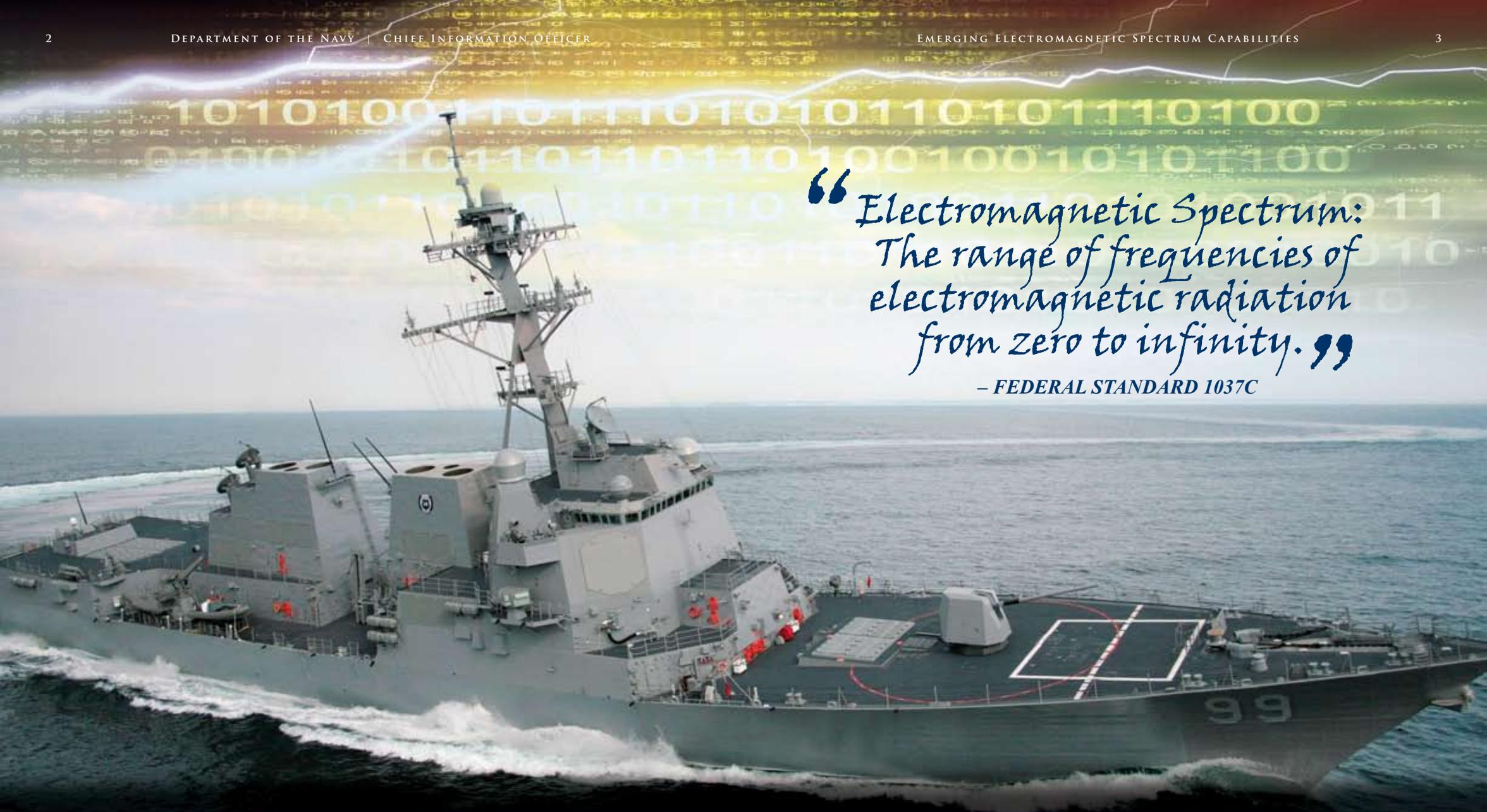


EMERGING ELECTROMAGNETIC SPECTRUM CAPABILITIES

DEPARTMENT OF THE NAVY
CHIEF INFORMATION OFFICER



“Electromagnetic Spectrum:
The range of frequencies of
electromagnetic radiation
from zero to infinity.”

– FEDERAL STANDARD 1037C

INTRODUCTION

The Department of the Navy (DON) has a long history developing and implementing leading edge technologies to attain and maintain a technological advantage over our adversaries. These innovations have changed the course of modern warfare, maintained the peace, and contributed to the advancement of our civilization. Introduced during World War II, Radio Detection and Ranging (RADAR) provided advance warning of air attacks as

invisible radio waves, traveling at the speed of light, reflected off enemy aircraft. Though rudimentary, emerging RADAR technology led to further research and development, and eventually the implementation of advanced, agile, sensor technologies that are now deployed and networked throughout the Navy and Marine Corps. Had it not been for military RADAR development, today's commercial airline industry might not exist.

The DON continues to enhance and leverage research, development, acquisition, operations, and governance in the evolution of a Naval Networking Environment (NNE). Identifying new technological advantages and unimpeded implementation of those technologies can be fraught with challenges. The cost of emerging technology can be an obstacle during an age of reduced resources and increased requirements. New technologies that

access radio frequencies can be problematic due to national and international radio frequency allocations and radio frequency interference concerns. Overcoming these challenges requires an environment where critical path issues are anticipated and successfully addressed. NNE fosters an environment where emerging technologies can thrive.



“Never before in history has innovation offered promise of so much, to so many, in so short a time.”

– BILL GATES *Entrepreneur*

WHAT ARE EMERGING TECHNOLOGIES?

“Emerging” generally refers to something that is newly developed or something that newly occurs. “Emerging technology” can be described as technology that works, but has yet to find wide distribution. So it goes to follow that emerging spectrum technologies are new capabilities that are made possible, to some extent, by new uses of electromagnetic spectrum.

“The difficulty lies, not in the new ideas, but in escaping the old ones.”

– JOHN KEYNES
Father of Modern Macroeconomics

SPECIFIC EMERGING TECHNOLOGIES

There are any number of emerging technologies appearing on the electromagnetic spectrum landscape. Three emerging in the second decade of the 21st century are Software-Defined Radio (SDR), Dynamic Spectrum Access (DSA), and Cognitive Radio Systems (CRS). As is common in the early days of an emerging technology, definitions of SDR, DSA,

and CRS vary; however, international and national organizations such as the International Telecommunications Union (ITU), the Institute of Electrical, and Electronics Engineers (IEEE), and the National Telecommunications Information Administration (NTIA), are refining these definitions and developing governance for these capabilities.



“You have to learn the rules of the game. And then you have to play better than anyone else.”

– ALBERT EINSTEIN *Father of Modern Physics*

SOFTWARE-DEFINED RADIO

Software-Defined Radio (SDR) is a radio communication system in which its traditional components that have typically been implemented in hardware (e.g., mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are

“Radio Has No Future”

– LORD KELVIN

Physicist & President of the Royal Society, 1897

now emulated in software. While the concept of SDR is not new, the rapidly evolving capabilities of digital electronics are making many processes practical that were once only theoretical. SDR capabilities currently exist in a number of commercial applications such as cellular telephones. Implementation may be as basic as emulating an existing communication system’s waveform. Or, the SDR may use new waveforms unobtainable in legacy hardware-based systems.

COGNITIVE RADIO SYSTEMS

Cognitive Radio Systems (CRS) is a new concept for electromagnetic technology in which a radio system changes its transmission or reception behavior based on knowledge of the electromagnetic environment. CRS is aware of its environment and internal state and can make decisions based on that information and predefined objectives. Cognitive Radio Systems learn from operations within their environment and vary their operating parameters accordingly.

While CRS includes facets of SDR and DSA, it does not yet exist in commercial or military applications. Once matured, CRS is anticipated to revolutionize the Department’s electromagnetic capabilities.



“Technology has to be deployed on a global basis and has to be user friendly.”

– SAUL BERMAN

Noted Global Strategy & Change Services Leader

DYNAMIC SPECTRUM ACCESS

Dynamic Spectrum Access (DSA) is the real-time adjustment of electromagnetic spectrum usage in response to changing circumstances and objectives. These radio systems select their frequencies based on software-controlled algorithms. DSA currently exists in limited commercial applications. One example of DSA

is implemented in wireless network standards and can be found in wireless routers, telephones, and other applications. These DSA capabilities are extremely efficient and effective ways to provide robust wireless networks around the world.

“The future is here. It’s just not widely distributed yet.”

– WILLIAM GIBSON *Coined the Term “Cyberspace”*

NAVAL BENEFITS

Due to the many spectrum-enabled and spectrum-dependent capabilities already in use throughout the Navy and Marine Corps, implementing emerging spectrum technologies may be a complex undertaking. However, emerging spectrum technologies hold great promise to enhance the warfighter’s ability to use spectrum with greater efficiency and effectiveness.

Over recent decades, challenges to ensuring worldwide operational capabilities for the Navy

and Marine Corps have escalated dramatically. Rigid frequency allocations implemented in sovereign nations often vary country by country. As a result, the authorized operation of naval spectrum-dependent equipment in one country may not be permitted in another. Emerging electromagnetic spectrum capabilities are expected to overcome a global plethora of foreign host nation requirements that currently confound naval spectrum access and use.

“The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man.”

– *GEORGE BERNARD SHAW* Playwright

“We must stop trying to catch up with the past and start catching up with the future.”

– *THOMAS P. KIDD, III*
Director, Department of
the Navy Strategic Spectrum

CHALLENGE THE STATUS QUO

Ensuring the Naval Networking Environment meets and exceeds the requirements of all Navy and Marine Corps personnel is a daunting challenge. Status quo is simply not good enough for the mission and safety of naval warfighters. Accordingly, the DON continuously strives to introduce leading edge technologies throughout its warfighting portfolio. Regardless of the specific technology, the introduction of leading edge technologies is often challenging and the introduction of new spectrum technologies is no different. Change is often met with skepticism and considered risky. CRS capabilities that adjust their behavior based on a wide array of factors will inevitably be received under significant scrutiny, as has

SDR. The Joint Tactical Radio System (JTRS) program has experienced this challenge. Most of the SDR capabilities in JTRS are used to emulate legacy waveforms that have been the mainstay of naval communications. But JTRS has met with skepticism and concern that many countries will not permit SDR enabled capabilities even though all new cellular telephones are essentially SDR. While there may be host-nation challenges to overcome, the multiband capabilities of JTRS, and yet to be defined and realized capabilities of CRS, will enhance the DON's NNE and ultimately increase the capabilities of the naval forces.

LEAD THE WAY

Demands on our networks and demands for communications interoperability are escalating. Wireless capabilities, made possible by the use of spectrum, enable the mobile capabilities of the NNE. Due to our global responsibilities; the DON's requirement for worldwide spectrum access and use has also escalated. The Department is now challenged to meet its global spectrum requirements. Legacy spectrum dependent capabilities that operate solely on fixed frequencies may eventually be unsupported as necessary frequencies become unavailable. Without the introduction of emerging spectrum technologies within the DON, this scenario is imminent and constraints on legacy spectrum capabilities will degrade

naval capabilities. In this regard, the Defense Business Board, in a January 2010 report, stated that current spectrum trends identify an “impending crisis.” Leveraging emerging spectrum capabilities provides a path to overcome spectrum supportability challenges within the U.S. and abroad. The development and introduction of emerging spectrum capabilities will be fraught with challenges, but the DON must embrace these challenges to ensure the United States Navy and the United States Marine Corps remain the most capable maritime fighting forces of the 21st century.



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