationally important uses and by antiquated concepts of "spectrum." The Task Force concludes that spectrum management must be a higher profile issue, within DoD and on a national level; and the development and prosecution of DoD's spectrum policy and strategies must be more actively managed to account for the changing spectrum management environment.

Summary of Recommendations

Promote a National Spectrum Policy

The Sec Def / Dep Sec Def Def should:

- **Push, together with DoD's Industry Association Allies (e.g., AFCEA, EIA), to Establish a White House Office of Information Resource Policy (OIRP)**
  - Serves as the focal point for US National Spectrum Policy and Strategy, analyze National consequences of allocation changes
  - Similar to the former Office of Telecommunications Policy, but with a broader charter
- **Insist on the Appointment of a Recognized OIRP Head, with Tenure, who is Knowledgeable and Experienced on Pertinent Issues.**
- **Insist that the OIRP Head be Dual-Hatted as Head of the US Delegation to Major International Telecommunications Union Conferences (including the World Radio Conference)**
  - Similar to the United States Trade Representative

Summary of Recommendations: continued

Update DoD's Spectrum Policies

The ASD(C3I) and OSAM, supported by the Services, should assure that DoD's Spectrum Policies are based on the following key principles:

- **US Spectrum is a National Resource; DoD Needs must be Balanced against other National Needs**
  - DoD must be an integral part of the national team working to maximize the collective value of Spectrum use.
- **Spectrum is a Critical Resource to be Managed at Senior DoD Levels**
- **Military Capabilities, not Frequency Bands, Drive Spectrum Requirements**
  - Goals must be based on assured function, not spectrum ownership
  - Seek efficient use of Spectrum, sharing allocations intelligently except where DoD has unique requirements
- **Spectrum Certification is as an Essential Element of System Development**

Summary of Recommendations: continued

Update DoD's Spectrum Strategies

The ASD(C3I) and OSAM, supported by the Services, should:

- **Adopt a Proactive Spectrum Stance based on Military Capabilities**
- **Conduct an On-Going Inventory of Current and Future DoD Spectrum Requirements / Allocations based on Military Capabilities**
  - Necessary basis for planning Spectrum negotiations
  - Needed to justify DoD position in US allocation deliberations
- **Treat Spectrum Allocation as a Joint Issue**
  - Continue central strategy and policy emphasis
  - Move joint activities closer to War Fighters
  - Maintain close relations with Service Frequency Managers
- **Share Spectrum with non-DoD Users if Military Capabilities Benefit – Gain Access to non-DoD Allocations**
- **Incorporate Spectrum Certification in System Development Milestones**
- **"Re-Mine" Spectrum - Scrap Legacy Systems of Marginal Utility that are Inefficient Spectrum Users**

Summary of Recommendations: continued

Update DoD's Spectrum Tactics

The Office of Spectrum Analysis and Management and the Joint Spectrum Center should:

- **Continue Identifying all DoD Systems using RF Spectrum including Communications, Radar, EW, Sensors, Other Devices**
  - Identify why they operate at the frequencies they use
  - Identify Host Nation Agreements for each system
- **For Each System (Radio, Radar, Platform) establish:**
  - Military capability associated with the system
  - How "spectrum" is used by the system
  - System cost
- **Use Derived Database to:**
  - Identify/pursue sharing, leasing, bartering for spectrum
  - Justify frequency use, determine what to scrap
  - Understand implications of moves to new parts of the Spectrum as a result of reallocation
  - Provide data for simulation/modeling tools for E^3, deployment coordination

Summary of Recommendations: continued

Update DoD's Spectrum Tactics (cont'd)

The ASD(C3I) should:

- **Require Spectrum to be Addressed in System Acquisitions – An Explicit DAB Checkpoint**
  - Spectrum managers members of OIPTs (and Service Equivalents)
  - E3, in addition to spectrum certification
  - Test/Evaluation to include spectrum use and compatibility
  - Spectrum conservation / efficiency a metric for program management
- **Seek Access to Private Sector Spectrum as User with Equal Rights**
  - Military users now considered secondary users of commercial capabilities

Summary of Recommendations: continued

Empower DoD's Spectrum Organization

The Dep Sec Def should:

Elevate the Spectrum Management Directorate to report directly to ASD(C^3I)

- Perhaps a DASD(SM)
- Sec Def/Dep Sec Def should be the ranking office representing DoD in Spectrum matters, delegating responsibility to the Director
- The Spectrum Management Directorate should work closely with OSAM/JSC in establishing policy and representing DoD in national and international forums
- Adequately staff the Directorate to cover International, Policy and Programming, Planning and Technical Oversight activities

- **Assign OSAM and JSC to the "Information System Architect"**
  - SPACECOMM?
  - Role of OSAM in developing strategies for efficient Spectrum use, including sharing and dynamic allocation should be expanded to strengthen inter-Service sharing.
- **Retain the Service Spectrum Management Offices with responsibility for day-to-day mission planning and tactical operations**
  - Service SMOs should continue to be physically located with OSAM to enhance joint coordination

Summary of Recommendations: continued

Emphasize Spectrum Planning during System Development

The USD(AT&L) should institute and/or enforce the following policies:

- **Spectrum Management / Re-use / Conservation must be Performance Metrics for System Developers**
- **The OIPT (and its Service Equivalents) must Proactively Address Spectrum Issues at the Inception of Each Program**
- **Spectrum Utilization and E^3 Qualification must be Mandatory "Checklist" Items in DoD's Acquisition Process for all "Spectrum Use" Programs, including COTS**
  - This applies to each level in the acquisition process: JROC, DAB, DRB, EDRB, MCEB, SAE decisions,etc.
- **DoD Must, in conjunction with the IRAC, NTIA and the FCC, Develop New Criteria for Coordinating and Certifying Software Programmable and Configurable Radios**
- **DoD (and other US government entities) must face directly the Challenge posed by use of Software Programmable and Configurable Radio Technology in Foreign / Sovereign Territories**

Summary of Recommendations: continued

Support Research and Development to Meet Spectrum Use Needs

- **The DDR&E and JSC Should Establish / Enhance Research and Development Efforts in Five Areas:**
  - Best practices for applying known advanced spectrum technology applications in Defense systems
  - Improved modeling and simulation tools for determining frequency / terrain / time scheduling for real time, mobile, congested combat environments
  - Improved models for assessing RADHAZ to ordnance, systems and personnel operating in joint environments
  - Operational and technical methods for efficient Spectrum use through sharing and diversity, improved receiver characteristics
  - New technologies for spectrum sharing (e.g., polarization, multi-beam directional antennas)
- **Spectrum Research and Development should be Specifically Addressed in the DDR&E's Annual S&T Plan**

Summary of Recommendations: continued

Test and Evaluation Special Needs

- **Spectrum Needs must be Factored Into DOT&E Test and Evaluation Plans Early**
  - Spectrum certification compliance should be a pass/fail T&E item
- **The DOT&E must Incorporate Improved Telemetry Techniques that Use Less Spectrum with enhanced Fidelity / Reliability into Test Range Telemetry Systems**

Staffing and Awareness Special Needs

- **The Services should each Ensure that they have Frequency Manager Career Paths for Enlisted Personnel**
  - All Service frequency management personnel should receive deliberate, specific training for theater and tactical spectrum management, especially as applied to coalition operations
- **The Services should Provide for Periodic Updates to Spectrum Management Training to encompass Changes in Regulations, International Developments and New Equipment Capabilities.**
- **The USD(AT&L) and Services should Insert Spectrum Literacy Training into the Required Curriculum for all Acquisition Executive Training**
  - Require that Program Management trainees become "Spectrum Literate" during their Professional Military Education (e.g., ICAF, DSMC)

Terms of Reference Summary

The DSB Frequency Spectrum Management Task Force will determine:

- **Adequacy of DoD's Vision** for Frequency Spectrum
- **Adequacy of DoD's Strategy** for Exploitation of Commercial and Unique Technologies impacting Frequency Opportunities
- **Adequacy of Forecasted Spectrum Requirements** for JV2020
- **Adequacy of DoD's Processes** for Spectrum Requirements:
  - Requirements Identification and Allocation
  - Certification and Electronic Environmental Effects
  - National / International Participation
  - US Policy and Conflicts Resolution
- **Impacts of National Policy / Statutory Requirements** on DoD Spectrum
  - Worldwide Deployment, Training and Range Operations
  - Space-Based Systems
  - Battlefield Constraints

Study Perspective

- **The Goal of this Study is to Ensure that RF Spectrum Limitations do not Limit US Military Capability**
- **The Task Force finds Evidence that Spectrum Allocation Issues Threaten to Limit Future Military Capabilities**
  - DoD's Spectrum requirements are growing rapidly
  - Economic pressures for private sector Spectrum allocation are growing rapidly
  - DoD has suffered Spectrum loss
  - Technology is changing Spectrum use
  - International spectrum access is complex and increasingly contentious, complicating OCONUS deployment
- **DoD must have the Policy, Processes, Technology, and Organization to Assure that Spectrum Access does not Limit its Options**

Study Perspective

RF spectrum is a resource vital to today's military forces. In the past 10 years, the environment affecting spectrum management, within DoD, across the nation, and around the world, has become very complex and is evolving rapidly: many interests vie for this limited resource. Some observe that, with the end of the Cold War, the U.S. military does not need the entire spectrum allocated to it; unused bands should be auctioned off to the highest bidder. International spectrum allocations now differ significantly from those in the U.S. Most important, the basis of national spectrum management, in place for 66 years, is being threatened by new product and service capabilities.

U.S. defense strength will be seriously harmed if the Department and the nation fail to husband our country's spectrum resources in the most effective way.

The goal of this Task Force is to ensure that RF spectrum limitations do not constrain U.S. military capability. That includes understanding the procedural, economic, and technical dimensions of the rapidly unfolding spectrum environment. The Task Force perceives that the RF spectrum environment rate of change is now fast enough that DoD must act aggressively to get ahead of developments and not wait to react when they become contentious issues.

The Task Force finds evidence that spectrum allocation issues threaten to limit future military capabilities:

- DoD's own spectrum needs are growing rapidly as new, "smart" RF technologies are applied in new systems. Sensor, communication, radar, and positioning systems are now being deployed that have expanded capabilities – but that also require expanded spectrum.

- Economic pressures for reallocating DoD spectrum to private use are growing rapidly as the same technologies that underpin leading-edge military systems enable attractive, inexpensive commercial, consumer, and professional products. Hundreds of millions of Americans now use wireless telephones routinely; untethered broadband data applications will be coming soon.

- DoD has suffered from spectrum loss during the past decade. This erosion is now in remission, but it threatens to re-emerge.

- New RF technologies are changing spectrum use. Established spectrum management practices are not adequate to deal with technology-based challenges to today's fixed allocation model.

- International spectrum access for U.S. forces operating abroad is complex and is becoming increasingly contentious as other regions, including traditional U.S. allies, go their own way in spectrum allocations.

DoD must be able to meet its spectrum needs to ensure U.S. military might.

The Task Force concludes that DoD must have the policy, processes, technology, and organization to ensure that spectrum access does not limit its military options. DoD must get ahead of spectrum change in order to prevail.

Spectrum Access is Essential for Military Operations

- **Wireless Communications, Radar, EW and Intelligence all are major spectrum users.**
  - Un-tethered Communications are essential to Dispersed Warfare called for in present and future warfare plans
  - DoD has a huge inventory of equipment and systems that are tied to the RF spectrum: over 800,000 active radiating units worth $100B.
- **DoD is No Longer Able to Meet its Domestic and International Spectrum Needs Easily**
  - Competing demands from the private sector and economic and political pressures have weakened DoD's dominance in the US.
  - Other nations are aggressively asserting their sovereign rights to manage their own spectrum, complicating OCONUS deployments
  - Many believe DoD is inflexible and hoarding spectrum

Spectrum Access is Essential for Military Operations –

Military operations rely on untethered communications, radar, EW, avionics, global positioning, and signals intelligence. All these, in turn, depend on RF spectrum access. Without that access, we do not have a modern military force. Wireless communication is particularly critical for the dispersed warfare contemplated in future concepts such as Force 21, the Army After Next, the Expeditionary Aerospace Forces, and the Marine Expeditionary Forces.

Over the years, the Department of Defense has invested heavily in spectrum-using equipment. The inventory now contains more than 800,000 RF emitters worth over $100billion and growing. Changing operating frequencies for equipment in this inventory can be expensive. Yet DoD's ability to gain access easily to the spectrum it needs for operations, both in the U.S. and abroad, is threatened. Fulfilling future U.S. military needs is likely to become more difficult.

In the past, the military was the nation's largest spectrum user and dominated U.S. spectrum allocation considerations. Military national security needs had a preeminent claim on spectrum resources. Now that the Cold War has ended, however, the dynamics of spectrum allocation are shifting:

- DoD's need for spectrum is escalating rapidly as "information superior" forces become real and deploy.
- Rapid growth in public demand for broadband wireless electronics is creating new private sector demands for spectrum access linked to economic growth that compete for military spectrum allocations.
- Many in the commercial world and in other government departments believe DoD is hoarding spectrum it does not need and is an inefficient user.
- Spectrum has come to be seen by some as a public asset to sell to reduce the national debt.
- Other nations are becoming aggressive in asserting their sovereign spectrum rights and are choosing wireless communications services as the backbone infrastructure for economic development. Their spectrum allocations differ substantially from those used in the U.S. Because OCONUS deployments of U.S. forces require spectrum coordination with host and surrounding nations, this complicates U.S. military operations abroad.

RF spectrum is a limited natural resource. Increased demands by military, private sector, and international users for access mean that DoD must act to ensure a spectrum-enabled U.S. military capability.

Spectrum-Based Information Infrastructure Lies at the Core of 21st Century Military Superiority

Source: Tactics and Technology for 21st Century Military Superiority, Defense Science Board, October 1996

A Spectrum-Based Information Infrastructure Lies at the Core of 21st Century Military Superiority

The technology section of the Defense Science Board's 1996 study, *Tactics and Technology for 21st Century Military Superiority*,[1] detailed operations needs of future military forces. This diagram illustrating the Board's findings clearly shows the central role of a tactical information infrastructure in the effectiveness of these forces. This infrastructure, which is heavily radio-based and thus spectrum access dependent, links all other force elements. If the information infrastructure does not work in a reliable and timely manner, there is no force. Remote fires, intelligence, logistics, global positioning, satcom, and medical support, all necessary for force survival, and command and control, will fail.

Because the information infrastructure operation hinges on RF spectrum access, spectrum is on the list of "must have" assets for today's and future forces.

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[1] Report of the Defense Science Board 1996 Summer Study Task Force on Tactics and Technology for 21st Century Military Superiority, Office of the Secretary of Defense, October 1996.

Military Spectrum Requirements are Growing Rapidly

- **Information Superiority, called for in JV2020, is driving ever greater bandwidth requirements**
  - New systems require more spectrum for improved functions; synthetic array radars can require more than 1 GHz bandwidth
  - Wireless systems becoming more widespread in the force
  - Coalition operations require additional Spectrum to accommodate allied equipment
- **DoD Requirements are based on War Scenarios, even in Peacetime**
- **The "Train As You Fight" Doctrine means that Spectrum Use during Training Exercises and Test and Evaluation should approximate Combat Needs**
- **Some Allocations reflect Unique DoD Needs (e.g., propagation, radar signatures, foliage penetration)**

Military Spectrum Requirements are Growing Rapidly

DoD's appetite for spectrum is large and growing, driven by the need for "information superiority" called for in JV2020.[2] New systems generate broadband signals and are becoming widespread as the Services modernize to fulfill the vision of future Army, Navy, Air Force, and Marine forces.

- U.S. future forces will be information-centric and will rely on spectrum-intensive systems. Modern systems, such as synthetic array radars, require much more bandwidth than their older counterparts.

- U.S. military spectrum requirements are based on wartime scenarios, even in peacetime, since the delay and disruption of reclaiming spectrum in a national emergency make such recovery impractical.

- U.S. forces must train as they fight. Spectrum requirements for training and test and evaluation (T&E) approximate wartime usage.

- DoD has special spectrum needs for propagation, radar signature, foliage penetration, and other situations.

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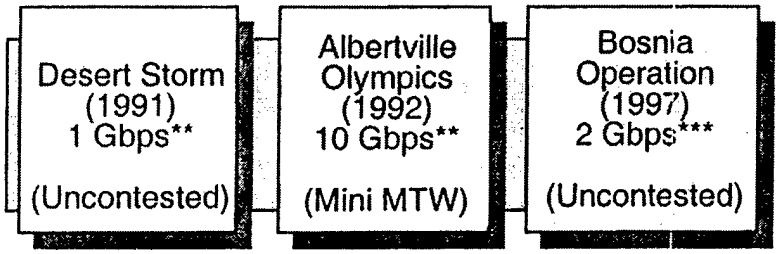
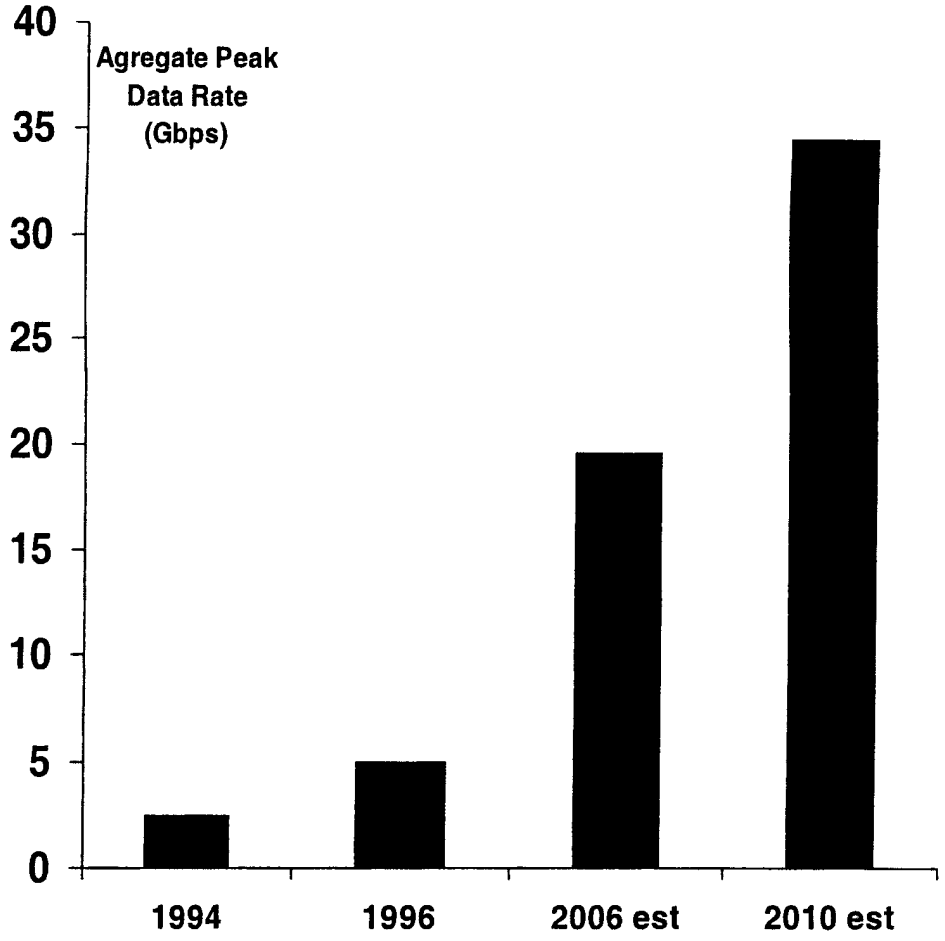
[2] Joint Vision 2020, Director for Strategic Plans and Policy, J5, June 2000.

DoD Information Requirements are Growing Exponentially[1]

- CMA* Extrapolated (2010)
  - ~1.75X growth over prior estimates for 2006
- Major drivers
  - Imagery and video
  - Computers and telephones
- Includes most theater reachback, long-haul intra-theater, and some brigade and below





Sources:* C4ISR Mission Assessment (CMA) Study - 1997 - ASD (C4I)/J6 - Study Director: Richard L. Mosier,

**** JASON Global Grid Study - 1992 ***** JCS/J6**

[1] after DSB Report, Tactical Battlefield Communications, 1999

DoD Information Requirements are Growing Exponentially

The 2000 Defense Science Board report, Tactical Battlefield Communications,[3] estimates total information requirements growth for the two Major Theater War (MTW) scenarios for the next decade. The report's conclusions are based on war or equivalent operations in Desert Storm, the Albertville Olympic Games, and Bosnia as well as DoD projections of future warfighter information requirements.

The report concluded that DoD's operational information requirements growth rate exceeds 18percent per year. The Kosovo campaign experience, which became available after the Tactical Battlefield Report was complete, is 6 to 8 Gbps on the projected growth curve.

- While information rates do not translate directly into RF bandwidth (since some bits are transmitted by fiber or wire and spectrum can be reused through use of spatial diversity), the exponential growth rate will inevitably result in rapid growth of military RF spectrum needs. Additionally, radar, EW, and other spectrum-using system bandwidths are also increasing.

- One recent Department of Commerce report estimated military spectrum growth over the next 10 years to be 70 percent.[4]

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[3] Report of the Defense Science Board Task Force on Tactical Battlefield Communications, Office of the Under Secretary of Defense for Acquisition, Technology & Logistics, February 2000.

[4] Federal Radar Spectrum Requirements, US Department of Commerce, NTIA Special Publication 00-40, May 2000.

At the Same Time, Private Sector Spectrum Pressures Mount:

- **New Wireless Communications Products are creating Compelling, New Spectrum Access Demands**
  - High performance RF device technologies now inexpensive, widespread and readily available
  - Number of cellular users growing rapidly; now 100M in US
- **Bandwidth of Wireless Subscriber Services growing rapidly**
  - 1980's: Kilobits / sec (cellular telephone)
  - 1990's: 10's of Kilobits / sec (Internet access)
  - 2000+: 100's of Kilobits / sec (Intelligent Network Space / Terrestrial Systems)
- **Spectrum is a Scarce Asset with a Large Market Value**
  - Spectrum auctions have ratified this value
- **Emerging Nations opting for Wireless in lieu of Wired Communications Infrastructure**
  - Wireless growth greatest abroad: 1.26 B cellular users worldwide by 2005
  - Regional allocations differ
  - Other countries' spectrum policies better organized than the US

At the Same Time, Private Sector Spectrum Pressures Mount

Private sector spectrum demands are growing even more rapidly than military needs.

- New wireless communications services, such as cellular telephones, have attracted hundreds of millions of users. Cellular phones are even replacing some wireline telephones in many locations.

- The same inexpensive, high-performance RF and micro computing technology that drives military system advances also spurs the explosive growth of economical, attractive consumer products for control and communication.

- Both the number of subscribers to wireless services and their bandwidth requirements are expanding. The introduction of untethered Internet access such as international mobile telephone (IMT) and Ricochet is driving user information rates from Kbps 10 years ago to hundreds of Kbps in the next decade.

- Spectrum is now seen as a scarce asset with substantial market value. The U.S. spectrum auctions of the 1990s and similar spectrum sales abroad have confirmed that value and have put in place spectrum ownership rights difficult to reverse should reallocation ever be necessary.

- Wireless communication infrastructures are much less expensive to install than wired networks. Developing nations (e.g., India) have chosen

- Substantial wireless national communication grids to rapidly and inexpensively supply information services needed for economic growth. The number of worldwide cellular subscribers is expected to reach 1.4billion by the year 2005.[5]

- Compared to the United States, other nations, both developed and developing, understand their national spectrum priorities and have established policies accordingly.

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[5] Strategy Analytics, Worldwide Cellular Markets 2000-2005, February 2000.

US Spectrum Management - Background

- **US Manages Spectrum According to Practices Established in 1934**:
  - The process is slow, exacting, legally strict and deliberate
  - Spectrum allocations are regarded as "owned" assets – rarely revoked
- **Allocations are Determined *A Priori* and Fixed**
  - Based on past analog communications needs
  - Ample spectrum assumed; liberal guard-bands
  - Frequencies and modulation determined by hardware
  - Bands based on type of service (broadcast, aeronautical, marine, industrial, government, . . .)
  - Receivers protected at the expense of Spectrum efficiency
- **DoD was Once "Understood" to be the Dominant User**
  - Separate allocation processes for government and private sector users
- **US Allocations were Originally Assumed to Apply Worldwide**
- **DoD manages Spectrum in accordance with these Principles**

U.S. Spectrum Management Background

U.S. spectrum management practices originated with the Communications Act of 1934, which established a schism between federal government and private sector/ public safety spectrum allocations. The Act established the FCC, an independent regulatory agency concerned with non-federal communications, and laid the groundwork for Code of Federal Regulation (CFR) 47, the regulations governing U.S. communications today.

In 1934, radio communications were very different from today. Signals were transmitted in Morse code or AM and FM signals. Inflexible hardware determined operating frequency, output power, and modulation types for each transmitter.

The primary goal of the 1934 Act was deconfliction of transmitters, thereby protecting receivers from interfering signals. Spectrum was plentiful, so generous guard-bands isolated individual, fixed frequency channels.

The Act established a legal and procedural framework for spectrum allocation that was leisurely, deliberate, and legally strict. Allocations, granted "a priori" – (before use), were fixed in frequency and location and came to be regarded as fixed assets, "owned" by licensed users. Although formally granted for limited terms, renewal is often assumed. Television channels, for instance, are considered the principal asset when TV stations are bought and sold. Standards for allocation renewal are based on minimum standards of broadcaster service.[6]

The U.S. government uses the same paradigm for allocation of spectrum assigned to government users, although spectrum for government use (including DoD) is allocated by a separate organization – now the NTIA in the Department of Commerce.

In 1934, the U.S. military was a dominant spectrum user. Since the United States was the first country to so organize its communications activities and was the model for other nations, U.S. allocations were generally assumed to apply globally.

DoD, along with the rest of the United States, still manages spectrum in accordance with the 1934 principles. The Department regards its allocated spectrum as its property.

[6] FCC Regulations, Part 27. Generally, licenses are renewed in comparative proceedings if 1) the applicant has provided "substantial" service during its past license term (substantial is defined in Section 24.16 as service that is sound, favorable and substantially above a level of mediocre service that might just minimally warrant renewal); 2) the applicant has substantially complied with applicable FCC rules and policies and the Communications Act.

Today's Spectrum Management Environment is Evolving:

- **Technology Advancements are Altering Spectrum Use**
  - Radar, EW, Sensors, GPS, Intelligence plus Broadband Communications
  - Analog being supplanted by digital systems
  - Flexible system performance no longer tied to fixed hardware capabilities
  - New signal characteristics allow spectrum sharing (cellular, CDMA, TDMA)
- **Private Sector Demand for Spectrum is Huge and Growing**
  - Telecommunications now 5.6% of US GDP; 207M US cellular subscribers by 2005
  - Ubiquitous wireless communications, broadband Internet connectivity (IMT, Ricochet)
  - Inexpensive wireless products for communications and control (Bluetooth,)
  - Wireless alternatives to wired infrastructure (FWA, Satcom)
- **"National Security" has been Redefined to Include Economic Well-Being**
  - "Military Security" no longer a trump card in allocation decisions
- **Other Countries are Aggressive Spectrum Users**
  - Cold War hegemony gone; strong regional allocation differences have arisen
- **DoD Spectrum Demand is Growing Rapidly**
  - Satcom up 500% by 2010; other requirements up significantly

Today's Spectrum Management Environment Is Evolving

Today's spectrum management environment differs substantially from that envisioned in 1934.

- Technology advancements are altering spectrum use. Individual system bandwidths are expanding in response to the needs of spread-spectrum, low probability of detection modulation, high-resolution synthetic array radars, global positioning, and electronic warfare. Each of these spectrum applications requires much more spectrum than its predecessors.

Digital techniques are replacing analog transmission. This shift enables significant changes in transmission and processing of voice and data signals

Flexible RF systems are becoming software-configurable and are no longer tied by hardware to specific frequencies or waveforms.

New communications system technologies, such as those used in cellular and packet switching applications, and digital modulation such as Code Division Multiple Access (CDMA) and Time Division Multiple Access (TDMA), allow many users to share frequencies without interfering with one another.

- Private demands for spectrum are large and growing. Telecommunications now provides 5.6 percent of the U.S. Gross Domestic Product (GDP) and the number of U.S. cellular subscribers is expected to grow from 100 million now to 207 million in 2005.

Additionally, subscribers expect wireless services beyond voice channel connections. Untethered broadband data services, such as Ricochet, and replacements of parts of the telephone local loop by Fixed Wireless Access (FWA) connection will generate new private user demands. New control standards such as Bluetooth promise still greater expectations.

Costs of these new wireless consumer products are low, made possible by microwave devices developed for military applications.

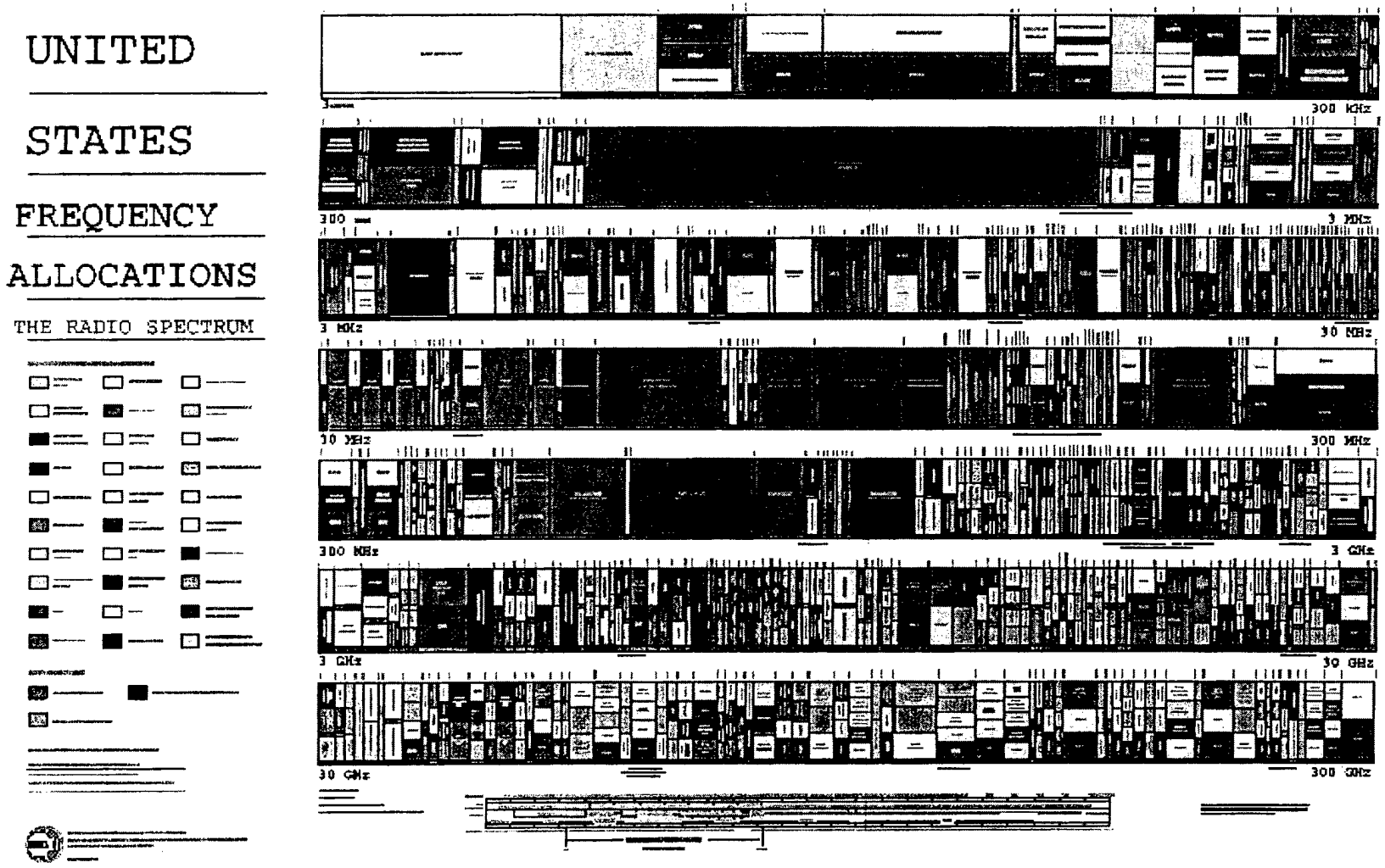
- The U.S. concept of "national security" is changing to a new balance between military and economic security.

- Other nations (e.g., South Africa), encouraged by low wireless system costs, are rushing to install wireless communications infrastructures to speed national economic development. Spectrum abroad, once largely unused, is now becoming crowded.

During the past 66 years, RF technology advances kept up with expanding demands for spectrum. As needs arose, new spectrum became available as reliable, inexpensive microwave and millimeter wave devices capable of operating at higher frequencies became available. The result was spectrum "Manifest Destiny"– applications arose to use new spectrum.

Now, however, the upward expansion of the RF spectrum has reached its practical limit as propagation limits halt future frequency expansion. The era of spectrum Manifest Destiny is coming to an end.

Spectrum Allocation is Often Thought to be One-Dimensional



Source: NTIA Website

Spectrum Allocation is Often Thought to be One-Dimensional

Many spectrum managers conceive of spectrum allocation as a one-dimensional process. This chart[7] of U.S. spectrum allocations clearly shows the density of frequency assignments. Thirty services are allocated spectrum in 450 bands extending from 9 KHz to 300 GHz. The battle for new allocations for future military systems and commercial products is an intense one, made more so by the unchanging nature of existing allocations.

[7] National Telecommunications and Information Administration, www.ntia.doc.gov/osmhome/allochart.html

The Spectrum Resource has Four Dimensions:

1. **Operating Frequency**
   - Once fixed by hardware, operating frequency is becoming software programmable by the operator or the system over a broad range (2 MHz to 2 GHz for JTRS)
   - Radios and radars (F-22) are frequency agile and broadband
   - Past advances in RF technology extended the usable frequency range into the microwave and millimeter wave range, keeping up with new user demands. Now, however, beginning to reach the limits of useful RF spectrum.
2. **Time (Duration)**
   - RF systems now transparently change channels in mid-transmission
   - "Smart" radios in development "sniff" the spectrum for open frequencies
   - TDMA and packet switching radios share channels by time multiplexing

The Spectrum Resource Has Four Dimensions (cont'd):

3. **Space**
   - Real-time RF output power controls limit transmitter range in real time
   - Antennas (such as electronically steerable arrays) can limit transmission to specific directions
4. **Modulation**
   - The rise of digital transmission has led to many new modulation / multiple access techniques: CDMA, TDMA, spread-spectrum, frequency-hopping
   - Some of these allow simultaneous users to share frequencies

- **Managing the Time, Space and Modulation Dimensions of Spectrum Increases Use of Scarce RF Spectrum Resources**
  - Control in real-time, sharing through separation in time, space and modulation, is more efficient than fixed allocation
  - Real time system controls dynamically assign frequencies to assure communications (cellular, trunked radio) allowing a multitude of users

The Spectrum Resource Has Four Dimensions

Spectrum management involves balancing four factors: operating frequency, time, space, and modulation. Frequency, time, and space have long been important considerations; however, they have generally been stationary or slowly changing factors in assigning spectrum use.

Technology now being deployed in new systems makes spectrum use optimization possible in real time through frequency agility (e.g., JTRS), dynamic channel and time slot assignment (e.g., trunking and TDMA), power control to limit transmitter range (e.g., cellular telephone), and mutually non-interfering modulation (e.g., CDMA). Done in real time, this optimization requires organization under a supervisory system in each instance. The dynamic nature of real-time spectrum management makes possible higher levels of spectrum utilization than can be obtained under a fixed assignment regime.

The Notion of "Spectrum" is Changing

- **User "Ownership" Rights to Specific Frequencies are becoming Out of Step with Modern Communications Practice**
  - Modern communications systems assign frequencies (cellular) and time slots (packets) during transmissions – the system controls assignment
  - Software programmable radios and radars are not limited to specific frequencies and modulation types
  - Improved sharing technology (e.g., TDMA, CDMA, dynamic power control) raises prospects of multi-user channels
- **Faster OPTEMPO places Demanding Requirements on Frequency Managers for Rapid Assignments, Anywhere in the World.**
- **Future Military Information Demands cannot be met using Purely DoD Spectrum**
  - Future spectrum use may be driven by common defense/commercial technology and systems – DoD already a major common carrier user
  - Private and public demands for spectrum may force sharing in hotly contested bands

The Notion of "Spectrum" Is Changing

The shifting spectrum environment forces changes in the notion of RF spectrum.

- The 1934 concept of quasi-permanent user "ownership" of spectrum assignments has been overcome in many instances by a "common carrier" model wherein user frequency, time-slot, transmitter power, and characteristic code are transparently assigned by a system. The system manages each of these user characteristics in response to user operation to ensure user service without resorting to fixed frequency/time-slot/code assignments permanently dedicated to each user.

  The system is the spectrum assigner; it makes no difference whether the user is military or civilian.

- The system technology that is the basis of such dynamic allocation systems is made possible by a host of revolutionary signal processing, software, RF, antenna, and modulation developments over the past 30 years.

- U.S. forces increasingly must deploy from continental U. S. (CONUS) bases to OCONUS operating areas. When deployments are ordered, joint and Service frequency managers are called upon to negotiate spectrum access with host and surrounding nations before the deployment can proceed. The pressures of increased OPTEMPO, and differing spectrum allocations abroad place a premium on frequency agility for operational systems to adapt to foreign spectrum environments.

- DoD's information needs, and hence its spectrum requirements, can no longer be met using only DoD spectrum allocations. The Department is already a major user of commercial satellite communications (satcom), cellular telephone, and mobile services. DoD's use of common carrier wireless services blurs the traditional distinction between federal government and private sector spectrum; DoD is now a user of both. To the system, all users are the same – it operates in each instance to ensure user function.

DoD's Practices Must Reflect the Realities of 21st Century Spectrum Management.

It Must:

- **Push for Development of a National Spectrum Policy which Balances Military with Economic Security**
- **Clearly Understand its Spectrum Needs; Develop Effective Departmental Policy, Strategy and Tactics**
- **Organize to Effectively Manage its Spectrum**
- **Coordinate Spectrum Use for New and Upgraded Systems Early in the Development Process**
- **Perform Research and Development into Spectrum Efficient Technologies**
- **Support Solutions to DoD Unique Needs**

DoD's Practices Must Reflect the Realities of 21st Century Spectrum Management

Spectrum is a limited resource. Given the importance of RF-based systems to military operations, DoD's rapidly growing bandwidth requirements and the private sector's hunger for access, growing assertion of foreign nations' spectrum rights, and the shifting notion of spectrum as an asset, DoD must adapt its management practices to reflect current realities.

The Task Force has identified six action areas:

1. Develop a U.S. national spectrum policy that balances military and economic security. This policy should bridge the gap between the federal government spectrum responsibilities of the NTIA and the FCC's private sector/public safety allocation duties. Further, this policy must ensure that the United States has the most effective possible representation in international spectrum negotiations.

2. DoD must gain a better understanding of its spectrum needs and use that understanding as the basis for policies, strategies, and tactics that ensure availability of spectrum needed for U.S. military capabilities. DoD must husband its spectrum and use it efficiently.

3. DoD must organize to implement its spectrum policies, strategies, and tactics effectively by raising policy considerations in the DoD leadership hierarchy and moving strategy and tactics as close to the warfighter as possible.

4. DoD must ensure that its new and upgraded systems use RF spectrum in ways that do not interfere with other systems, public or private, and are deployable outside the U.S.

5. DoD should support research and development into technologies that improve its use of RF spectrum.

6. DoD must attend to its unique spectrum needs in test and evaluation, operational force training, and spectrum management skills.

National Spectrum Policy - Findings

- **The United States of America Lacks a National Spectrum Policy / Strategy**
  - No clear frequency management governance addresses conflicting military and economic allocation initiatives; comparative analysis of allocation alternatives does not exist
  - National and International Spectrum Policy divided among FCC (a regulatory commission), the NTIA (part of the DoC) and the Department of State; no single point of oversight
- **No Well-Articulated, Single Voice at the International Level**
  - Each ITU and Regional Conference is a learning experience
  - Head of Delegation to the World Radio Conference is a short-term appointment who does not participate in many preparatory deliberations

National Spectrum Policy – Findings

The United States is unique among nations in that it lacks a national spectrum policy. Responsibility for spectrum allocation and international spectrum negotiations is split among the NTIA (federal government), the FCC (private sector and public safety), and the Department of State (international negotiations). These entities are only loosely coordinated through informal liaison – no overall U.S. spectrum policy exists that balances military and economic considerations.[8] [9]

U.S. representation at ITU gatherings is haphazard. The U.S. Head of Delegation for the WRC is a short-term appointee for each conference, named as the U.S. position is being finalized. Each conference is a new learning experience.[10]

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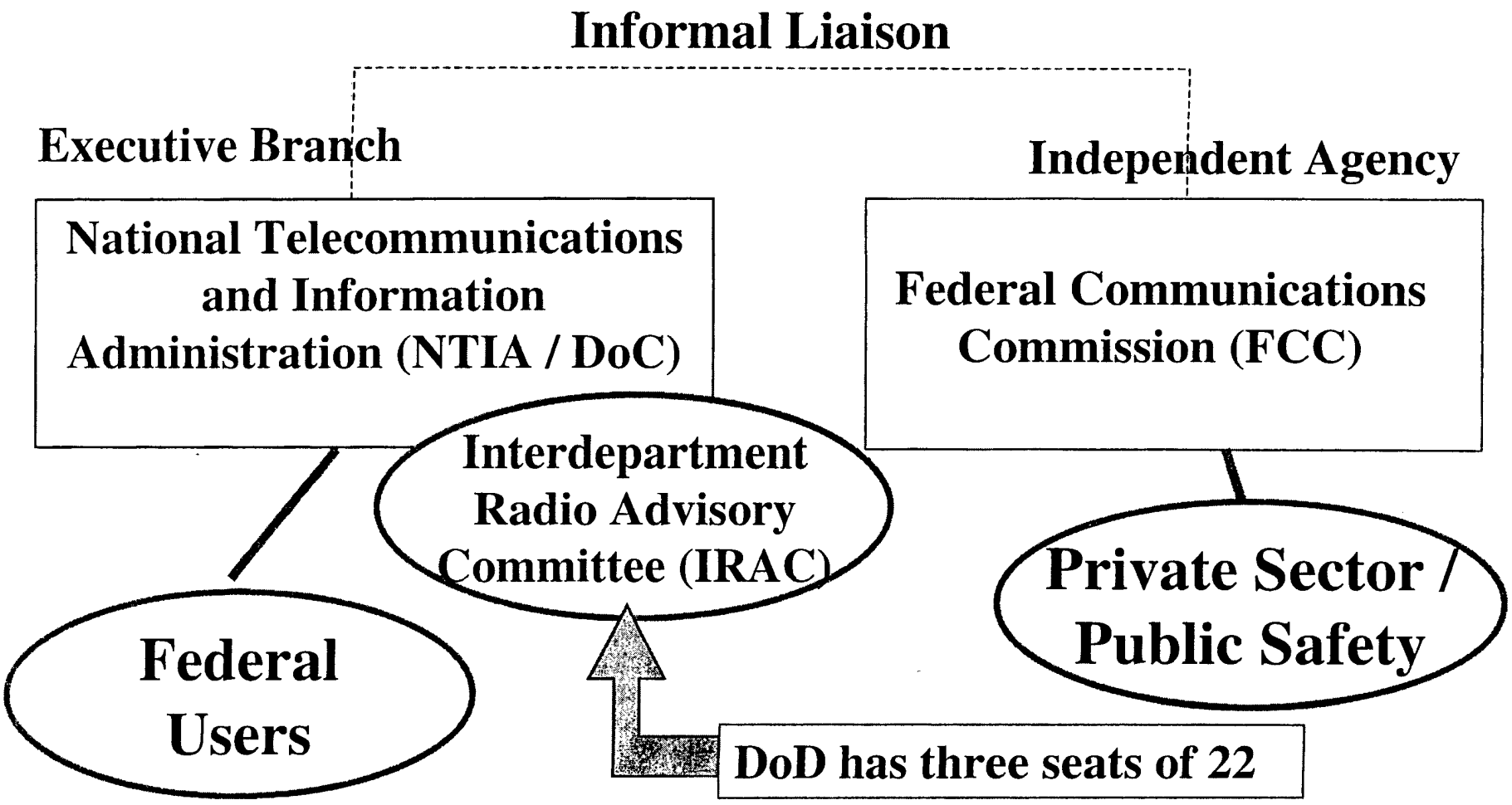
[8] Lt. Col Pimentel, USAF, National Security Council, briefing to the Task Force.

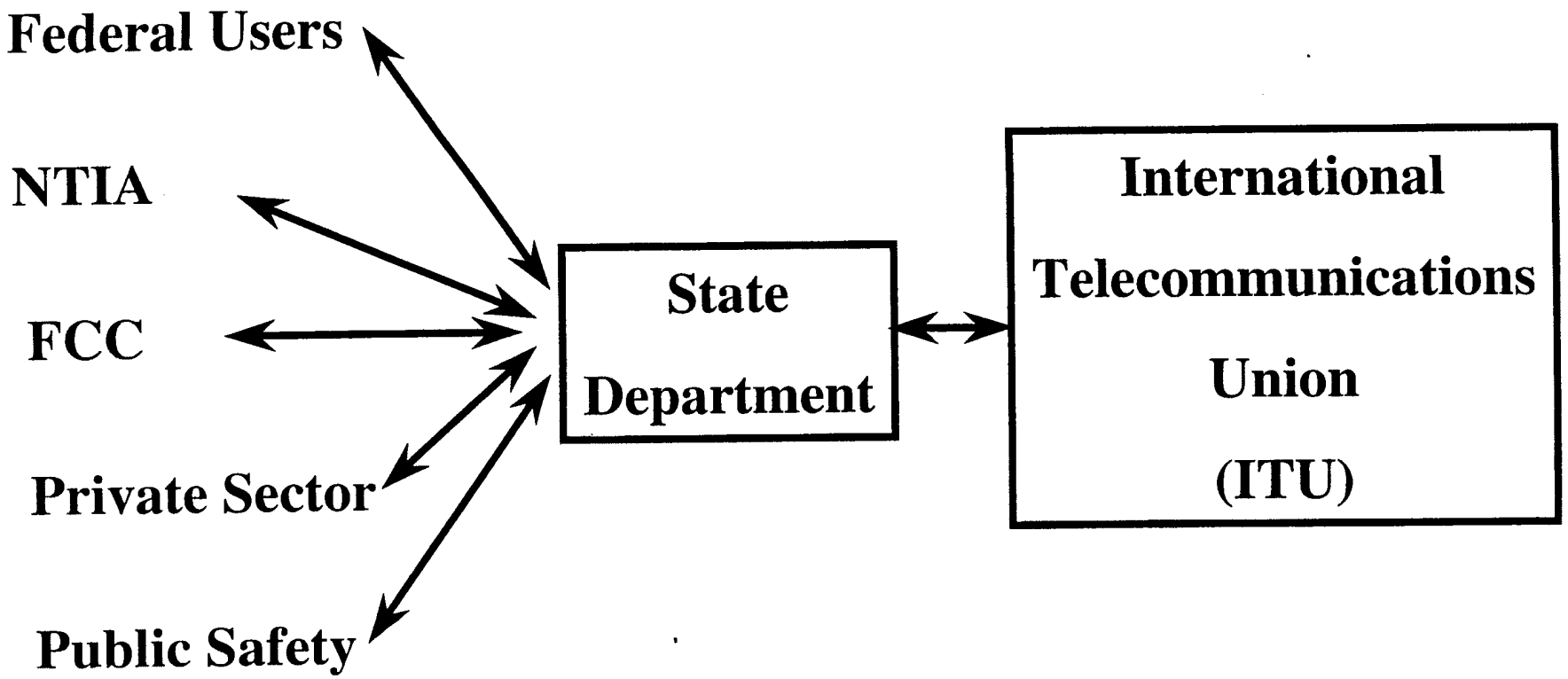
[9] See 98th Congress, 1st Session, S. 999, "To Amend the Communications Act of 1934 to provide for international telecommunications . . ." Title II, April 7, 1983.

[10] Raiford, Cindy, "United States Domestic Preparatory Process for the International Telecommunications Union (ITU) World Radio Conferences (WRCs)," unpublished manuscript, April 1998.

US Government Spectrum Management Structure



US Government and International Spectrum Management



National Spectrum Policy - Findings

- **Defense's Voice in the National Spectrum Dialogue is Disproportionate to its Importance as a User**
  - Navy, Army and Air Force are but three members of the 22-member IRAC which coordinates US government spectrum allocations, reporting to the NTIA. NTIA informally coordinates with the FCC
- **Commercial Influence in Spectrum Matters is Powerful**
  - Established commercial entities (e.g., broadcasters, manufacturers, private mobile, and satellite licensees) wield significant political influence, resist re-assignments or incursions, and push for new service allocations
  - Spectrum sales (e.g., auctions) seen as a means to raise funds to reduce the national debt and promote economic growth

National Spectrum Policy - Findings

DoD's influence in the U.S. national spectrum debate is less than its importance as a spectrum user. The Interdepartmental Radio Advisory Committee (IRAC),[11] which coordinates federal government spectrum use, consists of 22 representatives of departments throughout the U.S. government. DoD occupies three IRAC seats assigned to the Army, Navy, and Air Force.[12] NTIA coordinates informally with the FCC.

While DoD's national spectrum influence is relatively weak, the influence of commercial interests seeking spectrum is strong. Broadcasters, equipment manufacturers, common carriers and FCC licensees all wield significant influence through Congress and the Administration. They are not reluctant to use their clout to further their interests. Further, multinational corporations frequently have their representatives as part, not only of U.S. delegations to international meetings, but as members of other countries' delegations as well.

In 1994, the U.S. adopted the practice of selling spectrum rights to raise money to pay off the national debt. Some of the spectrum sold had been allocated to DoD in the UHF portion of the spectrum and was a serious loss to military operations, in terms of both capability and cost to relocate military users to new frequencies.

No further spectrum auctions are planned; however, the possibility remains that Congress will resume sales.

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[11] Manual of Regulations and Procedures for Federal Frequency Management, United States Department of Commerce, (2000 edition).

[12] The other IRAC members are the US Postal Service, General Services Administration, the Veterans Administration, Federal Emergency Management Agency, State Department, Commerce Department, Health and Human Services Department, Federal Aviation Administration, Treasury Department, Coast Guard, Justice Department, Interior Department, Agriculture Department, National Science Foundation, National Aeronautics and Space Administration, Broadcasting Board of Governors, and Energy Department. Additional nonvoting members represent the FCC and the NTIA.

National Spectrum Policy – Recommendations

The Sec Def / Dep Sec Def should:

- **Push, together with DoD's Industry Association Allies (e.g., AFCEA, EIA), to Establish a White House Office of Information Resource Policy (OIRP)**
  - Serves as the focal point for US National Spectrum Policy and Strategy, analyze National consequences of allocation changes
  - Similar to the former Office of Telecommunications Policy, but with a broader charter
- **Insist on the Appointment of a Recognized OIRP Head, with Tenure, who is Knowledgeable and Experienced on Pertinent Issues.**
- **Insist that the OIRP Head be Dual-Hatted as Head of the US Delegation to Major International Telecommunications Union Conferences (including the World Radio Conference)**
  - Similar to the United States Trade Representative

National Spectrum Policy - Recommendations

Lack of a U.S. national spectrum policy focus is detrimental to the long-term security of the United States. Spectrum sales and frequency reallocation from DoD to other users have cost DoD over 400 MHz in high-value bands since 1992.[13] As long as the NTIA and FCC remain independent of each other, there is no national mechanism capable of balancing military needs and economic pressures to reassign spectrum to economic growth opportunities.

The Task Force recommends that the Secretary of Defense and Deputy Secretary of Defense (SECDEF/DEPSECDEF) push, together with DoD's industry association allies (e.g., AFCEA, EIA), to establish a White House Office of Information Resource Policy (OIRP), modeled on the former Office of Telecommunications Policy. This office should develop the overall U.S. spectrum policy, bringing the NTIA, FCC, and Department of State under a common policy framework. Further, the OIRP should be the focus for setting U.S. international spectrum negotiating positions,

The head of OIRP should be an experienced spectrum policy professional who should also serve as the Head of Delegation to the World Radio Conference and other ITU spectrum negotiations.[14] This concept is similar to the U.S. Trade Representative, a position well supported by U.S. industry.

[13] Borky, Michael, AFSAB Spectrum Management Quick Look Study, briefing, November 1999.

[14] Raiford, Cindy, "United States Domestic Preparatory Process for the International Telecommunications Union (ITU) World Radio Conferences (WRCs)," unpublished manuscript, April 1998.

DoD Policy, Strategy and Tactics - Findings

- **Spectrum Access is a key enabler for JV2020 Information Superiority, yet Spectrum Issues are Not Well Understood throughout DoD**
  - Spectrum management is viewed as complicated and arcane
  - DoD has unique spectrum needs constrained by physics (e.g., propagation, radar target signatures, foliage penetration)
  - Developmental system spectrum coordination regulations often not followed
  - Forces in the field sometimes ignore spectrum allocations
- **The International Spectrum Environment is growing More Complex**
  - Number and OPTEMPO of international deployments increasing
  - International spectrum usage is a treaty / status of forces issue
  - Coordination necessary before US forces can deploy

DoD Policy, Strategy, and Tactics – Findings

"Spectrum happens." Spectrum access is taken for granted by many in DoD, yet it is a critical vehicle for the information superiority called for in JV2020. Many operational commanders assume their forces will not be affected by lack of spectrum access; spectrum issues are addressed late or not at all in the new systems development process. Yet aerial refueling operations during the Kosovo campaign were affected by failure to coordinate a new refueling navigation system for the KC-135 Enhanced Tactical Collision Avoidance System (E-TCAS) and intelligence operations had to be curtailed because of the possibility of interference from neighboring country commercial broadcast signals.

Spectrum management is generally regarded as complex and arcane. One look at an allocation chart quickly confirms this view. Terminology, technical considerations, and the entanglement of national, regional, and global rules, regulations, and agreements can be daunting to one not steeped in spectrum matters. Forces in the field sometimes overlook spectrum use constraints and interfere with friendly country radio services.

Spectrum is not an issue on the agenda of most DoD leaders.[15]

Spectrum use constraints are a particular problem for OCONUS deployments. International spectrum usage is governed by treaty and status of forces agreements with allied nations. Coordination must be undertaken before U.S. operational forces can deploy abroad. This can be a complex negotiation in light of the number and variety of U.S. systems and the intensity of spectrum use by some nations, especially if there is no prior status of forces agreement.

[15] One notable exception was DepSecDef John Hamre, who made spectrum an issue of personal interest.

Today's DoD Spectrum Policy - Findings

- **Spectrum Critical to DoD Operations**
- **Aggressively Defend Existing DoD Allocations in the US; Organize for the "Spectrum Battle"**
  - A reactive policy driven by external demands on DoD Spectrum
  - Participate in National and International allocation processes to defend Defense needs
  - Avoid Spectrum sharing
- **Certify New System Spectrum Use during the Acquisition Process**
  - Embedded in 5000-series regulations
  - Failures to enforce these regulations have resulted in deployment problems for E-TCAS, Global Hawk and other systems

Today's DoD Spectrum Policy - Findings

DoD's current spectrum policy is based on several principles:

- Spectrum is critical to DoD operations
- A vigorous defense must be mounted to counter any attempt to reallocate DoD spectrum. This principle leads to a reactive strategy, coming into play in response to assaults on DoD spectrum holdings.
- Participate as a national security advisor in national and international allocations processes to uphold Defense allocation positions. The DoD representative, however, was not party to discussions that established daily U.S. negotiating positions at the WRC.
- Avoid spectrum sharing on the basis that, once started, sharing leads to ultimate loss of control of the shared spectrum.
- Certify new and upgraded systems for spectrum use and E^3. Certification is embedded in DoD's 5000 Series acquisition regulations. However, it is often overlooked and, if it is addressed at all, this occurs late in the system development cycle.

Today's DoD Spectrum Strategy - Findings

- **Spectrum Requirements Study covering Current and Future Defense needs**
  - Concern that a comprehensive inventory would be a "target" list for Spectrum predators
- **Maintain Databases covering International and US allocations and Tools to Support their Use**
  - Joint Spectrum Center database inevitably lags National and International Allocations
- **Use the "National Security" Argument to Prevail in Allocation Disputes**
- **Insist on Compensation in case of Reassignment**
  - In FY99 Defense Appropriations Act

Today's DoD Spectrum Strategy - Findings

DoD's current spectrum strategy calls for developing an information base for Defense spectrum decisions. The *Warfighter Spectrum Requirements Analysis* (WSRA)[16] encompasses current and future DoD needs. There is reluctance to generate a comprehensive inventory for fear that it would be used as a tool supporting predatory attacks on DoD allocations.

A second strategy element calls for developing and maintaining, at the Joint Spectrum Center (JSC), databases covering U.S. and international spectrum allocations. This database, together with management tools developed and maintained by the Center, is the starting point for system spectrum certification and international spectrum access negotiations. Such a compilation of the world's spectrum allocations will always lag current status, since the number and rate of changes makes it impossible to keep up.

A tacit strategy element is to use the "national security" argument as needed to prevent allocation losses.

DoD will insist on reimbursement, as called for in the 1999 Defense Appropriations Act, for costs of relocating Defense users to other frequencies as a result of reallocation. This only helps recapture channel relocation costs and it may provide support for needed equipment modernization.

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[16] Holderness, Frank, Warfighter Spectrum Requirements Analysis Study, briefing, November 1999.

Today's Defense Spectrum Tactics - Findings

- **Organize for Central Spectrum Allocation, Assign Operational Frequencies by Service**
- **Respond to Crises as they Arise**
  - Deployment of un-certified systems
  - Assaults on existing DoD allocations
- **Work Out Problems at the Local Level, if Possible, "Borrowing" Frequencies, if necessary**
- **Use Frequencies as Needed when the "Flag Goes Up"**

For lack of a strategy, we have great tactics!

Today's DoD Spectrum Tactics - Findings

DoD's spectrum policy and strategic activities are currently centralized in the ASD/C3I Spectrum Management Directorate, OSAM and the JSC. Assignment of frequencies to operational users, on the other hand, is carried out by each Service for its own activities. The Services, acting through their SMOs, provide frequency coordinators with allocations to support operations.

The SMOs, supported by the JSC, are the first to respond when the order to deploy is given. They bear the brunt of deployment negotiations with host nations, work on problems caused by uncertified system use, and provide data when DoD spectrum allocations are threatened.

Local spectrum problems are worked out at the local level, if possible. For example, when the National Training Center needed frequencies normally allocated to cellular telephone systems for its COTS training instrumentation system, the Southwestern California Area Frequency manager was able to "borrow" frequencies from the local FCC office to temporarily fill the need.

Despite the energetic efforts of the SMOs and Frequency Coordinators, commanders occasionally use prohibited frequencies when they deem it an operational necessity.

The tactical level is where many operational spectrum problems are confronted and resolved. To quote one briefer, "In the absence of strategy, we have great tactics."[17]

[17] MG Robert Dickman, (Ret) USAF

DoD Spectrum Policy, Strategy and Tactics - Conclusions

- **Political and Economic Pressures on DoD to Relinquish Spectrum are Powerful.**
  - The Department may eventually be forced to cede some of its spectrum to non-DoD uses
  - Done unintelligently, this could compromise military capabilities
  - Rapid international growth will produce pressures making global allocations more difficult.
- **Assured Military Capability should be DoD's Goal**
  - Spectrum management is one means to that end.
- **DoD does not have a Clear Understanding of its Future Spectrum Needs**

DoD Spectrum Policy, Strategy, and Tactics - Conclusions

Based on the evidence it has seen in the course of this study and on the opinions expressed by its briefers, the Task Force concludes that political and economic pressures on DoD to relinquish portions of its spectrum are growing rapidly and that the Department will have to work hard to keep its spectrum holdings.

"In spectrum allocation, DoD is faced with competing interests – nation-to-nation and economics vs. national security issues. . . DoD is spread out across the spectrum for good reason. Trying to bring about 180 countries to consensus – with varying levels of development is very difficult" [18]

In one example, a Fixed Wireless Access trial system built in Arizona using temporary access to DoD spectrum was so successful that its private developer now wants nationwide use of the frequencies.

DoD must prepare to deal with spectrum allocation pressures. Frequency reassignment, done without regard to the consequences, would compromise important military capabilities.

Rapid growth of wireless use abroad may confound attempts to deploy new systems that have not been properly certified.

The Task Force concludes that DoD's spectrum policy, strategy and tactics must focus on military capabilities, not retention of frequencies for its own sake.

DoD must have better military impact data close at hand to justify its negotiating positions. Further, the Department should be prepared to reach beyond its current spectrum allocations or to share its existing allocations, perhaps with a common carrier of use to military applications, if military capabilities benefit.

Based on its study, the Task Force concludes that the DoD does not have a clear enough understanding of its current and future spectrum needs to implement such an approach.

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[18] Raidford, Cindy quoted in "DoD Successfully Defends Global positioning System (GPS) Spectrum at World Radio Conference," June 23, 2000.

Future DoD Spectrum Policy - Recommendations

The ASD(C3I), supported by the Services, should assure that DoD's Spectrum Policies are based on the following key principles:

- **US Spectrum is a National Resource; DoD Needs must be Balanced against other National Needs**
  - DoD must be an integral part of the national team working to maximize the collective value of Spectrum use.
- **Spectrum is a Critical Resource to be Managed at Senior DoD Levels**
- **Military Capabilities, not Frequency Bands, Drive Spectrum Requirements**
  - Goals must be based on assured function, not spectrum ownership
  - Seek efficient use of Spectrum, sharing allocations intelligently except where DoD has unique requirements
- **Spectrum Certification is as an Essential Element of System Development**

DoD Spectrum Policy - Recommendations

The ASD/C3I should base DoD's spectrum policy on a set of firm principles:

U.S. spectrum is a national resource; DoD needs must be balanced against other national needs. Many users, both government and private, vie for access to this limited commodity. DoD spectrum needs must be balanced against the gamut of national needs. **DoD must participate in national decisions of how best to use spectrum; and it must be an integral part of the national team working to maximize the collective value of spectrum use.**

Spectrum is a critical resource that should be managed at senior DoD levels, but interest in spectrum issues by top DoD leaders has been sporadic. More consistent involvement will be required as competing spectrum uses are negotiated.

DoD's spectrum requirements must be driven by military capabilities, not simply by frequency bands. Congressional debates and national policy deliberations must be argued on the basis of military utility.

At the same time, **DoD must be able to demonstrate that it is an efficient spectrum user**. Spectrum reuse is one element of efficient use. This may require sharing spectrum among military systems and between military and commercial services. DoD already shares through its use of commercial cellular and satcom services.

Efficient spectrum use requires new system qualification. **DoD must insist that all new systems be properly certified for spectrum use and for E^3.**

Future Spectrum Strategy - Recommendations

The ASD(C3I) and OSAM, supported by the Services, should:

- **Adopt a Proactive Spectrum Stance based on Military Capabilities**
- **Conduct an On-Going Inventory of Current and Future DoD Spectrum Requirements / Allocations based on Military Capabilities**
  - Necessary basis for planning Spectrum negotiations
  - Needed to justify DoD position in US allocation deliberations
- **Treat Spectrum Allocation as a Joint Issue**
  - Continue central strategy and policy emphasis
  - Move joint activities closer to War Fighters
  - Maintain close relations with Service Frequency Managers
- **Share Spectrum with non-DoD Users if Military Capabilities Benefit – Gain Access to non-DoD Allocations**
- **Incorporate Spectrum Certification in System Development Milestones**
- **"Re-Mine" Spectrum - Scrap Legacy Systems of Marginal Utility that are Inefficient Spectrum Users**

DoD Spectrum Strategy - Recommendations

The ASD/C3I, together with the Services, should adopt a spectrum strategy with the following elements:

DoD's spectrum strategy must be proactive, not reactive. It cannot await each new assault by others with spectrum claims that damage U.S. military capabilities. The Department must put forth its case on the basis of military capabilities.

A proactive, needs-based strategy requires detailed knowledge of DoD spectrum requirements. **The Department should expand its current requirements study into an ongoing inventory of current and future DoD spectrum needs linked to military capabilities.** This inventory should be the basis for planning spectrum negotiations and justifying DoD positions in U.S. allocation discussions.

Spectrum is a joint issue. Army, Navy, Air Force, and Marine forces use the same spectrum but have separate allocations; inter-Service spectrum sharing is nonexistent. Maintaining separate allocations for the three Services is inherently inefficient. **Since the U.S. fights jointly, spectrum policy and strategy must be managed on a unified basis, although strategy and tactics must be brought as close to the warfighter as possible to ensure an operational focus.** The current organization does not approach spectrum management from a joint perspective – emphasis is on meeting separate Service needs. Policy and strategy leaders should work closely with the Service spectrum managers to ensure the best use of this joint asset, encouraging sharing among the Services.

DoD must be prepared to share spectrum if military capabilities benefit. This specifically includes access to non-DoD spectrum through common carrier services as well as other sharing opportunities.

DoD strategy for qualifying new and updated systems for spectrum use and E^3 should include establishing milestones throughout the system development process.

DoD's inventory of RF emitters contains inefficient legacy equipment that encumbers DoD efforts to improve its spectrum use efficiency. **The Department should "re-mine" its RF spectrum by scrapping old systems that are inefficient users.** Re-mining is costly. However, DoD's spectrum use efficiency cannot improve without removing legacy systems from use. The cost, in terms of spectrum assets wasted, is much larger than the equipment investment. Further, older RF equipment does not meet the needs of today's forces and can be dangerous to users on the battlefield.

Future Spectrum Tactics - Recommendations

The Office of Spectrum Analysis and Management and the Joint Spectrum Center should:

- **Continue Identifying all DoD Systems using RF Spectrum including Communications, Radar, EW, Sensors, Other Devices**
  - Identify why they operate at the frequencies they use
  - Identify Host Nation Agreements for each system
- **For Each System (Radio, Radar, Platform) establish:**
  - Military capability associated with the system
  - How "spectrum" is used by the system
  - System cost
- **Use Derived Database to:**
  - Identify/pursue sharing, leasing, bartering for spectrum
  - Justify frequency use, determine what to scrap
  - Understand implications of moves to new parts of the Spectrum as a result of reallocation
  - Provide data for simulation/modeling tools for E^3, deployment coordination

DoD Spectrum Tactics - Recommendations

The inventory of spectrum-using equipment should identify all DoD RF systems. The inventory should note why each item uses which frequencies and should identify applicable host-nation agreements. Further, the inventory should cite each system's military utility, how it uses the spectrum, and the cost of moving its operating frequencies to new bands.

The database has many uses. Besides setting the basis for DoD's spectrum position, the inventory serves to point out legacy systems that can be scrapped to re-mine existing allocations. Further, the database will help to identify costs and the military impact of reallocation; it will provide modeling and simulation data to facilitate E^3 analysis and deployment considerations.

DoD Spectrum Tactics - Recommendations

The ASD/C3I should insist that use of spectrum by new and upgraded systems be considered throughout the development process. Spectrum conservation and use efficiency should be a metric for program managers. To ensure adherence, system spectrum strategy should be an DAB checkpoint. Spectrum managers should be members of Overarching Integrated Product Teams (OIPTs) and their Service equivalents. As a final check, test and evaluation should include ensuring that the system meets certification criteria.

The military today is considered a secondary user of commercial services and spectrum. For instance, a soldier using a cell phone on government business is considered to have lower status than the same person calling home on the same phone on personal business. While this has no practical importance in the case of cellular phone use, it has a major impact when users sharing a radio channel interfere with one another. DoD's effectiveness as a user of commercial carriers and its ability to effectively share spectrum with non-government applications requires that **military users have status at least equal to that of other users.**

DoD Spectrum Organization - Findings

- **DoD Spectrum Management Organization, established in 1998 under DRID 31, has Three Elements:**
  - Spectrum Management Directorate, part of ASD(C^3I), provides policy and guidance
  - Office of Spectrum Analysis and Management (OSAM) and the Joint Spectrum Center (JSC), reporting to DISA, are joint strategy, planning and support focal points
  - Three Service Spectrum Management Offices (SMOs) handle Service operational needs and direct Frequency Managers in operational units
- **The Organization generally Works Well, however Some Changes are Needed to Improve its Effectiveness**

DoD Spectrum Organization - Findings

DoD's spectrum management activities are organized into three elements, as determined in 1998 by DRID31: [19] [20]

The Spectrum Management Directorate within ASD/C3I is responsible for developing DoD spectrum policy, serves as the focal point for national and international (ITU and NATO) spectrum matters, and provides policy guidance to OSAM and JSC.

The Office of Spectrum Analysis and Management (OSAM) and the Joint Spectrum Center (JSC), reporting to DISA, are the centralized strategic planning, coordinating, and supporting focal points. Additionally, JSC is responsible for managing the E^3 program and developing and supporting automated spectrum management tools.

The Military Department Spectrum Management Offices (SMOs) support the mission needs of the Services, direct frequency managers assigned to operational units, and support their respective Services on spectrum matters.

The 1998 structure is a major improvement over earlier organizations that were overwhelmed by the accelerating pace and complexity of spectrum policy issues.[21] However, the Task Force has found substantial policy and execution shortcomings, notably a lack of focus and insufficient operational focus. Further, the Task Force notes the need for command-level attention to the issues, value, and importance of spectrum availability, efficiency of use, and other factors associated with this limited, but vital, resource.

Spectrum policy must have increased visibility inside and outside DoD to demonstrate the Department's concern with this issue.

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[19] "Department of Defense Reform Initiative Directive #31 - Realignment of DoD Spectrum Management Responsibilities" memorandum from DepSecDef Hamre, March 23, 1998.

[20] "Department of Defense (DoD) Spectrum Management Roles and Guidance," (draft) October 4, 1999.

[21] " Spectrum Management," memorandum from DepSecDef Hamre, December 22, 1997.

DoD Spectrum Organization - Findings

- **The Spectrum Management Directorate is Hampered in National and International Negotiations because its Reporting Level in DoD is Too Low**
- **OSAM's and JSC's Reporting Relationship to DISA Reduces their Effectiveness with War Fighters**
  - DISA's focus is on management of DoD's Telecom and Management Information Systems – less with operational spectrum strategy and management.
  - Spectrum strategy should be close to the focus for battlespace information systems
  - Future spectrum coordination will require more comprehensive databases and tools to manage the pace and complexity of the task
- **The Three Service Spectrum Management Offices appear to be Effective in Coordinating and Assigning Frequencies to Meet Service Operational Needs**

DoD Spectrum Organization - Findings

The effectiveness of the Spectrum Management Directorate in departmental, national, and international negotiations is impaired because its reporting level is too low and its staff too small. Its place in the organizational hierarchy does not reflect the importance of spectrum policy to DoD.

"Spectrum allocation, once a subject for radio-communications engineers, has become a major economic and political matter."[22]

Spectrum management policy is currently the responsibility of a very small staff in the office of the ASD/C3I. Matching spectrum requirements to operational considerations is minimal in OSD, hence policy is largely unfocused and subject to crisis definition rather than ordered planning. The small ASD/C3I staff must deal with national policy bodies such as the FCC, and the NTIA and NATO, as well as those representing the United States in WRC and ITU negotiations. At the same time, this small staff must support the interests of the myriad of DoD operational elements of DoD in an increasingly intense atmosphere of international competition for allocations. The rigorous competitive environment and complex departmental, national, and international policy issues and concerns preclude any other than superficial handling of quickly evolving spectrum matters.

[22] Raidford, Cindy quoted in "DoD Successfully Defends GPS Spectrum at World Radio Conference," June 23, 2000.

The result is that the Spectrum Management Directorate is overwhelmed and out-gunned.

OSAM and the JSC are directly charged with planning and supporting system development and military operations. They report to DISA, an agency concerned primarily with managing DoD's telecommunications and management systems. The RF spectrum and its efficient use are military system factors that are addressed as separate and distinct from system requirements definition, design, development, acquisition, and employment. The current organization perpetuates that separation.

The three Spectrum Management Offices appear to be effective in supporting the mission requirements of their Services.

DoD Spectrum Organization - Findings

- **Spectrum is a critical part of the overall military operational system**
  - An integral part of the battlespace communications, intelligence and sensing architecture
- **Spectrum strategy should reside with the operational information system architect.**
  - US Space Command is the emerging as the Operational Information Systems Focus in DoD
  - Consistent with the Unified Command Plan trends
  - Consistent with Tactical Battlefield Communications Task Force "CINC-IS" recommendations
- **Co-Location of OSAM and the Service Spectrum Management Offices is Working Well**

DoD Organization - Findings

Spectrum is a critical element in the overall military operational electronic system. Like system nodes and their interconnecting links, RF spectrum considerations must be integral parts of the overall architecture of battlespace communications, intelligence and sensing. Emphasis must be on function, not existing allocations. Hence, spectrum strategy should be determined in conjunction with the overall information operational architecture. It is unclear to the Task Force where responsibility for the operational architecture now resides. Ultimately, serious information warfare will require an Information Operations CINC, with responsibility for overall operational system architecture as well as warfighter support. It now appears that U.S. Space Command is evolving into the information warfare focus in DoD. The assignment of the Joint Task Force for Computer Network Defense to Space Command in October 1999[23] is a clear indication of the expansion of the space support role of the Command to encompass an information support role. The recent *Defense Science Board Task Force Report on Tactical Battlefield Communications* recommended that U.S. Space Command be charged with responsibility for joint information systems is a further step in the same direction. If the Uniform Command plan continues in this direction, USSPACECOM will evolve into "USINFOCOMM" – the logical home for spectrum strategy responsibility.

[23] "Uniform Command Plan Changes Announced," American Forces Press Service, www.defenselink.mil/news/Oct1999/n10071999_9910076.html

The co-location of OSAM and the SMOs is effective in coordinating strategic and tactical spectrum activities.

DoD Spectrum Organization - Recommendations

The Dep Sec Def should:

Elevate the Spectrum Management Directorate to report directly to ASD(C^3I)

- Perhaps a DASD(SM)
- Sec Def/Dep Sec Def should be the ranking office representing DoD in Spectrum matters, delegating responsibility to the Director
- The Spectrum Management Directorate should work closely with OSAM/JSC in establishing policy and representing DoD in national and international forums
- Adequately staff the Directorate to cover International, Policy and Programming, Planning and Technical Oversight activities

- **Assign OSAM and JSC to the "Information System Architect"**
  - SPACECOMM?
  - Role of OSAM in developing strategies for efficient Spectrum use, including sharing and dynamic allocation should be expanded to strengthen inter-Service sharing.

DoD Spectrum Organization - Recommendations

A proactive DoD spectrum policy requires an effective Spectrum Management Directorate. **The formulation of spectrum management policy should be elevated to a higher leadership level in ASD/C3I- reporting directly to the ASD/C3I, perhaps a Deputy Assistant Secretary of Defense (DASD)(SM).** The SecDef/DepSecDef should be the ranking office representing DoD in spectrum matters, delegating responsibility to the Director of the Spectrum Management Office. The Spectrum Management Office should work closely with OSAM and JSC to establish a military capability-based spectrum policy and negotiating position for national and international spectrum deliberations.

The Office should be adequately staffed to develop and enforce a proactive DoD spectrum policy.

As the putative CINC responsible for Information Operations, CINC USSPACECOM should also be responsible for joint spectrum requirements formulation, policy recommendations to the Spectrum Management Office, formulation of guidance for spectrum to support joint operations, and guidance to the military Services in support of such operations.

The role of OSAM in developing strategies for efficient spectrum use, including spectrum reuse and dynamic allocation, should be expanded. Additionally, OSAM, together with JSC, should expand its effort to complete an inventory of current and future DoD spectrum needs linked to military applications. Further, they should undertake a stronger joint role in defining spectrum use by the Services.

DoD Spectrum Organization - Recommendations

- **Retain the Service Spectrum Management Offices with responsibility for day-to-day mission planning and tactical operations**
  - Service SMOs should continue to be physically located with OSAM to enhance joint coordination

DoD Spectrum Organization - Recommendations

Retain the military Spectrum Management Offices with responsibility for mission support of their respective Services. They should continue to be physically co-located with OSAM to enhance joint coordination.

Spectrum and System Development - Findings

- **Each System which Transmits using the Radio Frequency Spectrum must be Compatible with Other Spectrum Users to Avoid Interference.**
  - Frequencies and modulation employed by each system must be coordinated with other users, both in the US and abroad
  - Electromagnetic Interference must be prevented by assuring compatibility using E^3 procedures
- **Failure to Coordinate New Systems has resulted in Deployment Problems (e.g., E-TCAS, Global Hawk)**
- **New Systems (e.g., JTRS and COTS) do not fit established qualification procedures**
  - Software programmability and frequency agility complicate spectrum coordination and certification
- **COTS equipment is not covered under existing certification procedures.**

Spectrum and System Development - Findings

Spectrum management exists primarily to prevent RF systems from interfering with one another. Each system that transmits using the RF spectrum must be compatible with other spectrum users to avoid interfering with them. The consequences of interference can range from garage doors opening to disruption of essential avionic systems. Interference on the battlefield may impede support vital to the survival of U.S. forces. Frequency, location, time and modulation of each system must be coordinated with other spectrum users, both in the U.S. and abroad.

Other forms of electromagnetic interference, such as activation of weapons fuses, are encompassed in E^3 considerations.

Many new DoD systems are not properly spectrum or E^3 qualified. A 1998 Inspector General Audit Report [24] noted that "89 telecommunications systems, including spectrum-dependent components of major systems, were deployed within the European, Pacific, and Southwest Asian theaters without proper certification and host-nation approval. As a result, communications equipment deployed without host-nation approval and frequency assignments cannot be utilized to its full capacity for training, exercises, or operations without risking damage to host-nation relations and degraded performance." Failure to coordinate developmental system spectrum use impaired aerial refueling during the Kosovo conflict (E-TCAS, mentioned earlier) and cut short long-distance reconnaissance tests of Global Hawk.

Technology being employed in new systems does not fit established spectrum and E^3 certification procedures. Software programmable, modular configurable and frequency agile radios raise new issues for spectrum coordination and certification.

Commercial off-the-shelf (COTS) products also present new certification problems (both spectrum use and E^3). Certification procedures do not now address equipment acquired as COTS; host-nation coordination is rare.

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[24] "Coordination of Electromagnetic Frequency Spectrum and International Telecommunications Agreements," Office of the Inspector General, Department of Defense, Report No. 99-009, October 9, 1998.

Spectrum and System Development - Findings

- **As the Spectrum becomes Increasingly Crowded and Military and Private Sector Users Share Allocations, Spectrum Coordination and Efficiency are Essential**
- **Spectrum Coordination for New and Upgraded Systems is often an Afterthought and occurs Late in the Systems Development Process**
- **Existing DoD Spectrum Coordination Regulations are Often Not Followed**
  - Both Spectrum coordination and E^3 certification are inadequately performed
  - Program managers developing new RF systems frequently do not follow Executive Branch guidance in OMB A-11 and DoD 5000 series for Electromagnetic Environmental Effects (E^3)

Spectrum and System Development - Findings

The RF spectrum is becoming increasingly crowded as both government and private users seek to make the most efficient use of this limited resource. This congestion makes new system spectrum coordination and efficiency essential.

Spectrum coordination of new and upgraded systems, if it is done at all, occurs late in the system development process. By the time spectrum issues are addressed, system concepts, specifications, and design are complete; addressing certification problems is difficult and time-consuming. When certification is addressed, it is frequently an afterthought.

Both spectrum and E^3 certification are required by federal and DoD regulations (Executive Branch guidance in Office of Management and Budget (OMB) circular A-11 and the DoD 5000-series directives). Despite these mandates, spectrum coordination is often not followed, and when addressed, is inadequately performed.

Just as important, spectrum efficiency is not an issue in many new system development programs.

Spectrum and System Development - Conclusions

- New and Upgraded Systems (including COTS equipment) must account for Spectrum Requirements and Impact Based on Military Capabilities and Spectrum Efficiency
- Coordination and Certification Rule Enforcement is a Must to Avoid Spectrum Chaos
- Early Delivery of System/Spectrum Models for use in Compatibility Evaluation will Facilitate E^3 Analysis

Spectrum and System Development - Conclusions

The Task Force concludes that program managers must follow DoD's spectrum and E^3 certification practices more closely.

- All new and upgraded systems (including COTS equipment) must account for their spectrum use and impact based on military capabilities and spectrum efficiency.

- Coordination and certification rules must be enforced to avoid spectrum chaos, both in CONUS and abroad. Spectrum must be a conscious consideration from system conception through system deployment.

- System spectrum compatibility evaluation models developed early in the system development process can facilitate E^3 analysis.

Spectrum and System Development - Recommendations

The USD(AT&L) should institute and/or enforce the following policies:

- **Spectrum Management / Re-use / Conservation must be Performance Metrics for System Developers**
- **The OIPT (and its Service Equivalents) must Proactively Address Spectrum Issues at the Inception of Each Program**
- **Spectrum Utilization and E^3 Qualification must be Mandatory "Checklist" Items in DoD's Acquisition Process for all "Spectrum Use" Programs, including COTS**
  - This applies to each level in the acquisition process: JROC, DAB, DRB, EDRB, MCEB, SAE decisions,etc.
- **DoD Must, in conjunction with the IRAC, NTIA and the FCC, Develop New Criteria for Coordinating and Certifying Software Programmable and Configurable Radios**
- **DoD (and other US government entities) must face directly the Challenge posed by use of Software Programmable and Configurable Radio Technology in Foreign / Sovereign Territories**

Spectrum and System Development - Recommendations

The Under Secretary of Defense for Acquisition, Technology and Logistics should ensure that acquisition activities support the following objectives:

DoD must be an efficient spectrum user – new systems must make the best possible use of spectrum consistent with their military utility. The Task Force recommends that **measures of efficient spectrum efficiency, reuse, and conservation be made performance metrics for system developers.**

Spectrum coordination and certification cannot wait for consideration until late in the system development process. **The OIPT and its service counterparts must proactively address spectrum issues from the inception of each new and upgraded program.**

DoD must assert its spectrum regulations throughout the development process. **Spectrum utilization and E^3 qualification must be mandatory checklist items in DoD's acquisition process for all spectrum-using systems (including COTS).** This includes the entire spectrum of system development review boards and executive decisions.

Spectrum and System Development - Recommendations

- **DoD Must, in conjunction with the IRAC, NTIA and the FCC, Develop New Criteria for Coordinating and Certifying Software Programmable and Configurable Radios**
- **DoD (and other US government entities) must face directly the Challenge posed by use of Software Programmable and Configurable Radio Technology in Foreign / Sovereign Territories**

Spectrum and System Development - Recommendations

New RF technology, in the form of processor-based, software-controlled hardware raises new qualification issues. DoD is not alone in facing these challenges – other government and regulatory agencies are similarly challenged. **DoD must work in conjunction with the other members of the IRAC, NTIA, FCC, and other countries (e.g., NATO) to develop new criteria for coordinating and certifying software programmable and configurable radios.**

International deployment of software programmable radios raises serious host-nation agreement problems in that frequencies and waveforms are user-programmable and not limited by hardware to fixed operating modes. The possibility of interference with civilian services is real. **DoD (and other U.S. government agencies) must confront the challenge posed by use of this new technology in foreign countries.** The Department must be able to assure host nations that U.S. qualification and coordination procedures guarantee that their communications systems will not be disrupted by U.S. military signals.

Spectrum Research and Development - Findings

- **Dynamic Frequency Assignment, such as Performed by Spectrum "Sniffing" Radios, Presents Unknown Problems in Spectrum Management**
- **Advanced System Technology, such as Software Programmable Radios, Spectrum Sharing, and Dynamic Frequency Allocation / Assignment raise Two Kinds of Technical Issues in Spectrum Management:**
  - How best to apply existing technologies?
  - What technologies can be developed for future Spectrum Management?
- **Research and Development in Spectrum Management-Related Technologies is not Commonly Pursued Outside DoD**

Spectrum Research and Development – Findings

Inserting new technology into RF systems presents unknown problems for spectrum managers. Real-time, dynamic frequency assignment under control of spectrum "sniffers" is particularly troublesome because these systems can interfere with fixed services. Spectrum sharing and software programmability also are compelling technologies with important spectrum implications.

Research and development into the spectrum management implications of the application of these technologies is not commonly pursued outside the defense community.

Before they can benefit military users, DoD must understand how best to apply these new system technologies. Further, it must develop new technologies for managing spectrum in a dynamic assignment environment.

Spectrum Research and Development - Recommendations

- **The DDR&E and JSC Should Establish / Enhance Research and Development Efforts in Five Areas:**
  - Best practices for applying known advanced spectrum technology applications in Defense systems
  - Improved modeling and simulation tools for determining frequency / terrain / time scheduling for real time, mobile, congested combat environments
  - Improved models for assessing RADHAZ to ordnance, systems and personnel operating in joint environments
  - Operational and technical methods for efficient Spectrum use through sharing and diversity, improved receiver characteristics
  - New technologies for spectrum sharing (e.g., polarization, multi-beam directional antennas)
- **Spectrum Research and Development should be Specifically Addressed in the DDR&E's Annual S&T Plan**

System Research and Development -Recommendations

To be able to employ dynamic RF system technologies, DoD should establish/promote research and development in five areas:

1. **Best practices for applying known advanced spectrum technology in Defense systems.** Establish the system environment needed to make dynamic technologies effective.

2. **Improved modeling and simulation tools for determining frequency/terrain/time scheduling for real-time, mobile, congested combat environments.**

3. **Improved models for assessing electromagnetic radiation hazards to ordinance, systems, and personnel operating in joint environments (E^3).**

4. **Operational and technical methods for efficient spectrum use through sharing and diversity**. Develop transmitter and receiver technologies (e.g., smart antennas) for use in shared spectrum environments.

5. **New technologies for spectrum sharing such as polarization, directional antennas, and new modulation types.**

The research and development efforts needed to address spectrum issues should be addressed in the Director of Defense Research and Engineering's (DDR&E) annual Research and Development (R&D) plan.

DoD Special Needs - Findings

- **DoD has Unique Spectrum Management Needs in Three Areas:**
  - Test and evaluation
  - Operational force training
  - Spectrum management staffing and awareness

DoD Special Needs: T&E - Findings

- **Test Ranges Require Significant Spectrum Resources**
  - High-altitude tests impact large CONUS areas
  - New systems require wide bandwidths (e.g., UAVs with multiple video sensors)
- **Actual Capability Testing of some Systems (e.g., EW Systems) poses Problems in Areas Adjacent to Test Ranges**
- **Test and Evaluation Spectrum Needs are Growing:**
  - More bandwidth needed for system operation
  - Collection of larger numbers of test conditions and results
  - Instrumentation / telemetry of multiple evaluations per test to reduce number of test runs

DoD Special Needs: T&E - Findings

DoD's test ranges pose special problems to spectrum managers. High-altitude tests, even in isolated parts of the country, produce signals that affect large areas, almost always including major metropolitan areas. For instance, emissions from the Edwards Air Force Base test range overlap Point Magu, Los Angeles, and sometimes other areas in Arizona and Nevada.

In addition, new systems (for instance UAV reconnaissance vehicles) under test require wide operating bandwidths, in addition to telemetry for the test.

Some signals (such as EW emissions) can interfere with private sector services and other military systems in areas in the vicinity of the test range.

Test and evaluation spectrum needs, like those of the rest of DoD, are growing. Bandwidths required by systems under test are expanding as the new system capability expands. Additionally, the number of test conditions and monitored conditions requiring data telemetry has been rising as budget constraints and high test cost reduce the number of test runs.

Test activities are constrained by overlapping signal footprints, so that test schedules of nearby ranges must be interleaved.

DoD Special Needs: T&E - Recommendations

- **Spectrum Needs must be Factored Into DOT&E Test and Evaluation Plans Early**
  - Spectrum certification compliance should be a pass/fail T&E item
- **The DOT&E must Incorporate Improved Telemetry Techniques that Use Less Spectrum with enhanced Fidelity / Reliability into Test Range Telemetry Systems**

DoD Special Needs: T&E Recommendations

The Director, Operational Test and Evaluation (DOT&E) should see that:

Spectrum needs of developmental systems are factored in to test plans early so that test sequencing can be established.

Adherence to spectrum certification criteria should be a pass/fail DT&E item.

More modern, improved telemetry techniques that use less bandwidth with enhanced fidelity and low error rates should be incorporated into test range telemetry systems.

Findings and Recommendations – Operational Force Training

- **Operational Force Training Exercises Require:**
  - Spectrum for "blue" forces
  - Spectrum for "red" forces
  - Spectrum for telemetry, monitoring and training evaluation
- **Spectrum Access to meet these Needs is being Adequately Handled at the Local Level**
- **Spectrum problems are particularly acute for ECM / ECCM training and for Air-Based Systems that can Impact Large Areas, some Outside the US.**
- **Use more advanced distributed simulation to realistically mimic EW effects without radiating interfering signals**

DoD Special Needs: Operational Force Training

Like test and evaluation, operational force training exercises have large spectrum requirements. Requirements for both red and blue forces as well as bandwidth for telemetry, monitoring and training evaluation make such exercises big spectrum users.

The Task Force concludes that the "train as we fight" doctrine requires this large spectrum and that training facility spectrum is being well managed. It does not recommend any changes to current practices.

Spectrum problems are particularly acute for Electronic Counter Measures/Electronic Counter Counter Measures (ECM/ECCM) training. In the case of air-based systems, emissions can affect large areas, some outside the U.S.

The Task Force recommends that DoD use distributed simulation as much as possible to mimic EW effects without radiating interfering signals.

DoD Special Needs: Staff and Awareness - Findings

- **DoD's Spectrum Management Staff is Approximately 150 People**
  - The primary source of staff is the enlisted Frequency Manager cadre
  - The Army and Navy have no career path in Frequency Management.
- **The Dynamic, Volatile Nature of Future Spectrum Use and Management will Require Continuous Upgrading of Key Staff.**
- **Acquisition Managers who are not Spectrum Professionals are often not Aware of Spectrum Issues**
  - Spectrum management is a rarely chosen option at ICAF

DoD Special Needs: Staff and Awareness – Findings

DoD's spectrum management staff is of modest size – approximately 150 people. The Service Frequency Manager MOS is the primary source of spectrum managers capable of overseeing Service level and Joint spectrum issues. The pool of candidates is limited because only the Air Force has a career path in frequency management – the Army, Navy, and Marines do not. Limited personnel resources play a crucial role in assigning spectrum to meet operational needs.

The volatile nature of the spectrum management environment, in both the U.S. and foreign countries, requires that spectrum management professionals receive continuous training to stay on top of events affecting their jobs.

DoD acquisition managers who are not spectrum management professionals are often not aware of spectrum issues. Spectrum management is an elective at the Industrial College of the Armed Forces that is rarely chosen by students.

DoD Special Needs: Staff and Awareness - Recommendations

- **The Services should each Ensure that they have Frequency Manager Career Paths for Enlisted Personnel**
  - All Service frequency management personnel should receive deliberate, specific training for theater and tactical spectrum management, especially as applied to coalition operations
- **The Services should Provide for Periodic Updates to Spectrum Management Training to encompass Changes in Regulations, International Developments and New Equipment Capabilities.**
- **The USD(AT&L) and Services should Insert Spectrum Literacy Training into the Required Curriculum for all Acquisition Executive Training**
  - Require that Program Management trainees become "Spectrum Literate" during their Professional Military Education (e.g., ICAF, DSMC)

DoD Special Needs: Staff and Awareness - Recommendations

To ensure sufficient numbers of frequency managers for operating units, and to feed the pool of spectrum management professionals needed by the Department, **each Service should have frequency manager career paths for enlisted personnel. Each manager should receive deliberate, specific training for tactical and theater spectrum operations support, particularly as applied to coalition operations.**

DoD and Service spectrum managers should receive periodic updates to their spectrum management training to encompass changes in regulations, international developments, and equipment capabilities.

Spectrum literacy training should be a part of the required curriculum for all acquisition executive training and professional military education (PME). Program management trainees must become "spectrum literate" during their professional military education.

Summary of Major Recommendations

- DoD must Push for a Single National Spectrum Policy Focus that Balances Military and Economic Security
- DoD must Embrace Proactive Spectrum Policies and Strategies to Ensure US Military Capabilities at Home and Abroad.
- DoD should Raise the Organizational Level of the Spectrum Management Directorate and Move OSAM / JSC Closer to the War Fighter (Operational Architect – CinCSpace?)
- DoD must Vigorously Embrace Spectrum Certification Procedures for Developmental Systems and Develop Techniques for Certifying Software Programmable RF Systems
- DoD must Perform Research and Development into Spectrum Efficient Technologies
- DoD must take Spectrum into Account in T&E Plans
- DoD must Improve Spectrum Literacy of its Acquisition / Program Leaders

Summary of Major Recommendations

Information dominance is key to the success of U.S. military operations of all kinds; spectrum access is indispensable in achieving that dominance. Demands for spectrum to handle the rapidly increasing information demands of modern, joint, dispersed forces are escalating rapidly. Access to the spectrum resources needed to achieve the goals of JV2020 is endangered by pressures for reassignment to other nationally important uses and by antiquated concepts of "spectrum." The Task Force concludes that spectrum management must be a higher profile issue within DoD and on a national level; and the development and enforcement of DoD's spectrum policy and strategies must be more actively managed to account for the changing spectrum management environment.

The Task Force concludes that, in order to ensure U.S. military capabilities, DoD must modernize its approach to spectrum management consistent with changes taking place in RF-dependent systems. DoD's notion of spectrum must change to encompass more flexible concepts of spectrum use.

Specific areas requiring Departmental action include:

- Pushing to establish a U.S. national spectrum policy mechanism
- Implementing policies, strategies and tactics that are based on military capabilities and ensure the deploy ability of new systems
- Organizing to demonstrate the critical importance of spectrum policy to DoD and to bring spectrum strategy close to operational systems architecture
- Improving the spectrum and E^3 qualification process for new and upgraded systems by employing spectrum considerations throughout the systems development and upgrade process
- Supporting research and development of spectrum-efficient technologies
- Supporting solutions to unique DoD needs in test and evaluation, training, and leadership awareness.

Appendix A
Terms of Reference

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

SEP 24 1999

DEFENSE SCIENCE BOARD

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference--Defense Science Board Task Force on DoD Frequency Spectrum Issues

You are requested to form a Defense Science Board (DSB) Task Force to examine the competing interest in, and access to, the RF frequency spectrum and its impact on military readiness and national security in the 21st century. This study will review and evaluate DoD user frequency spectrum requirements and related advances in technology to improve utilization of this finite resource.

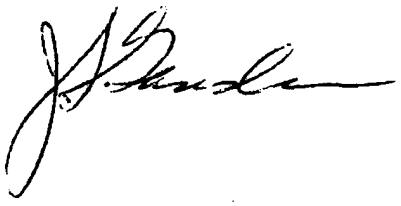
Tasks to be Accomplished:

The DoD Frequency Spectrum Issues Task Force will determine:

- Adequacy of DoD's vision for frequency spectrum.
- Adequacy of DoD's strategy for exploitation of commercial and unique technologies impacting frequency opportunities.
- Adequacy of forecasted warfighter spectrum requirements for JV2010.
- Adequacy of DoD's processes for spectrum management:
  - Requirements, identification and allocation
  - Certification and Electromagnetic Environmental Effects (E3)
  - National/International participation
  - US policy and conflict resolution
- Impacts of national policy/statutory requirements on DoD spectrum:
  - Worldwide deployment, training and range operations
  - Space based systems
  - Battlefield constraints

The study will be sponsored by the Under Secretary of Defense (Acquisition and Technology), the Senior Civilian Official for ASD/C3I and JCS/J-6. Dr. William Howard will serve as the Task Force Chairman, Ms. Renae Davis will serve as the Executive Secretary and Maj Tony Yang, USAF, will serve as the Defense Science Board Secretariat Representative.

The Task Force will be operated in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Directive 5104.5, "DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, United States Code, nor will it cause any member to be placed in the position of acting as a procurement official.



J. S. Gansler

Terms of References Map

Terms of Reference Item	Slides
Adequacy of DoD's frequency spectrum vision	23, 30, 33, 34, 35, 40, 41
Adequacy of DoD's strategy for exploiting commercial and unique technologies impacting frequency opportunities	47, 48, 49, 50
Adequacy of forecasted warfighter spectrum requirements for JV2020	15, 16, 32, 34, 36, 37
Adequacy of DoD's processes for spectrum management	13, 31, 33, 34, 36, 40, 42, 43
Requirements, identification, allocation	22, 44, 45, 46
Certification and electromagnetic effects (E3)	31, 35, 36, 37, 44, 45, 46, 47 ,48
National/International participation	26, 28, 31, 32, 33, 35
US policy and conflict resolution	25, 29, 35
Impacts of national policy/statutory requirements on DoD spectrum	18, 25, 29, 38
Worldwide deployment, training, and range operations	30, 52, 53, 54
Space-based systems	17, 20
Battlefield constraints	6, 9, 13, 20, 23, 27, 31, 33

Appendix B
Task Force Members

Defense Science Board Task Force
On Frequency Spectrum Issues

Task Force Members

Chairman:
Dr. Bill Howard

Panel Membership:
Dr. Reza Eftekari
Mr. Jim Evatt
Dr. Mike Frankel
Hon. Noel Longuemare
Mr. Travis Marshall
Prof. Gary Minden
Gen Carl O'Berry, USAF (Ret)
Mr. John Stewart
Mr. Owen Wormser

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Mr. Joe Capps, ASM USA-CESO
Ms. Rebecca Cowen-Hirsch, OSAM
LTCOL Tom Groff, USAF, AFFMA
Mr. Frank Holderness, OSAM
Mr. Scott Hoschar, NAVEMSCEN
Mr. Bruce Swearingen, NAVEMSCEN
Mr. Rick Larson, JSC
CAPT Chauncey Mitchell, USN, J-6
Mr. Nelson Pollack, AFFMA
Mr. Vic Sparrow, OASD(C3I)
Ms. Cindy Raiford, OASD(C3I)
CAPT Doug Swoish, USN, J-6
Mr. Tom Trimmer, ASM USA-CESO
Col Joe Yavorsky, USA, JSC

DSB Support:
LtCol Tony Yang

Support Staff:
Richard Balzano, SAIC
Donna Preski, SAIC
Allison Troutman, SAIC

Appendix C
Task Force Meetings and Briefs

Meeting Dates	Briefs
October 13, 1999:	JCS/J6 – Gen. M. Quagliotti OSAM/C3I – Mr. Vic Sparrow NTIA – Mr. Karl Nebbia
November 9-10, 1999:	Vision/Requirements – Mr. Frank Holderness FCC – Mr. Julius Napp C3I – Mr. Russ Latimer MITRE – Mr. Jim Chadwick USAF SAB – Dr. Mike Borky Nat'l Spectrum Managers Association – Mr. Chris Hardy COMSEARCH – Mr. Mark Gibson
December 10-11, 1999	Conference Highlights/Overview of JSC – COL Yavorsky Acquisition Support Program – Lt Col Orville Earl JSC Operations – CDR Henry Brus DoD E3 Program – Mr. Bill Lenzi Databases/Tools/SM Systems – Lt Col Paleczny
January 20-21, 2000	Certification Process/HNA – Mr. Scott Hoschar JTRS – COL Michael Cox SATCOM – Ms. Rebecca Cowen-Hirsch NSA Condor Program – Ms. Anna Entrichel FCC – Mr. Dale Hatfield Motorola – Mr. Jerry Harrison DARPA – Dr. Mark McHenry
February 24, 2000	CITEL – Ms.G. Piedras NSC OSTP – Lt Col Pimentel NRO – Col Charles Cornell NSSA – Col Hagemeier
March 29-30, 2000	ASD(C3I)SM Directorate – Ms. Joanne Ferguson USSPACECOM -- Mr. Peter Dayton DOT&E – Mr. Coyle SAF/ST – Gen Robert Dickman
April 20, 2000	Executive Session
May 22, 2000	AFC, Mojave Coordination – Mr. Ray Marler

Appendix D
Acronyms

AFCEA	Armed Forces Communication & Electronics Association
ASD/C3I	Assistant Secretary of Defense for Command, Control, and Communications
AWACS	Airborne Warning and Control System
C3I	Command, Control, Communications, and Intelligence
C4I	Command, Control, Communications, Computers, and Intelligence
CDMA	Code Division Multiple Access
CFR	Code of Federal Regulation
CINC	Commander in Chief
CINCIS (Proposed)	Commander in Chief for Information Systems
CINCSpace (Proposed)	Commander in Chief for Space
CMA	C4ISR Mission Assessment
CONUS	Continental United States
COTS	Commercial Off The Shelf
DAB	Defense Acquisition Board
DASD	Deputy Assistant Secretary of Defense
DDR&E	Director of Defense Research & Engineering
DEPSECDEF	Deputy Secretary of Defense
DISA	Defense Information Systems Agency
DoC	Department of Commerce
DoD	Department of Defense
DODD	Department of Defense Directive
DOT&E	Director, Operational Test and Evaluation
DRA	Design Review Activity
DRID 31	Defense Reform Initiative Directive 31
DSB	Defense Science Board
DSMC	Defense Science Management College
E3	Environmental Electromagnetic Effects
ECM	Electronic Counter Measures

ECCM	Electronic Counter Counter Measures
EDRB	Enhanced Defense Resource Board
EIA	Electronics Industry Alliance
EMCP	Electromagnetic Compatability Program
E-TCAS	Enhanced Tactical Collision Avoidance System
EW	Electronic Warfare
FCC	Federal Communication Commission
FWA	Fixed Wireless Access
FY	Fiscal Year
GDP	Gross Domestic Product
GPS	Global Positioning System
ICAF	Industrial College of the Armed Forces
IMT	International Mobile Telecommunications
INFOCINC	Commander in Chief for Information
IRAC	Interdepartment Radio Advisory Committee
ITU	International Telecommunication Union
JCS	Joint Chiefs of Staff
JIER	Joint Information Exchange Requirements
JOA	Joint Operational Architecture
JROC	Joint Requirements Oversight Council
JSC	Joint Spectrum Center
JTRS	Joint Tactical Radio System
JV 2010	Joint Vision 2010
JV 2020	Joint Vision 2020
MCEB	Military Communications and Electronics Board
MHz	Mega Hertz
MTW	Major Theater War
NATO	North Atlantic Treaty Organization
NTIA	National Telecommunication and Information Administration
OCONUS	Outside the Continental United States
OIPT	Overarching Integrated Product Team

OIRP (Proposed)	Office of Information Resource Policy
OMB	Office of Management and Budget
OPTEMPO	Operational Tempo
OSAM	Office of Spectrum Analysis and Management
OT&E	Operational Test and Evaluation
PME	Professional Military Education
R&D	Research and Development
RADHAZ	Radiological Hazard
RF	Radio Frequency
S&T	Science and Technology
SAE	Service Acquisition Executive
SECDEF	Secretary of Defense
SMO	Spectrum Management Office
T&E	Test and Evaluation
TDMA	Time Division Multiple Access
UAV	Unmanned Air Vehicle
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics
USINFOCOM (Proposed)	United States Information Command
USSPACECOM	United States Space Command
USTR	United States Trade Representative
WRC	World Radiocommunications Conference
WSRA	Warfighter Spectrum Requirements Analysis