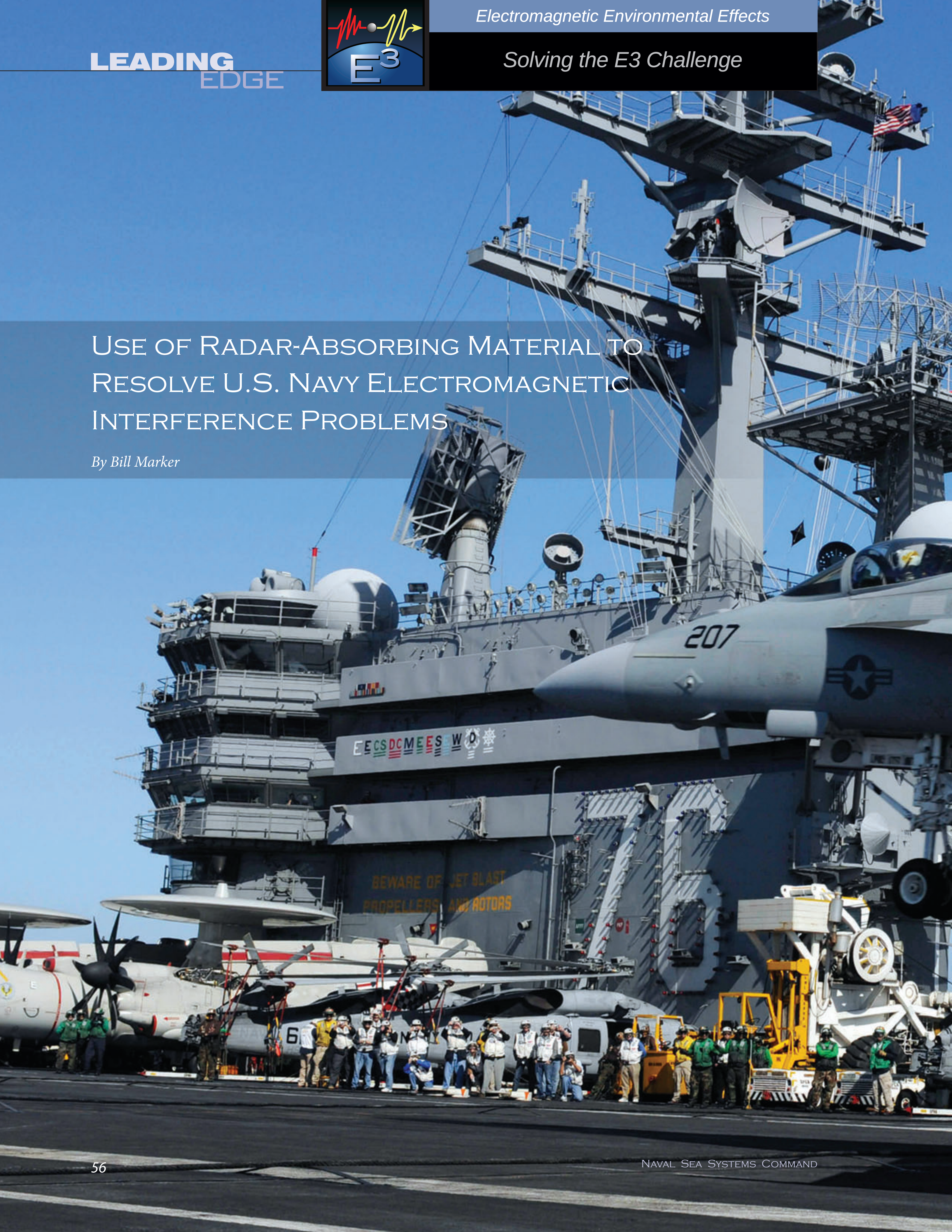
Use of Radar-Absorbing Material to Resolve U.S. Navy Electromagnetic Interference Problems

By Bill Marker



Introduction

The topside environment on today's typical U.S. Navy ship is a complex electromagnetic (EM) conglomeration of radar, navigation, communications, fire control (FC), and electronic warfare (EW) systems all trying to operate simultaneously in an extremely small area. Due to high output power requirements, overlapping operating frequencies, and sensitive receiver requirements, numerous interoperability problems can occur among shipboard systems.

One of the proven methods for resolving (or reducing to an acceptable level) some of these severe EMI problems is with the use of radar-absorbing material (RAM). RAM can be used to increase electromagnetic compatibility (EMC) among shipboard systems by providing isolation between source and victim equipment, by increasing antenna-to-antenna decoupling, and by reducing false targets resulting from signal reflections from ownship structures such as masts, yardarms, and bulkheads. In general, RAM is a multilayered material that contains at least one resistive layer. When applied to a radio frequency (RF) energy-reflective surface, some of the incoming or incidental RF energy is absorbed as it passes into the RAM, and the remainder is canceled by the reflected (180-degrees-out-of-phase) energy within the confines of the RAM. Currently, there are several types of RAM being used on U.S. Navy ships to resolve EMI problems among sensitive electronic systems. RAM is also used to reduce the radar cross section (RCS) or EM signature of Navy ships, but this article will focus on the various types of RAM utilized by the Navy for EMI reduction, including design material pros and cons, trade-offs, and maintenance issues faced by the fleet.

Background

The Shipboard Electromagnetic Compatibility Improvement Program (SEMCIP) was founded in 1973 in an effort to combat the growing number of EMI problems that plagued the fleet. SEMCIP engineers spent many days and long nights at sea investigating, troubleshooting, and successfully resolving EMI problems. Early on, most types of fixes employed by SEMCIP involved the use of filters, blankers, bonding and grounding, or tuning (frequency management) to reduce or eliminate the EMI problems. SEMCIP engineers were very successful at resolving the majority of the known EMI problems, but certain "reflection" problems could not be resolved using traditional EMI fix methods. However, with the introduction of RAM in the late 1970s, the SEMCIP engineers' EMI fix arsenal was now complete, and the battle against the unresolved EMI problems could continue to be fought and won. The NSWC Dahlgren RAM Installation Team (RAMIT)—consisting of government and contractor EMI experts in the field of RAM—was subsequently formed to investigate and resolve RAM-related EMI issues in the fleet.

Types of RAM

When considering the use of RAM for shipboard EMI reduction, there are basically two types to choose from. ***Narrowband*** or "tuned" RAM is one in which its peak performance is focused to a specific, narrow frequency or frequency band. This type of RAM is more likely used for attenuating the undesired output from a radar or other type of system that transmits a narrow frequency spectrum. On the other hand, ***broadband*** RAM has its performance spread out over a wide frequency range. This type of RAM is more likely used for simultaneously attenuating the undesired emissions from an EW system or several narrowband systems, where attenuation of signal energy across a wide band of frequencies is required. In general, greater attenuation performance (25–30 dB) can be achieved with a tuned RAM, but the performance is available only over a narrow frequency range. A broadband RAM will provide somewhat less attenuation performance (15–20 dB) but will do so over a much wider frequency range. This is but one of several engineering trade-offs that the SEMCIP engineer must address when using RAM to resolve an EMI problem.

RAM Design Trade-offs

When it comes to selecting a particular RAM for shipboard use, there are several trade-offs the EMC engineer must consider. While the frequency of operation and attenuation performance are usually the primary determining factors, maintainability, durability, weight, color, material sizing and, of course, cost are also critical factors in the equation.

- Maintainability: One of the biggest drawbacks to using RAM is the need to maintain it. High heat, exhaust stack gases, wind, salt, and freezing temperatures of the shipboard environment are extremely hard on RAM. All of these contribute to the rapid deterioration of RAM if it is not properly maintained. Today's RAM is very durable, but all shipboard EMI RAM requires painting. Painting of the RAM not only protects it from the environment but also allows it to visually blend in with the surrounding surfaces. When it is properly maintained and painted "haze gray," it is sometimes hard to notice that it is installed. However, maintaining RAM that is installed on the mast or yardarms is difficult, as staging/scaffolding is often required to access the RAM. Therefore, when RAM is installed in these locations, it might be better to use a carbon-loaded silicone material since it tends to hold the paint longer than some others.
- Durability: Depending on the installation location of the RAM, durability of the material must be considered. If the material will be in an out-of-the-way, out-of-reach location, durability of the material is not as crucial, and a less durable, better performing material may be used. However, if the material will be installed in a high-traffic or easily reached area, then a more durable material should be considered. Iron-loaded urethane RAM is very durable, while carbon-loaded silicone RAM has better performance but is not nearly as robust.
- Weight: Shipboard RAM used today can be designed to operate fairly well down to about 2 GHz, and tuned RAM that provides about 15 dB of attenuation at that frequency is readily available. However, once one goes below 2 GHz, the performance begins to drop off, and another undesired trade-off begins to emerge—weight. Weight is an unfortunate characteristic that becomes a factor in RAM at low frequencies due to the primary material used in the RAM's composition—iron. Also, as the desired frequency of operation decreases, the corresponding thickness of the RAM increases. Carbon-loaded silicone RAM tuned to 3 GHz might weigh about 1 lb/ft^2, but an iron-loaded urethane RAM tuned to 1 GHz weighs about 8 lb/ft^2. If the material is being installed on the ship's hull or superstructure, the added weight may not be much of a factor. But if it is being installed on the mast or yardarms, it can definitely be a factor, depending on the quantity required.
- Color: While all of the shipboard RAM must be painted, some of the RAM vendors can supply certain types of RAM that is color-matched to the ship's haze-gray exterior and does not require painting. Currently, there is no color-matched RAM being used on U.S. Navy ships for EMI control; the reason is that after the RAM is installed, all of the edges must be caulked in order to prevent water intrusion and promote long-term adhesion.

Since the optimal sealing caulk is not available in haze gray, painting is still required to make everything blend with the topside surroundings.

- Material Sizing: Depending on the quantity of RAM needed for a certain application, the available size of the RAM may drive which type is selected. Most RAM is available in 12″ × 12″ tiles, and many of the carbon-loaded and iron-loaded types can be manufactured in 18″ × 18″ and 24″ × 24″ sizes. One of the neoprene-based materials is manufactured to 36″ × 48″ tiles and others are available in 36″-wide rolls of any length.
- Cost: In these days of shrinking budgets and program cuts, cost-reduction efforts are now, more than ever, a factor in Navy acquisition and maintenance. When it comes to employing RAM as an EMI fix, the goal of the EMC engineer is to provide the ship with the best possible fix for the lowest cost. All of the RAM procurement factors must be considered in order to arrive at the best overall solution. Sometimes this may require using a material that initially costs more per square foot but will require less funding to maintain over its expected life cycle.

Installation and Maintenance

Whether it is used for EMI or RCS reduction, the following installation and maintenance concepts are applicable to all RAM installations:

- Years ago, both the thickness of the adhesive used for the installation of RAM tiles and the corrosion of the surface underneath the RAM were factors that affected the operating frequency of the RAM. Consistent thickness of installation adhesive in accordance with the manufacturer's specifications will result in consistent performance. This is not really an issue today since all RAM procured for Navy use is supplied with a pressure-sensitive adhesive (PSA) or "peel-and-stick" backing. When the adhesive is factory-supplied with the RAM, the thickness of the adhesive is maintained within pre-established tolerances, thus ensuring consistent RAM performance. Warm, dry weather conditions are desired for RAM installation, and a surface temperature of 50°F is required for optimum adhesive performance.
- Once the RAM tiles have been installed, all of the exposed seams and edges must be caulked in order to prevent water intrusion and promote long-term adhesion to the mounting surface.
- After the caulking has dried, all RAM must be painted. Care must be exercised to ensure that RAM surfaces are never coated or painted with any substance that affects its ability to absorb RF energy. Only latex-based paint should be used on RAM surfaces exposed to the elements. Metallic-based or epoxy-type paints normally found on board ships should never be used for RAM preservation or identification.
- Proper RAM installation is the paramount step to ensuring that the designed performance is attained and sustained. If properly installed and maintained, the useful service life is estimated to be a minimum of 5 years and, in most cases, significantly longer. Some ships have RAM that has been installed for 12 years and is still in good condition.
- Planned Maintenance System (PMS) procedures have been developed and implemented by NSWC Dahlgren's Electromagnetic Environmental Effects (E3) Force Level Interoperability Branch for all EMI-control RAM in the fleet. Ship's force FC, electronic technician (ET), and EW personnel are the ones who are responsible for performing the PMS on the RAM as it applies to their systems. The PMS consists mainly of a biannual inspection of the RAM and an annual (or "as-needed") paint requirement. When repair of the EMI RAM is required, the ships are instructed to contact NSWCDD for assistance.

Figures 1 and 2 show a typical RAM installation; note that the new RAM tiles are black. Figure 3 shows the completed RAM installation; the installed RAM tiles now blend in with the rest of the ship's topside structure.

The Way Ahead

Significant advances have been made over the last several years as to the technology and raw materials available for RAM design and fabrication. The use of iron-loaded RAM (which historically has been a popular choice but has a major drawback in that it tends to rust if not constantly maintained) has been somewhat phased out by the development of iron silicide, a similarly durable material that will not rust. Precurved RAM—for use on masts, yardarm supports, and other curved surfaces—has contributed to higher installation quality. Also, neoprene-based broadband RAM is now available in extra-large tile

Figure 1. X-Band RAM Installation on USS *Ronald Reagan* (CVN 76) Stubmast

sizes, thus reducing installation and maintenance costs, while increasing the service life due to higher quality installations. Quarterly working-group meetings are held with the RAM vendors to review the latest technological advances in the market and to ensure that emerging Navy RAM requirements continue to be addressed and resolved. These advances, combined with proper RAM maintenance, will help to ensure that the Navy's radar, navigation, communications, FC, and EW systems all will be able to operate simultaneously despite high-output power requirements, overlapping operating frequencies, sensitive receiver requirements, or other interoperability or interference issues. Consequently, our naval warfighters can remain confident that their systems will work effectively as they execute their missions.

Figure 2. X-Band RAM Installation on USS *Ronald Reagan* (CVN 76) Stubmast Showing New (Black) Tile

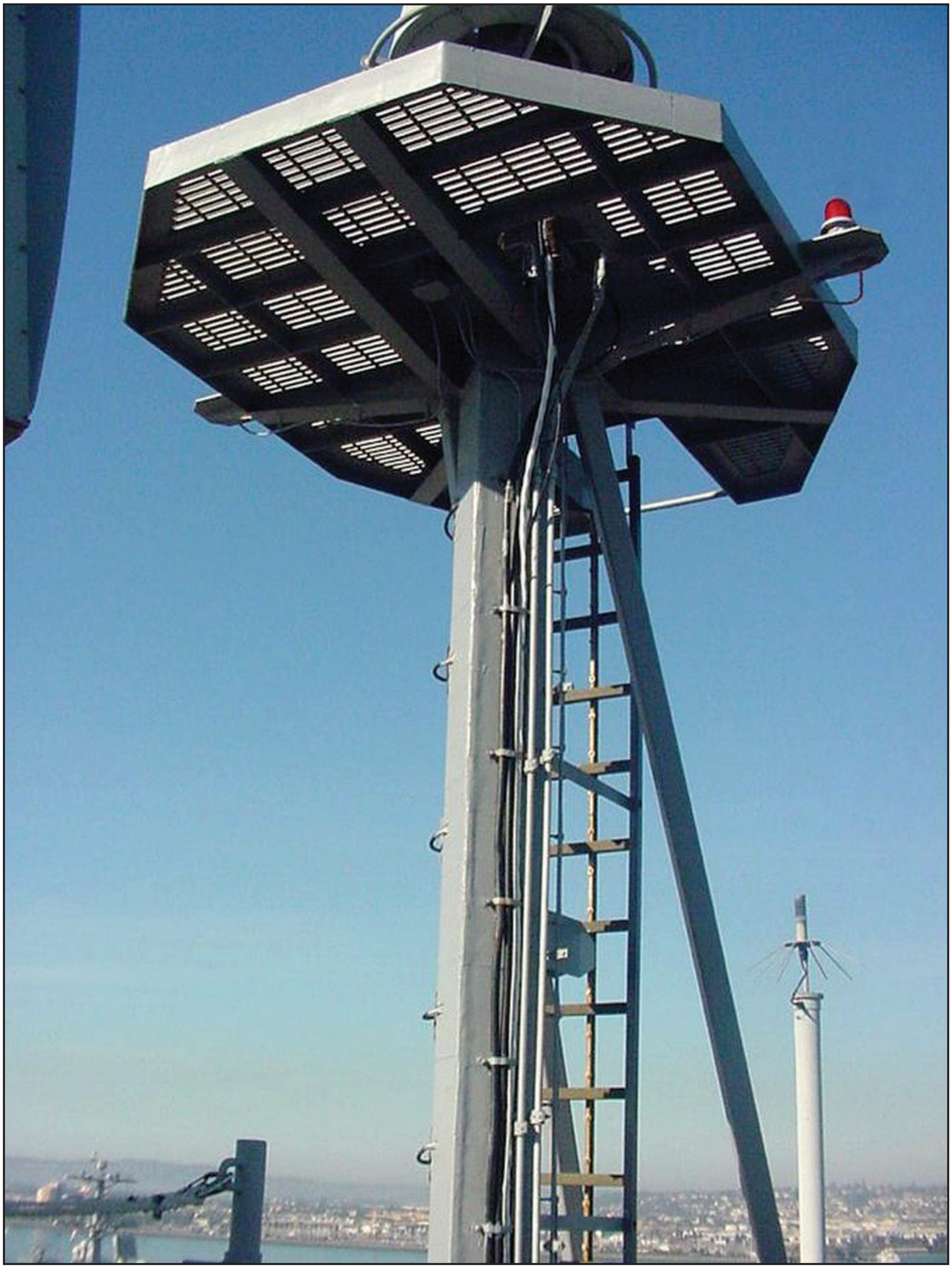
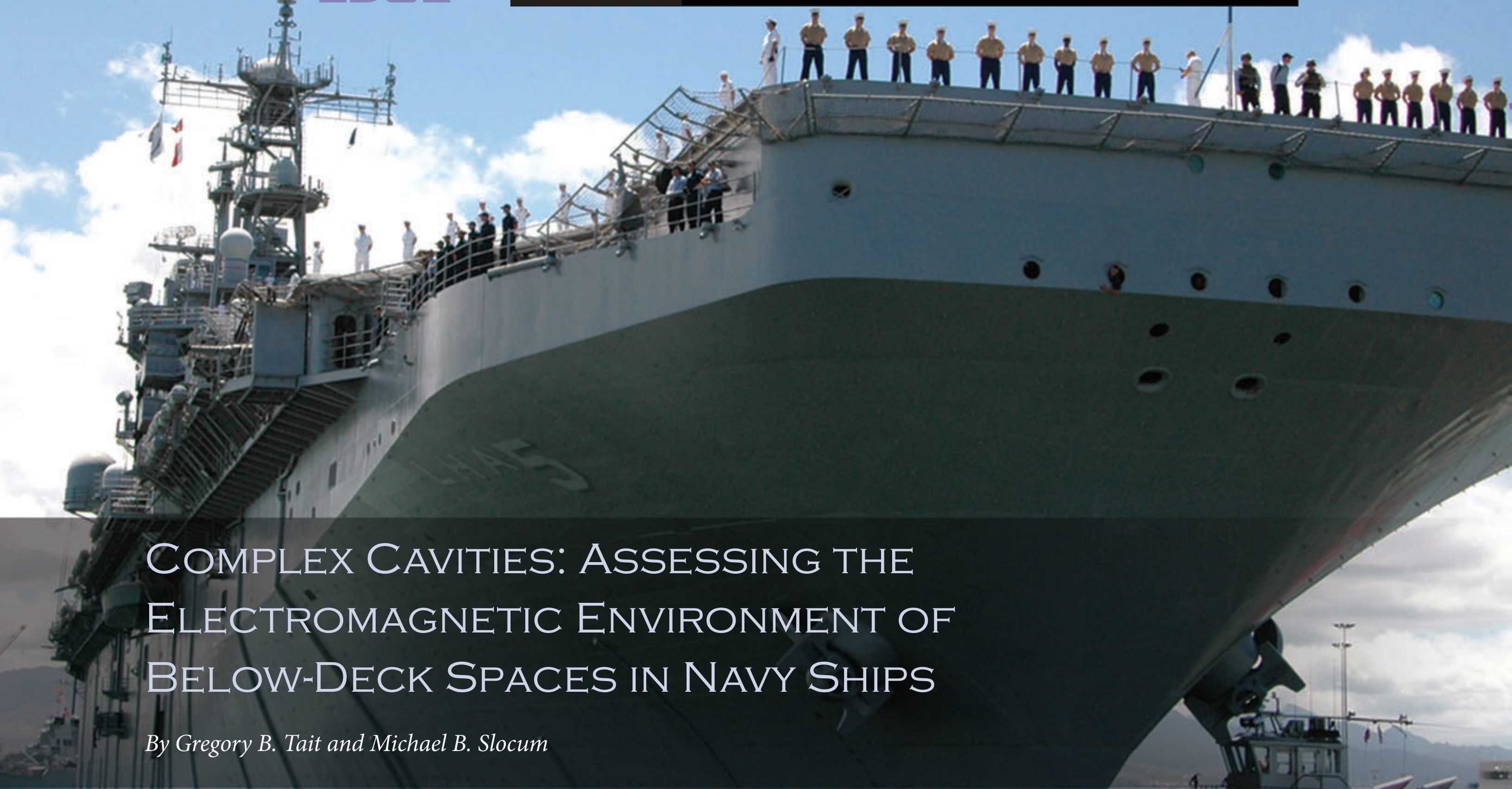


Figure 3. Completed X-Band RAM Installation on USS *Ronald Reagan* (CVN 76) Stubmast



Complex Cavities: Assessing the Electromagnetic Environment of Below-Deck Spaces in Navy Ships

By Gregory B. Tait and Michael B. Slocum

Introduction

With the proliferation of wireless systems currently being deployed in below-deck spaces on Navy ships, it is critical to assess the resultant electromagnetic environment of these confined, highly reflective cavities, especially where potentially disruptive or harmful effects to electronic equipment (electromagnetic interference/electromagnetic vulnerability (EMI/EMV)) or hazards to ordnance (HERO) may exist. In addition, these same wireless components and systems, with their associated risks, are being installed in similar confined, reflective spaces in ashore facilities. Examples of complex cavities or spaces include below-deck compartments aboard Navy ships, ammunition bunkers, aircraft cabins and bays, and buildings such as hangars and prefabricated metal storage facilities. As shown in Figure 1, it is often necessary to utilize any available area for temporary storage and assembly of ordnance in support of a broad array of mission requirements. Of particular significance is the introduction of radio frequency identification (RFID) and wireless local area network (LAN) systems in these spaces. Consequently, in assessing the potential impact associated with using radio frequency (RF) transmitters in reverberant spaces, we must address the cumulative buildup of the electric fields.

The Naval Surface Warfare Center (NSWC) Electromagnetic Effects Division, located in Dahlgren, Virginia, was instrumental in pioneering the use of reverberation chambers as electromagnetic test facilities. These efforts contributed greatly to an understanding of RF propagation within enclosed, electrically reflective boundaries. It became readily apparent that the statistical analysis techniques developed for use with reverberation chambers are well suited for application in defining electromagnetic environments within any such enclosed volumes. Figure 2 shows one of Dahlgren's reverberation chambers, which is typically used to assess electromagnetic compliance of various electrical or electronic weapons and control systems.

Electromagnetic Environment

The term ***electromagnetic environment*** is used to describe radiated electric fields generated by both intentional and unintentional sources of RF transmissions. These

Figure 1. During Gulf 1, space constraints required that ordnance be staged in a carrier's mess deck.

Figure 2. Dahlgren Reverberation Chamber

fields propagate as wave energy in an open air (free space) condition and attenuate at a rate of $1/r^2$, where r is the distance from the source. In an enclosed, electrically reflective space, such as a ship's compartment, this energy repeatedly reflects off of walls and other metallic structures. Accordingly, free-space attenuation is no longer applicable as these reflections combine together, effectively increasing the resultant electric field intensity.

Just as the propagation within such spaces is unique, characterization of the electromagnetic environment within requires a unique approach. Such characterizations are conducted using a spatial or volumetric methodology in place of the line-of-sight techniques used for free-space environments. Studies conducted at NSWC Dahlgren have demonstrated that such reverberant spaces can be characterized using either of two techniques. The first is to physically stir the energy within a space using large, electrically conductive tuner assemblies, while simultaneously measuring the resultant electric field intensity. This technique is shown in Figure 3.

The second technique is to physically move (carry) both the transmit and receive antennas throughout the space, which results in sampling the electric field intensity at many locations and orientations. It has been demonstrated that the two measurement techniques are equivalent. This equivalence is important, as setting up and operating large tuners for effective mechanical stirring of the fields is not practical in the characterization of a large number of spaces aboard a ship. It is thought, however, that the changes in the cavity boundary conditions—such as from movement of personnel, equipment, and materiel—will stir the fields to a large extent over a longer period of time. The second technique, therefore, has proven to be the better approach due to the operational constraints of conducting such characterizations outside of a

Figure 3. Energy Stirring Using Tuner Assemblies Aboard USNS *Sacagawea* (T-AKE 2)

laboratory environment. Figure 4 depicts the test equipment utilized in this preferred technique.

In conducting these measurements, limitations exist on test time, working volume (with minimal disruption of normal functional operations), test equipment (number, weight, and size), availability of AC power, manpower, and cost. These challenges are common to both ashore and afloat facilities. From measurements of power insertion loss in the space, a cavity calibration factor is derived that is used to predict a resultant maximum diffuse electric field as a function of frequency and total radiated power in that space. Due to the additive nature of multiple RF emitters in confined, highly reflective spaces, the potential exists for maximum fields to exceed current HERO unsafe criteria in ordnance magazines and assembly areas, which could result in dudding or premature detonation of ordnance. The latter poses serious risk through loss of life and, in the extreme case, could destroy the ship or platform carrying such ordnance. Consequently, the ability to predict maximum electric fields in a space will be critical for placing restrictions on the number of RF emitters allowed in that space.

There are two general requirements for a space to be reverberant:

1. The space must be large in terms of the wavelength (overmoded).
2. The space must be reflective of electromagnetic energy (many reflections of waves).

Therefore, the field at any point within some working volume consists of a large number of individual wave components that, upon effective mode stirring, generate a field that is statistically uniform, isotropic, and randomly polarized. In reverberation chamber test facilities, these conditions are met, usually with a large mechanical tuner providing effective mode stirring. In many field-operational spaces, the conditions that the cavity be overmoded and reflective are generally fulfilled at

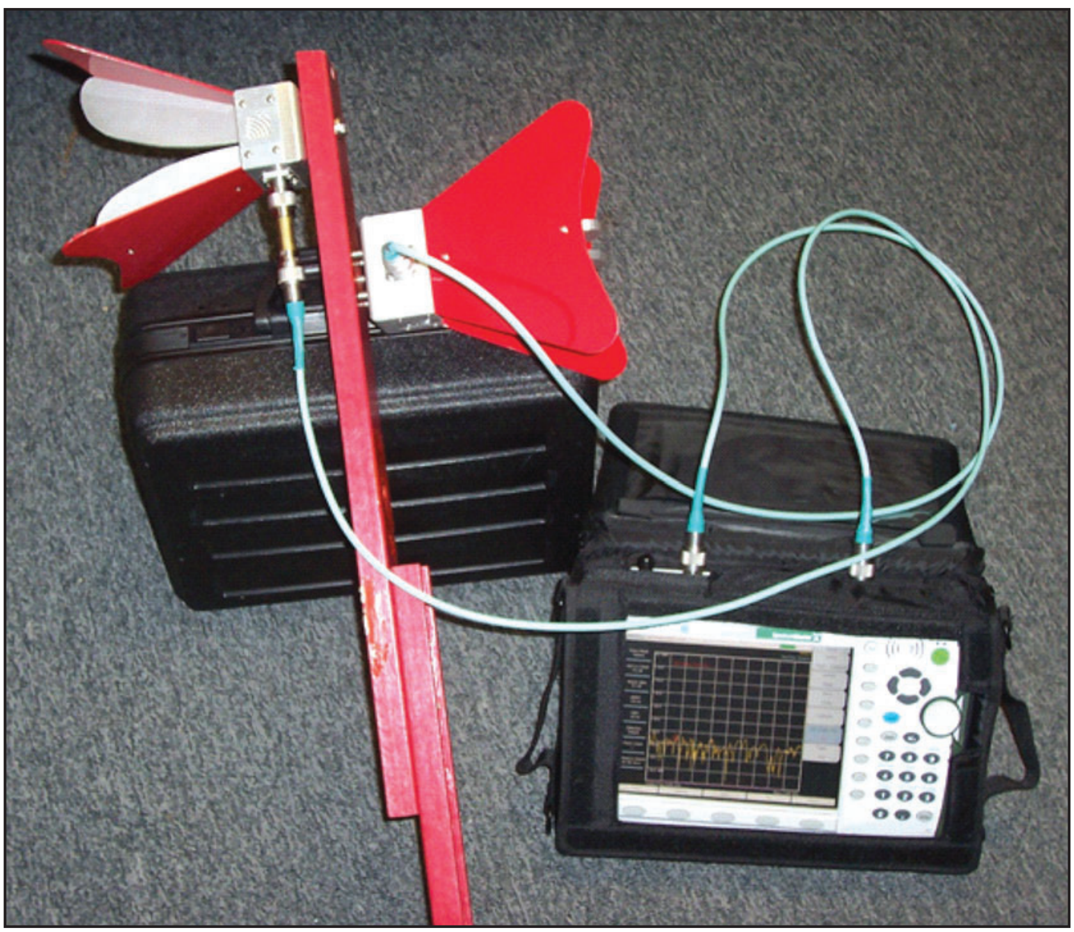


Figure 4. Test Instruments Used in Preferred Measurement Technique

frequencies of interest. A similar situation has been found to exist in aircraft cavities.

Electrically large and reflecting spaces with arbitrary shape and loading are often referred to as complex cavities. The complex cavity is characterized by a chaotic electric field standing-wave pattern of maximums and minimums whose locations are very sensitive to small changes in boundary conditions, such as occur from changes in physical structure (mechanical stirring), frequency (frequency stirring), loading (materiel, personnel, equipment), temperature, etc., over a period of time. Figure 5 shows a computer-generated visualization of the rapidly and randomly varying spatial field pattern in a complex cavity. A deterministic analysis, either by measurement or by modeling/simulation of such chaotic fields is neither practical nor useful, as substantial changes are caused by perturbations. Useful descriptions must be statistical in nature and independent of details.

Application of Theory

With sufficient number of modes excited in a complex cavity, the central limit theorem of statistics states that the field components are normally distributed with zero mean and equal standard deviation. Hence, the received power of a linearly polarized antenna in the space should follow a chi-squared distribution with two degrees of freedom (χ_2^2) as the receive antenna position is randomly changed. Demonstration of χ_2^2 statistics in the space is a good indicator of its reverberant nature and allows us to exercise the appropriate statistics to predict such things as maximum field values within specified levels of confidence.

To date, the Electromagnetic and Sensor Systems Department engineers from NSWC Dahlgren have measured the electromagnetic environments in over 60 below-deck compartments in several ships (T-AKE 2, LHD 5, LHD 7) in port at Naval Station Norfolk. Figure 6 shows a measurement in progress. It was found that these spaces can be characterized as complex reverberant cavities that can sustain fairly high maximum electric field levels over the 200 MHz to 10 GHz frequency range. Due to the cumulative build-up of electric fields from multiple radio-frequency emitters, care must be exercised to assure that

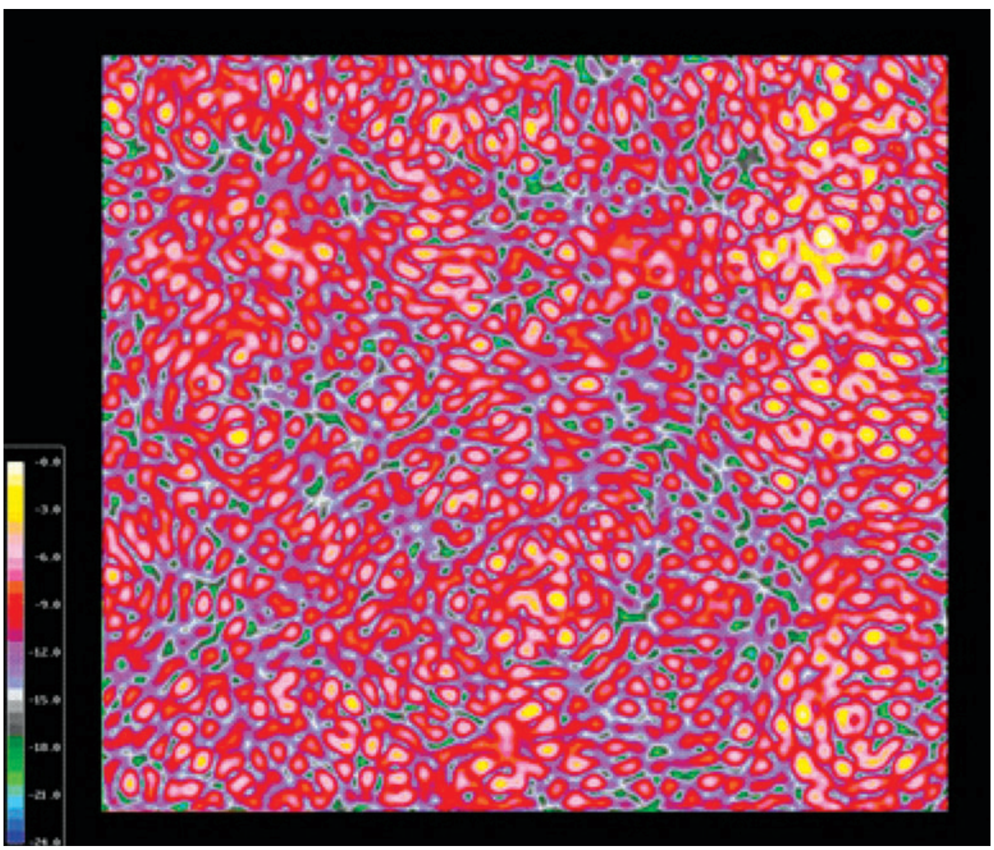


Figure 5. Computer-Generated Visualization of the Chaotic Electric Field Standing Wave Pattern in a Reverberant Complex Cavity

the maximum allowable environment for electronics and ordnance is not exceeded. As an assessment figure of merit for below-deck spaces, a cavity calibration factor is derived from measured power-insertion loss data and is used to estimate field strengths as a function of frequency and total radiated power into the space. Typical maximum cavity calibration factors range from 1–10 V/m/√W in ordnance magazines, operations centers, and electronics rooms to as much as 10–20 V/m/√W in small, highly reflective pyrotechnics storage compartments. Guidelines for allowable total transmitter powers for RFID and wireless LAN systems are established from the results of this investigation.

Conclusion

Due to ever-increasing pressures on our Navy to provide a dominant presence in remote portions of the world with fewer ships and personnel, we are more dependent on technology than ever before in naval history. One of the primary roles NSWC Dahlgren plays in supporting this technology boom is to assure that such systems are both capable and safe for fleet operations in a severe electromagnetic environment. The scientists and engineers of Dahlgren charged with this task support Naval Sea Systems Command (NAVSEA) as the engineering agent for the electromagnetic effects warrant holder's office (05W43), as well as the Naval Safety and Security Activity (NOSSA) through compliance evaluations and managing the Navy's Hazards of Electromagnetic Radiation to Ordnance (HERO) program. Unlike other services deployed in our nation's defense, our sailors literally sleep on their ordnance, and they are counting on us to ensure that it is both safe and functional. To that end, assessing the electromagnetic environment in below-deck spaces in Navy ships enables improved warfighter efficiencies by leveraging technologies such as wireless LAN and RFID in a safe and reliable manner.

Figure 6. Dahlgren engineers conduct an electromagnetic assessment in a radio transceiver room aboard the amphibious assault ship USS *Iwo Jima* (LHD 7).

The Department of the Navy's HERO Program

By Charles C. Denham


U.S. NAVY
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X-RAY SOURCE
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Introduction

The Department of the Navy (DON) has an established and comprehensive Hazards of Electromagnetic Radiation to Ordnance (HERO) Program. This program is critical in ensuring a safe environment, both afloat and ashore, for the safe handling of ordnance without compromising operational flexibility and readiness. This article describes the Navy's overall HERO Program, important elements of the program, some history behind the program, and how the program has evolved over the years to get where it is today.

HERO Defined

The HERO discipline is concerned with the electromagnetic environment (EME), in which electrically initiated ordnance will be exposed while performing its intended mission throughout its operational life cycle. Consequently, HERO can be defined as the situation in which transmitting equipment (e.g., radios, radars, electronic countermeasures, ground penetrating radars) or other electromagnetic-radiating devices can generate radiation of sufficient magnitude to induce or otherwise couple electromagnetic energy, which inadvertently causes the actuation (or dudding) of electrically initiated ordnance. The result is that the affected ordnance is unable to function as intended, or worse, that there is an immediate catastrophic event, which either destroys equipment or injures personnel. An electrically initiated device (EID) is defined as a single unit, device, or subassembly that uses electrical energy to produce an explosive, pyrotechnic, thermal, or mechanical output. Examples include electroexplosive devices such as hot bridgewire, semiconductor bridge, carbon bridge, conductive composition laser initiators, exploding foil initiators, burn wires, and fusible links, all of which have different response characteristics. For HERO, the EME is defined as the totality of electromagnetic energy—both intentional and unintentional radiation—to which platform/system or subsystem/equipment will be exposed within the land, air, space, and sea domain, while performing its intended mission during its stockpile-to-safe separation sequence. The HERO problem arises from a fundamental incompatibility between EIDs and their firing circuits and the external EME that the ordnance encounters.

History and Philosophy

As early as the 1940s, a number of unexplained accidents involving electrically initiated ordnance were suspected to have been directly related to stray radio frequency (RF) emissions. In the 1950s, an Mk 6 Mod 13 torpedo exploder mechanism was known to have been set off by RF energy. Around this time, a number of other aircraft carrier HERO incidents were also documented. Consequently, in 1956, the Chief, Bureau of Ordnance initiated a formal HERO Program at the Naval Surface Warfare Center, Dahlgren Division (NSWCDD), then known as the Naval Proving Ground (NPG), Dahlgren. For the next 3 years, the development of the HERO Program was primarily one of organization, both philosophically and practically. In late 1959 and early 1960, money was appropriated to build the first ground plane to support HERO testing. By 1963, the Navy HERO Program expanded in response to a requirement to test all ordnance containing EIDs, which has become one of the fundamental pillars of the program. To accommodate this effort, a second ground plane was built to support off-site testing at the Naval Air Station (NAS), Patuxent River, Maryland.

The year 1965 marks the introduction of the second pillar of the HERO Program: HERO shipboard and field surveys. In the early 1970s, these surveys became the direct responsibility of the Naval Sea Systems Command (NAVSEA). Throughout the years, the Navy HERO Program has continued to grow with regard to the testing of ordnance, the survey efforts, and the approaches to addressing the HERO problem in the guidance provided to the fleet. The ensuing paragraphs introduce and discuss the current philosophy for each of the Navy HERO Program core elements in an attempt to illustrate the importance of each to the overall program and why each of these program elements must continue to be maintained in order to effectively sustain the Navy HERO Program.

Core Elements of the Navy HERO Program

Traditionally, the program has identified three broadly defined core elements (or pillars) to describe the overall DON HERO Program (see Figure 1): HERO certification testing, HERO surveys, and HERO guidance. These elements, when viewed as individual parts of the overall program, represent very different, but important, efforts and together form a comprehensive HERO Program and an effective means for managing HERO and mitigating the hazards throughout the DON. For that reason, it is important to describe in some detail each of the three critical program elements to better understand how their synergy provides a total approach for managing HERO in the Navy, joint,

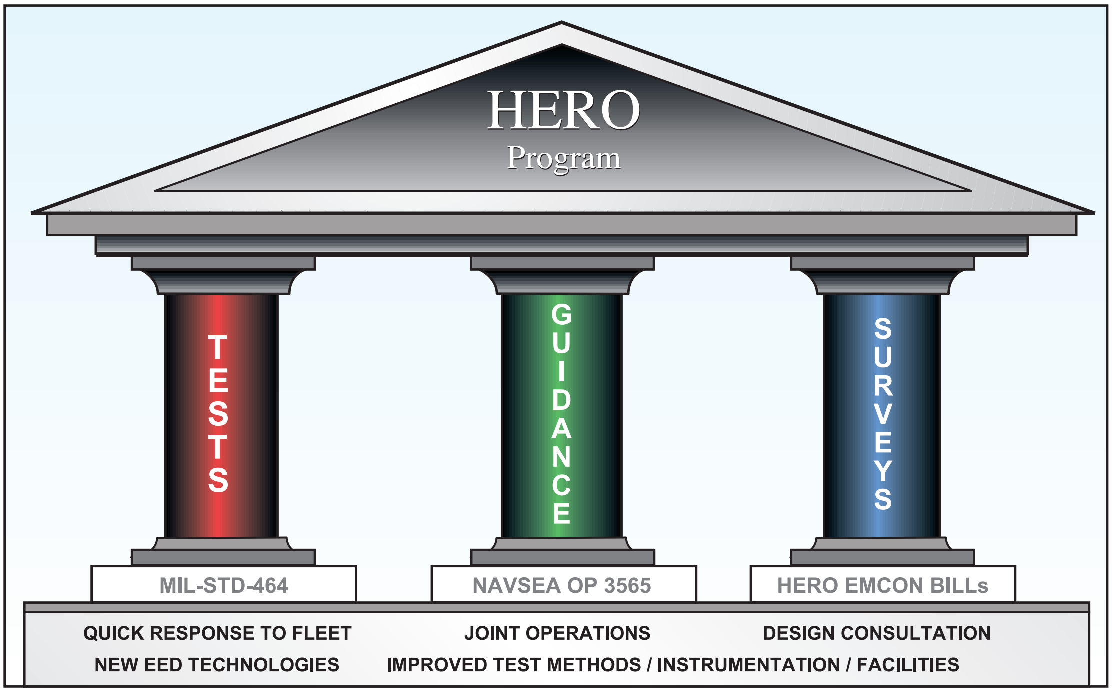

Figure 1. Pillars of the HERO Program

coalition, and North Atlantic Treaty Organization (NATO) environments. It is also important to illustrate how these program elements have matured over the years to provide the breadth and depth of the Navy's HERO Program.

HERO Certification Testing

Ordnance certification testing (or HERO testing) is an important element of the HERO certification process. This process contains step-by-step procedures through which a program manager (PM) obtains a HERO certification or a HERO operational waiver for new or modified weapons or weapons systems containing EIDs. This certification or waiver is a mandatory milestone in obtaining an active National Stock Number (NSN) or Navy Ammunition Logistic Code (NALC) so that these weapons or weapons systems can be delivered to the fleet for use. All weapons containing EIDs are required to be evaluated for HERO as part of this process. Currently, MIL-STD-464, titled *Department of Defense Interface Standard for Systems Electromagnetic Effects Requirements*, establishes the electromagnetic environmental effects (E3) interface and performance requirements and verification criteria for systems. The HERO test identifies the item's susceptibility or immunity to the operational EME and, if susceptible, identifies the maximum allowable environment (MAE) that the item can be exposed to during its stockpile-to-safe separation sequence. It should be emphasized that testing is the preferred means of determining how an ordnance item will respond to the expected EME.

As stated previously, HERO testing should include exposure of the ordnance to the test EME in all life-cycle configurations, including transportation and storage, assembly, handling and loading, staged, and pre- and post-launch (see Figure 2). There are many other things to consider during the HERO test in order to ensure that the item has been properly evaluated. First and foremost are the description and characteristics of the EIDs contained in the system under test (SUT), how these EIDs are used, and their firing effects. Technical details—such as the type of EID, the bridgewire resistance, the firing sensitivity, the thermal time constant, and the firing consequence (safety/reliability)—are necessary in order to predict potential susceptibilities and determine instrumentation requirements. Other details must also be considered, such as firing circuit designs, system wiring and cabling, gaskets, connectors, shielding, and the SUT's physical dimensions.

Somewhat unique to the Navy is the test approach whereby all stockpile-to-safe separation configurations are evaluated during ordnance testing. Inasmuch as ordnance configurations can be expected to offer different levels of RF protection, all must be given due consideration. With many

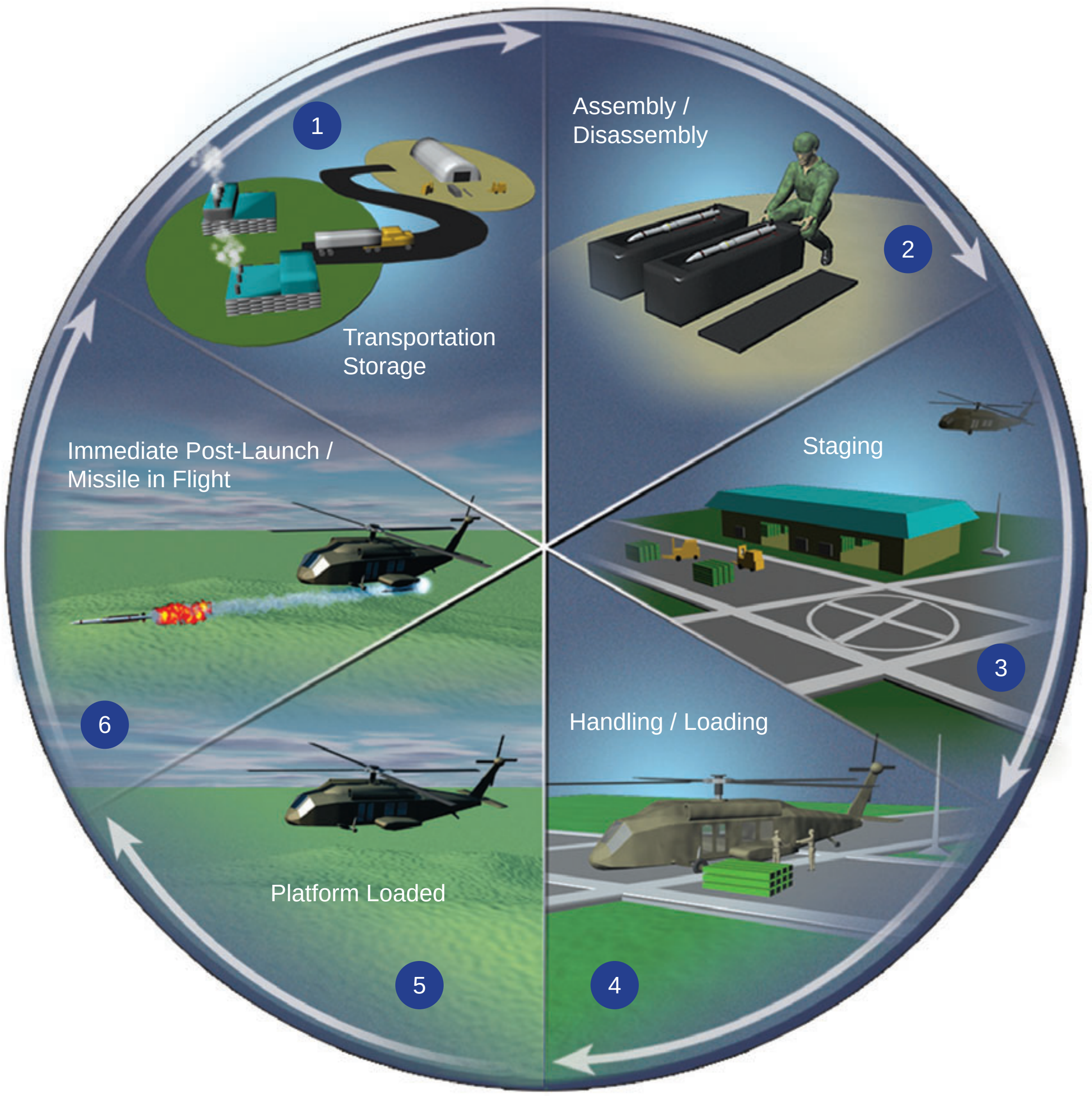

Figure 2. Ordnance Stockpile-to-Safe-Separation Sequence

ordnance items, the host platform/system (e.g., airframes, bomb racks, dispensers, or interface cables) varies as it progresses through the stockpile-to-safe-separation sequence, and these differences can have a pronounced influence on the amount of RF coupling. Furthermore, it can be expected that the EME associated with each will be quite different and, therefore, must be fully understood. The test EME should simulate the specified operational EME to the extent necessary to stimulate maximum EID and firing-circuit responses. In order to stimulate the specified operational EME, frequency, power levels, polarization, illumination angle, pulse widths, pulse repetition frequencies, and dwell times must be carefully chosen, and ordnance stockpile-to-safe separation configurations must be fully understood. Thus, it becomes immediately obvious that the HERO survey process is critical to the certification testing process, as this is where operational EMEs are characterized, and specific ordnance configurations and procedures are identified.

Ultimately, all of the aforementioned HERO test criteria are considered in order to ensure test standardization within the Navy HERO Program. The Navy's test methodology is well documented and provides a strong foundation on which Navy HERO certification relies. This test philosophy and methodology has been documented in MIL-HDBK-240 for the other services to use as a model for HERO testing to ensure Department of Defense (DoD) consistency within the respective HERO programs. The strength of the ordnance certification testing conducted by the Navy facilitates the Navy's HERO certification process as a whole by providing important data to the Weapon System Explosives Safety Review Board (WSESRB) and NALC verification process (i.e., cataloging request) to ensure proper hazard classification and HERO certification so that ordnance systems can be safely introduced into the fleet.

HERO Surveys

Also unique to the Navy HERO Program is the extent to which the operational EME is characterized through HERO surveys. HERO surveys are necessary to ensure the safety of simultaneous operations involving ordnance and electromagnetic emissions from radar and communication systems. While HERO certification testing allows for defining an item's MAE, the HERO survey defines the actual operational environment that the item will be exposed to. A HERO survey is an on-site visit, in which measurements of the RF environment are made at all ordnance locations, including assembly areas, handling and loading locations, staging areas, and transportation routes. This characterization of the EME is combined with a detailed data-gathering process in which all emitter systems are documented, and all operational requirements are reviewed.

The information gathered during the HERO survey is used to prepare operational recommendations and an emission control (EMCON) bill, and often results in a more efficient use of ordnance areas, while minimizing the operation restrictions placed on radar and communication systems. Environmental studies such as these (i.e., characterization, monitoring, and documentation of EMEs), particularly aboard ships, remains a vital part of the HERO Program and allows for the translation of an extensive amount of technical HERO data into ship or site-specific (easy to use) guidance for the fleet. Surveys also serve as a means for providing critical training, as well as a tool for soliciting feedback on existing HERO guidance and operational procedures. Figure 3 illustrates the dangers of ordnance on deck being exposed to electromagnetic radiation (EMR) from powerful radar and communications emitters in the immediate vicinity.

In recent years, the HERO survey program has increased its emphasis on joint and coalition forces' operations on board Navy platforms and at forward-deployed locations. To better address these concerns, more measurements are made on the flight deck of all air-capable ships. Moreover, the Navy HERO EMCON bill (guidance) has evolved to address joint and coalition forces' operations. Data gathered during shipboard HERO surveys are also provided to other related programs that rely on the Navy to define the operational EME.

Characterization aboard ships and shore facilities are used to update MIL-HDBK-235B to address tailored EMEs and are currently being used to update the HERO certification EME tables found in MIL-STD-464. The survey data is also used to update the EME module in the Joint Spectrum Center (JSC) Ordnance E3 Risk Assessment Database (JOERAD) and is contributing to NATO's efforts to capture the NATO operational EME.

It is also important to note that knowledge of the operational EME is critical in order for weapon system programs to specify and address E3 performance-based requirements within the Operational Requirements Document (ORD), Test and Evaluation Master Plan (TEMP), and the Mission Needs Statement (MNS). Not only is it vital to characterize the operational EME as a means for E3 design, development, and test and evaluation (e.g., HERO and electromagnetic vulnerability (EMV)), but this data is necessary for managing any and all unresolved susceptibilities once introduced into the fleet.

HERO Guidance

Previous initiatives have shown that HERO certification testing enables identifying the MAE that an ordnance item or weapon system can be exposed to; the survey process allows for defining the operational EME that the item will actually see.

The final pillar is the guidance that is provided and, most critical to the warfighter, is the guidance provided in the HERO EMCON bill. The HERO EMCON bill, included in the HERO instruction, is a specific set of procedures (i.e., frequency/power management or procedural management) that identifies the ordnance/weapon system scenario, the susceptibility, and the specific guidance to safely and effectively manage the event. It is the culmination of all of the efforts and data gathering of the certification testing and survey efforts, whereby specific information germane to a ship or shore facility is filtered out to provide platform/system scenario-specific HERO guidance for a defined operational EME.

Figure 3. Ordnance Exposed to Radar and Communications Emitters in the Immediate Environment

For the Navy HERO Program, guidance comes in other forms, including technical manuals, instructions, shore facility site approval analyses, shipboard system certifications, and general fleet guidance to support naval operations. *Electromagnetic Radiation Hazards (Hazards to Ordnance)* is the Navy HERO Program technical manual.[1] It provides information on how to calculate the RF environment, determine the safe separation distance for ordnance classified as either HERO SUSCEPTIBLE and HERO UNSAFE ORDNANCE, manage HERO in the NATO environment, establish a HERO EMCON Bill, and request a HERO survey; it also provides information on other general HERO requirements. The *Electromagnetic Radiation Hazards* (Hazards to Ordnance) Datasheets[2] provides HERO classifications (e.g., SAFE, SUSCEPTIBLE, and UNSAFE) for all ordnance evaluated and contains the Navy's susceptibility data (as a result of HERO testing). Another document generated by the Navy HERO Program is *Design Principles and Practices for Controlling Hazards of Electromagnetic Radiation to Ordnance* (HERO Design Guide).[3] The design guide is intended primarily to assist the ordnance system developer solve the problem of premature actuation or degradation of EIDs through sound design practices.

Perhaps the best tool the Navy HERO Program has today for capturing information and providing HERO guidance is the E3 Team Online tool. The E3 Team Online is a Navy HERO Program knowledge-management system for supporting the creation, capture, storage, and dissemination of E3 information, particularly as it relates to the HERO Program. This tool, developed in the late 1990s, started out as an engineering tool to aid in the development of HERO test and survey reports and was used solely by the HERO Program engineers. Currently, the tool is being used by a number of components within the various services and, in the near future, will be available as a fleetwide tool. This management system contains the HERO database, with over 18,000 records that provides a catalog of ordnance items by NALC/Department of Defense Identification Code (DoDIC) with specific information pertaining to each item, including the current MAEs and HERO status. This database serves as the data source for NAVSEA OP3565, Volume III and will also soon contain a cross reference table for EIDs with some 2,176 unique EIDs.

E3 Team Online also has built-in e-tools to calculate safe separation distances and MAEs and contains over 13,000 technical reports dating back to the 1960s, including all of the HERO test and survey reports. More recently, E3 Team Online now provides an interface (Platform Management Tool) to manage and retrieve information pertaining to specific ship, shore, vehicle, and aircraft platforms. Platform information includes:

- HERO reports
- Transmitter/antenna configurations
- Photos and drawings
- EME measurement data
- Ordnance listings
- Aircraft/vehicles supported
- EMCON bills

This data is used by all of the services and is used to feed information to JOERAD, the Shipboard Electromagnetic Compatibility Improvement Program (SEMCIP) Technical Answers Network (STAN) Database, and the Navy's Capabilities (CAPs) and Limitations (LIMs) Program efforts. It also supports other information sources for the fleet, such as the Naval Air Systems Command's (NAVAIR's) Air Systems Electromagnetic Interference Corrective Action Program (ASEMICAP) E3 Integrated Planning Team (IPT), Fleet Combat System Operational Sequencing System (CSOSS) Development and Implementation Team, *Aegis*-class advisories and master procedures, and the integrated topside design process. In the future, E3 Team Online will provide a risk management tool and a shipboard EME prediction tool to supplement the HERO guidance capabilities (see Figure 4).

Navy HERO Program Today

In the 1970s and 1980s, the Navy HERO Program performed HERO certification testing and HERO surveys. For the most part, all of the program's efforts were stovepiped into these two areas, and there was little focus on guidance or operations beyond the Navy environment. In the 1990s, the Navy HERO Program expanded in breadth and depth, and began to reach out beyond the Navy to address HERO concerns from a DoD perspective.

The program also began to work within a yearly structured business plan, such that funding and manpower was directed to other programmatic areas of concern, such as the site approval process and system certifications, the ordnance database, forward-deployed HERO support; and assurance that the various Navy and DoD instructions and publications were updated to reflect the current HERO philosophy and methodology. In addition, the HERO Program began to invest in the future by conducting HERO studies related

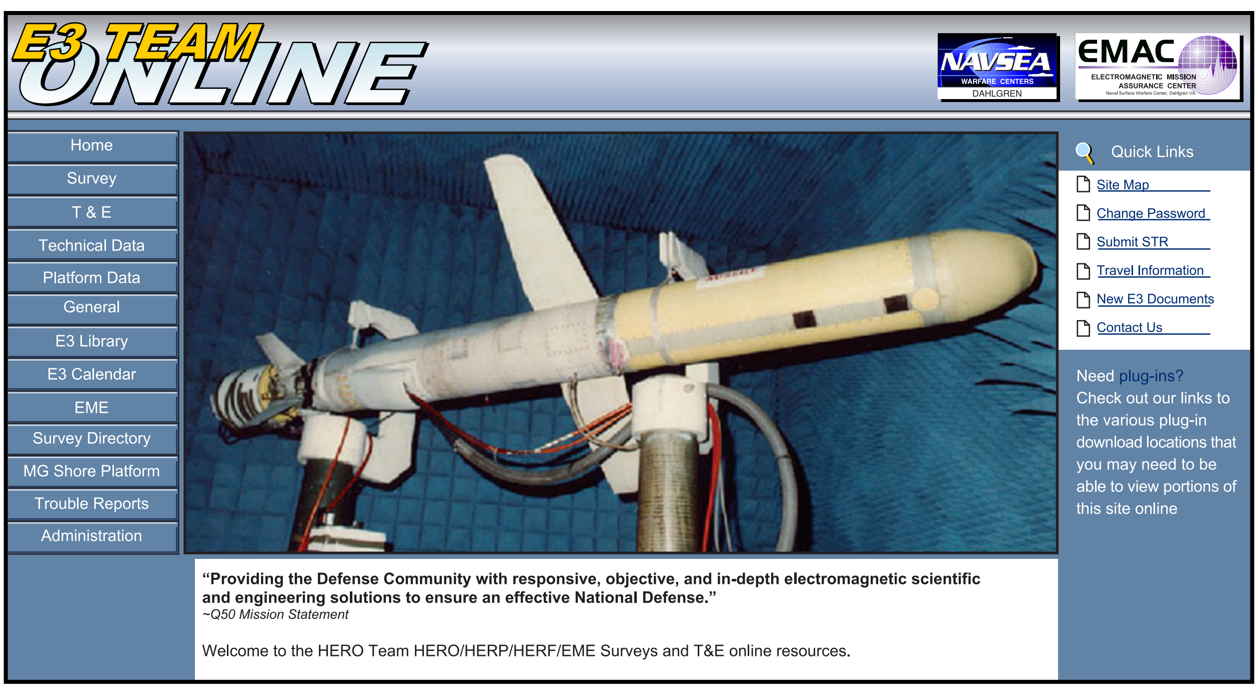

Figure 4. E3 Team Online

to HERO instrumentation, low-frequency/transient radiation effects on ordnance, EID technology assessments, passive/active radio frequency identification (RFID) device test methodologies and certification processes, gamma irradiation of explosives, below-deck measurement techniques and complex cavity effects, and the use of the mode-stirred chamber for HERO certification.

Inasmuch as the program placed an emphasis on defining the requirements within the appropriate DoD instructions for HERO certification testing and for establishing a HERO survey process with defined periodicities for ship and shore facilities, the number of tests and surveys increased in the 1990s. The Navy HERO Program also began to provide a DoD leadership role through its effort in the Joint Ordnance Commander's Group (JOCG) HERO Subcommittee. Through its efforts in the JOCG, the Navy provided MIL-HDBK-240, the Joint HERO curves, and the MAE tool to help ensure consistency for the services' HERO programs, particularly for HERO certification testing and joint operational HERO guidance. Today, this triservice approach to HERO continues to grow such that the services and, in particular, the Navy are better able to address HERO concerns when joint forces are present aboard naval platform and ashore.

Furthermore, through the Master Data Exchange Agreement (DEA) programs in place with the various NATO nations and the U.S. Navy's representation in the NATO Radio and Radar Radiation Hazards Working Group (RADHAZWG), the Navy HERO Program has similarly improved its capabilities to deal with coalition forces present in the naval environment. Not only has the international efforts allowed U.S. input to the development of NATO EME standards, but it has also helped ensure rationalization, standardization, and interoperability of U.S. forces in NATO operations.

Today, the Naval Ordnance Safety and Security Activity (NOSSA), located at the Indian Head Division, Naval Surface Warfare Center, Indian Head, Maryland, is designated the Navy's Technical Authority for HERO.[4] As such, NOSSA provides policy guidance and is responsible for issuing appropriate instructions and publications necessary to implement a comprehensive program. NAVSEA issues procedures for the implementation of the DON's HERO Program and outlines the program's requirements and responsibilities.[5] The HERO Program encompasses the establishment and implementation of explosives safety standards, test and survey criteria, instructions, regulations, and electromagnetic EMCON procedures for radar and communication emitters throughout the DON. The instruction also designates NSWCDD as the technical agent for the DON's HERO Program.[6] As such, NSWCDD is responsible for the engineering and technical support to evaluate all Navy and Marine Corps materiel with EIDs to determine their immunity to EMR hazards, and to perform assessments and surveys for all Navy and Marine shore facilities and ships. NSWCDD is often called upon to evaluate ordnance with a joint force application and to perform assessments and surveys of forward-deployed areas.

Consequently, today's HERO Program is more than just HERO surveys or HERO certification testing and more than just Navy concerns in the naval environment. Current and future efforts will continue to include forward-deployed HERO surveys and operational guidance from a joint and coalition perspective. Through its comprehensive program, the Navy will continue to be a repository for operational EMEs aboard ship and at shore facilities, and will continue to provide a leadership role within the DoD for all matters related to HERO. The breadth and depth of the Navy HERO Program can be attributed to its broad scope of efforts within the three major pillars of the program through which it is able to provide effective operational guidance to the warfighter while maintaining safety. As a result of the program, naval, joint, and coalition warfighters not only operate more safely, but more effectively during peacetime or war.

References

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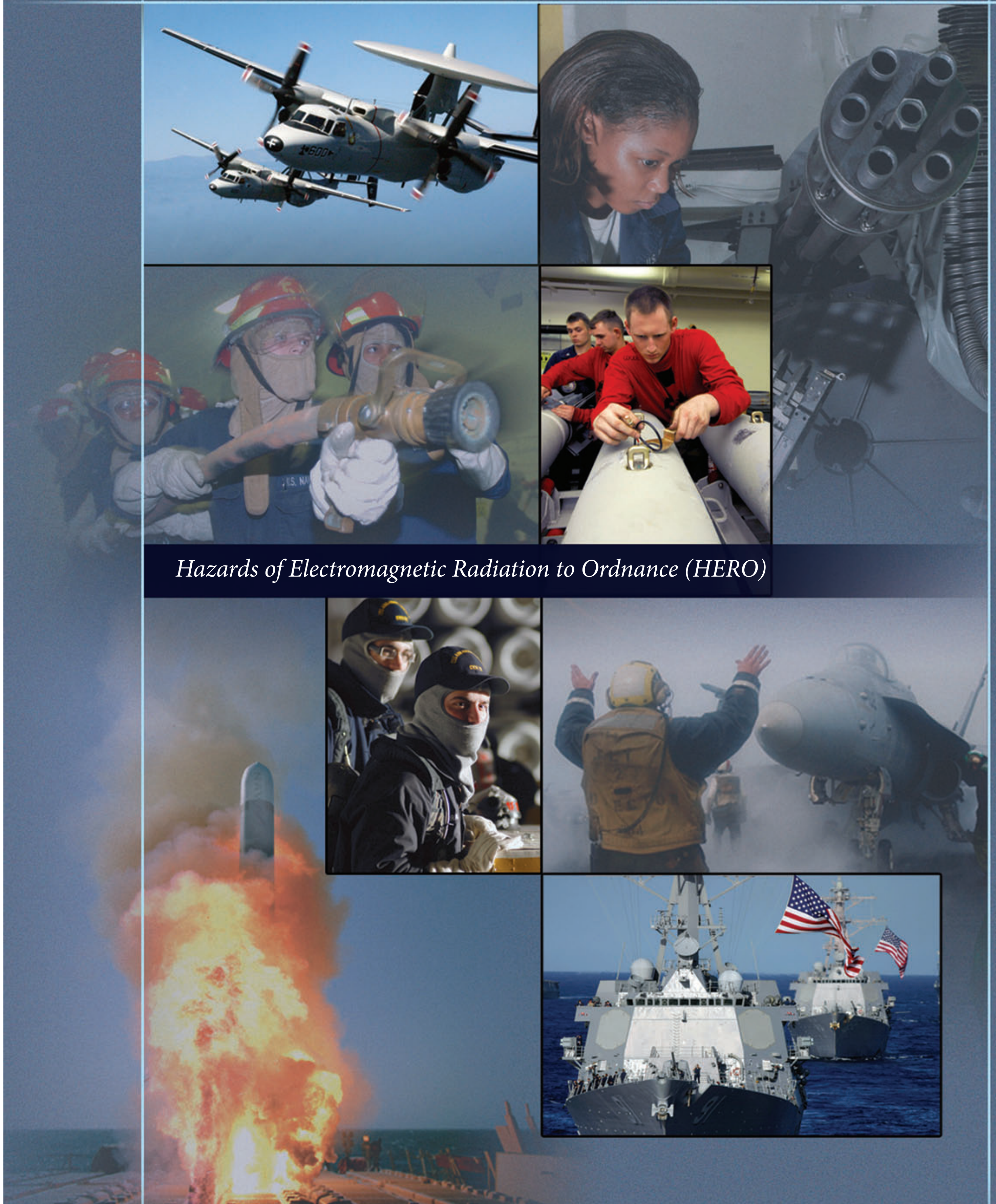
2. NAVSEA OP 3565/NAVAIR 16-1-529 Volume III.
3. NAVSEA OD 30393.
4. Chief of Naval Operations (CNO) and the Commandant of the Marine Corps (CMC) joint instruction, OPNAVINST 8020.14/MCO P8020.11, titled *DON Explosives Safety Program Policy and Procedures*.
5. Instruction 8020.7D, titled *Hazards of Electromagnetic Radiation to Ordnance Safety Program*.
6. IBID.

Hazards of Electromagnetic Radiation to Ordnance (HERO)



Joint and Coalition Forces in the Operational Electromagnetic Environment

By Charles C. Denham

Background

This article explains Hazards of Electromagnetic Radiation to Ordnance (HERO) challenges that the Department of Defense (DoD) is faced with when conducting joint and coalition operations. It describes, in some detail, the leading role the U.S. Navy has played in establishing HERO standardization among the U.S. service components through its leadership and efforts in the Joint Ordnance Commander's Group (JOCG) HERO Subcommittee. It also presents example solutions that have provided DoD-wide HERO mitigation techniques in supporting joint and coalition operations.

Overview

U.S. armed forces are involved in military operations throughout the world, including joint force operations (e.g., Air Force, Army, Navy, and Marine Corps). Many of these operations are conducted from forward-deployed areas and include coalition partners. For these armed forces to be most effective, they must be fully integrated: operationally, doctrinally, and technically.

Over the years, one of the technical challenges for the U.S. armed forces involved in joint and coalition integrated operations has been the ability to address HERO, which is defined as the ability of the operational electromagnetic environment (EME) to inadvertently induce currents and/or voltages of magnitudes large enough to initiate or dud electroexplosive devices or other sensitive explosive components of weapon systems, ordnance, or explosive devices. Proper HERO guidance can prevent undue operational restrictions or even loss of life and mission abort. The Defense Spectrum Organization (DSO), formerly the Joint Spectrum Center (JSC), and the Naval Ordnance Safety and Security Activity (NOSSA) routinely interact with the unified combatant commands and joint task forces (JTFs), providing operational spectrum management and HERO support and, as a result, understand the need for being proactive in addressing HERO.

The (JOCG) HERO Subcommittee was established in 1994 by the JSC. Its primary goal was to establish a consolidated triservice approach to HERO to facilitate the collection, development, and dissemination of the data necessary to manage the conflict between ordnance and RF emitters employed in integrated joint operations or exercises. The Navy—because of the depth and strength of its existing HERO program, and its knowledge of the shipboard environment that routinely hosts joint operations and exercises—has been at the forefront of establishing the triservice HERO approach. Since its inception, the JOCG's main focus has been the development of HERO tools such as the Maximum Allowable Environment (MAE) Analysis Tool, the JSC Ordnance Electromagnetic Environmental Effect (E3) Risk Assessment Database (JOERAD), and the establishment of DoD-wide HERO philosophies and methodologies now captured in the *Hazards of Electromagnetic Radiation to Ordnance (HERO) Test Guide*.[1] In addition to the work done in the JOCG, the JSC and NOSSA have sponsored a number of HERO surveys at forward-deployed locations to provide HERO training and to help manage HERO from a joint perspective.

Challenges

There are a number of activities within each service that are assigned various HERO program responsibilities, including both administrative and technical roles. The individual services manage HERO adequately; however, until recently, they did not have the necessary information to address ordnance safety when integrated joint operations and exercises occurred. This was particularly true in 1994 in the case of Operation Restore Democracy, where Army and Air Force helicopters, loaded with Army/Air Force ordnance, were exposed to the Navy shipboard EME off the coast of Haiti. This presented numerous concerns, in that the weapons were not designed, much less evaluated, to the Navy's unique shipboard EME. Consequently, the HERO guidance provided by the Navy HERO program was restrictively placing a burden on the ship's ability to conduct ordnance operations while, at the same time, impeding the effective use of its radar and communication systems.

A continuing concern has been the lack of a cohesive policy within the DoD to address this issue. Due to the varied service histories, it is not surprising that service-unique approaches dealing with HERO exist. Army, Navy, and Air Force HERO programs reflect fundamental differences in the perception and magnitude of the problem. Other factors, such as the way the services store, transport, and use ordnance, as well as the practical options available for managing HERO, influence the way each service manages its respective programs. Consequently, these differences influence not only the HERO certification testing of ordnance (i.e., test philosophy and methodology), but also the guidance that is provided to mitigate the concern for HERO at the operational level. From the HERO test perspective, service ordnance may not be tested or designed for the joint integrated operational EME. Due to these differences, HERO guidance in the joint arena, particularly in the naval environment, becomes difficult at best.

Another significant difference in the services' HERO programs is the characterization of the operational EME. To date, only the Navy's HERO program has a comprehensive HERO survey process, whereby the operational EME at shore facilities and aboard ships is characterized and documented. This perhaps best reflects the different "perception of the problem" that each service has with regard to HERO. The Army and Air Force generally operate with more real estate and can apply a calculated safe separation distance between emitters of concern (e.g., radars and communication antennas) and ordnance operations without imposing undue restrictions to their operations. However, the Navy operates in limited space aboard ship and a purely theoretical approach using calculations and derived safe separation distances provides overly restrictive solutions to managing HERO. The HERO survey process has allowed the Navy to better understand the operational EME and manage the HERO problem while maintaining operational effectiveness.

Despite the differences in the way each of the services manage HERO, there are certain elements common to all of the service HERO programs. Each of the services provides a definition of the expected EME levels for all ordnance configurations, a prescribed method to quantify system degradation (i.e., deficiencies), a process to develop and validate effective, practical HERO fixes for known deficiencies, and an established means by which operational procedures or restrictions are provided to minimize risks. While these commonalities exist, each service uses a somewhat different approach to manage HERO; however, these commonalities provide a starting point at which a triservice approach to HERO can be implemented. As a result, the JOCG chose to focus its efforts on the establishment of a triservice approach for HERO certification testing and the tools necessary for providing operational guidance. As a result, MIL-HDBK-240 was created, the joint HERO curves were established, and the MAE Analysis Tool was developed—all by Naval Surface Warfare Center, Dahlgren Division (NSWCDD) engineers, with input from the other services. In addition, the JOERAD database was created and populated with the services' HERO data, and forward-deployed surveys were implemented to provide training and immediate operational guidance to the warfighter.

HERO Test Guide

The *Hazards of Electromagnetic Radiation to Ordnance (HERO) Test Guide* (MIL-HDBK-240) was prepared by the services under the sponsorship of the JOCG HERO Subcommittee and provides recommended practices for conducting HERO evaluations across the service components for ordnance items and support equipment for all mission areas. There were four specific objectives of the HERO Test Guide:

1. The documentation of a HERO triservice test methodology
2. The promotion of a test standard
3. The identification of alternative techniques and identification of instrumentation
4. The facilitation of the exchange of HERO test data

It was determined that each of the service components must establish and maintain the same test philosophy and methodology in order to provide triservice guidance. This was critical because HERO test data is used to determine the MAE for ordnance and weapon systems containing EIDs and that, ultimately, MAE information is used to assess HERO risks and develop effective control measures to minimize these risks. In order to evaluate service test data in the joint environment, the guidance must translate down from a standardized test methodology (i.e., the proper test EME, evaluation of the SUT in the various stockpile-to-safe separation configurations, and knowledge of the instrumentation techniques used during testing). It followed that once standardized test methodologies were established to define the MAE, the exchange of meaningful HERO test data could be accomplished once the operational EME was defined.

Joint HERO Curves and the MAE Analysis Program Tool

While each of the service components had established programs to evaluate ordnance and commonality for HERO testing, as established under MIL-HDBK-240, the JOCG HERO Subcommittee tasked NSWCDD to develop a computer-based software program capable of predicting the maximum response of an ordnance system's EIDs to a wide range of EMEs and translating this information into service guidance in the form of MAEs. The goal of the MAE analysis program was to provide a tool that would provide service guidance consistent with one another. In addition, the program needed to be capable of calculating the distance at which an ordnance system will remain safe and reliable from a given emitter source. Calculations were to be based on the characteristics of the transmitter/antenna system and the ordnance system's MAE for the frequency range of concern. The safe separation distance calculations needed to take into account near-field as well as the far-field EMEs.

In order to develop a common "worst-case" MAE curve or a set of curves for a given system, the HERO Subcommittee needed to understand the existing means by which each service

- Developed MAEs and HERO guidance
- Established a common set of HERO curves that would adequately address each of the service's ordnance physical configurations
- Established an accepted approach for calculating EMEs in the near-field

Prior to this effort, it was discovered that there were a wide range of "worst case" MAEs being used by each of the services. In addition, it was important to understand the factors that were considered (i.e., physical configuration, EID sensitivity, firing consequence, or stockpile-to-safe separation phase) by each of the services for the derivation of these service-unique "worst-case" graphs. Through the efforts of the JOCG HERO Subcommittee, a triservice "worst-case" graph was developed, and the MAE analysis program was completed. This tool, developed at Dahlgren, provides the service components a consistent means for establishing the minimum EME levels that will be placed on a system for which there is no information known about the item, except that it contains an EID and also provides a means of calculating EMEs in both the near-field and far-field.

JOERAD Database

It was decided that the JOCG would help with the development of the JSC JOERAD database. The primary goal of JOERAD was to provide operational commanders and planners with the necessary information to safely and efficiently manage the conflict between ordnance and RF emitters employed in an integrated joint operation or exercise. Within JOERAD, there currently exist four modules:

1. The HERO ordnance module containing the HERO data from the service components
2. The equipment characteristics module containing emitter/antenna data for known systems
3. The operational unit/platform module containing emitter suites and ordnance loadouts for operational platforms
4. The impact assessment module that provides operational guidance through a process that compares the known ordnance susceptibilities to the platform EMEs

As can be seen in Figure 1, the success of JOERAD relies on the ability of the service components—particularly the Navy through its survey efforts—to populate the modules with the necessary data. The efforts of the JOCG HERO Subcommittee and the standardization of the HERO test methodology within the HERO test guide, not only allowed for the interpretation of the service components archival test data for population into the susceptibility module, but also ensured that future susceptibility data would be readily incorporated into JOERAD. The establishment of a joint uniform test criteria and a process for properly managing the service components' information facilitated the

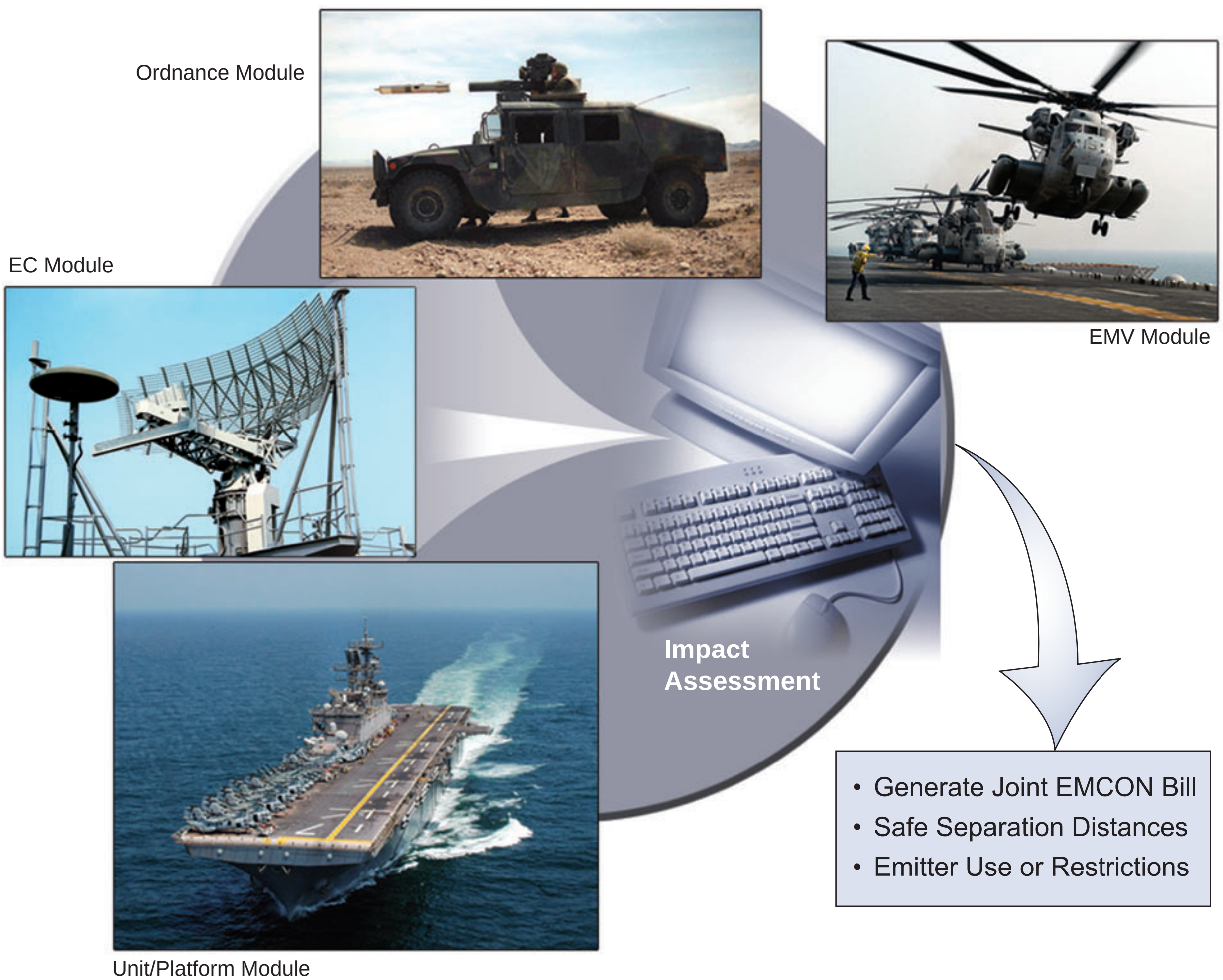


Figure 1. JOERAD Functionality

Figure 2. Integrated Operations

transfer of operational guidelines, procedures, and technical information to the warfighter for use in planning, coordinating, and controlling HERO during integrated operations and exercises in the joint environment (see Figure 2).

Forward-Deployed Surveys

In recent years, the Navy's HERO survey program has increased its emphasis on joint and coalition forces' operations at the request of the JSC and NOSSA. Since the Army and Air Force have not established HERO surveys as part of their HERO programs, the Navy has taken the lead to address joint and coalition forces' operations in theater. The survey data is also used to update the EME module in JOERAD in order to provide better joint HERO guidance. To date, NSWCDD has been responsible for planning, conducting, and reporting the findings on forward-deployed surveys, as well as for providing joint, integrated HERO guidance specific to these facilities. Some of the surveys performed include:

- NAVSUPPACT in Diego Garcia
- Prince Sultan Air Base in Saudi Arabia
- Naval Air Station (NAS) Bahrain in Bahrain
- NAS Sigonella in Italy
- Korea
- Al Dhafra Air Base in United Arab Emirates
- Al Udeid Air Base in Qatar
- Camp Lemonier in Djibouti
- Manas Air Base in Kyrgyzstan

More recently, surveys have been performed at:

- Naval Special Warfare Group at Panzer Kaserne, Germany
- Ali Al Salem Air Base and Ahmed Al Jaber Air Base in Kuwait
- Al Asad Air Base and Al Taqaddum Air Base, in the Anbar Province of Iraq

Triservice HERO Approach

The strength of the Navy's HERO program, coupled with the efforts of the JOCG HERO Subcommittee, has proven to be a successful approach for dealing with more recent joint and coalition forces when operating in the joint and naval EMEs. In 2001, the Navy HERO program developed operational procedures for USS *Kitty Hawk* so that its complement of Joint Special Operations Command (JSOC) personnel could safely embark and disembark from this platform. Since that time, in support of joint and combined operations from Diego Garcia (see Figure 3), Saudi Arabia, Iraq, and Bahrain, the Navy HERO program has provided rapid responses to urgent mission needs for joint and coalition forces regarding new radar, satellite, telemetry, mobile, and high-frequency (HF) systems that were being deployed. Additionally, multiple forward-deployed ship platforms have requested and received assistance in determining if existing HERO control measures adequately address potentially new HERO issues in the midst of joint and coalition force operations. The success of the more recent efforts described above were directly related to the strength of the Navy's HERO program and the HERO tools established through the efforts of the JOCG HERO Subcommittee. Armed with the access to, and an understanding of, all of the service component's HERO test data, planning, coordinating, and controlling HERO during these integrated joint operations has become more streamlined.

As this triservice approach to HERO continues to grow, the services and, in particular, the Navy

Figure 3. Diego Garcia Joint and Combined Operations

will better be able to address HERO concerns when operating with joint forces aboard naval platforms, afloat, and ashore. Furthermore, through the master data exchange agreement (DEA) programs in place with the various North Atlantic Treaty Organization (NATO) nations and the U.S. Navy's representation in the NATO Radio and Radar Radiation Hazards Working Group (RADHAZWG), the Navy HERO program has similarly improved its capabilities to deal with coalition forces present in the naval environment (see Figure 4). Not only have the international efforts allowed U.S. input to the development of NATO EME standards, but it has also helped ensure rationalization, standardization, and interoperability of U.S. forces in NATO operations.

Naval shipboard and forward-deployed ashore forces' EME is continually increasing in scope and magnitude. In light of the fact that joint integrated operations (both helicopter and ground forces) are becoming more commonplace, particularly in the naval environment, it is especially important to ensure that a triservice approach for mitigating HERO is maintained. This will ensure that the combatant commanders (COCOMs), JTF commanders, host platforms, and service components have the ability to address HERO issues from an integrated joint perspective. Thus, it is imperative that all ordnance containing EIDs be evaluated for HERO under a standardized HERO certification test methodology using a common set of risk management procedures, and that automated tools be put in place to address HERO concerns. The operational EME must be defined through the HERO survey process, and operational guidance for missions must be clearly defined. Through its efforts in the JOCG HERO Subcommittee, NSWCDD has met these objectives and has been instrumental in developing the tools necessary to successfully provide effective HERO guidance for joint operations aboard ships and at forward-deployed bases. It has also demonstrated these capabilities in support of Operations Iraqi Freedom and Enduring Freedom. Inasmuch as joint military operations often require a careful balance of weapons, delivery platforms, and ordnance-handling procedures in the midst of an extreme EME, these tools have provided the necessary data needed by operational commanders and planners to safely and efficiently manage conflicts between ordnance and RF emitters employed in integrated joint and coalition operations.

Reference

1. *Department of Defense (DoD) MIL-HDBK-240*, 1 November 2002.

Figure 4. UK/US Forces Complete Exercise "Constant Alliance"—UK and U.S. forces participated in the joint military exercise "Constant Alliance" off the East Coast of the United States from March 30–April 10, 2008. The exercise focused on an antiterrorist scenario and was aimed at ensuring UK and U.S. amphibious interoperability on future operations.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