

The Expeditionary Fighting Vehicle (EFV) is a key component of the Marine Corps' Expeditionary Maneuver Warfare (EMW) and Ship-to-Objective Maneuver (STOM) warfighting concepts. It represents the Marine Corps' primary means of tactical mobility for the Marine Rifle Squad during the conduct of amphibious operations and subsequent ground combat operations ashore. The EFV is a self-deploying, high-water-speed, armored amphibious fighting vehicle capable of seamlessly transporting Marines from ships located beyond the visual horizon to inland objectives. While providing the speed and maneuvering capabilities to operate with the main battle tank on land, current obstacles to the landing force, oceans, lakes and rivers, can be used by the EFV as high speed avenues of approach and maneuver. The EFV is an armored, fully tracked infantry combat vehicle that is operated and maintained by a crew of three Marines, and has a troop capacity of 17 Marines with their individual combat equipment. The EFV is a replacement for the current Assault Amphibious Vehicle (AAV), which was originally fielded in 1972 and will be over 35 years old when the EFV begins production.

The EFV Program is a showcase of 21<sup>st</sup> Century Weapons System acquisition and development practices, from innovative applications of the latest Acquisition Reform Initiatives to unprecedented Government-Industry commitment to Environmental, System Safety and Occupational Health (ESOH) awareness from the earliest stages of the EFV design. Since the inception of the program, the vehicle design has evolved through two prototype design cycles resulting in the second generation prototype vehicles currently in developmental testing. A primary philosophy that has guided the EFV design is consideration of ESOH standards and regulations. There is a tendency to focus on performance aspects of the system during the Research & Development phases, while leaving the consideration of ESOH issues to after-the-fact inspections and reviews. This approach increases the risk of schedule delays and cost increases as unacceptable ESOH issues are identified after vehicle build. The EFV Program has implemented a "Safety First" mentality, and has successfully integrated ESOH into every aspect of the acquisition program from the beginning, significantly reducing the risk of delays from ESOH issues and overall life cycle costs of the vehicle.

The DRPM AAA Programmatic Environmental, System Safety & Occupational Health Integration (PESOH) Division is responsible for ensuring the EFV is designed, manufactured, tested and fielded to the Marine Corps in the safest manner possible. Their strategy is as follows: Integrate ESOH requirements into systems engineering processes; integrate ESOH Risk Management and mitigation measures into Life Cycle Cost and development of the EFV; be an integral part of the test – fix – test analysis to provide the user with a product they need and can safely and healthfully use; and be a key member of a product and process improvement approach to the design and fabrication of EFVs that will meet the user's needs. By working day-to-day with the prime Contractor of the vehicle, the PESOH Division has been involved with every step of the design

process since the beginning of the program and will continue that involvement throughout the life cycle of the program.

As mentioned, the EFV program is one of only a few programs in the DoD that has fully integrated the ESOH program within the acquisition cycle. ESOH-related concerns and issues are addressed at all stages of the EFV program design and production throughout the lifecycle. The current Program Manager, Colonel Michael M. Brogan, reinforced the integration of ESOH by signing an ESOH Policy Statement when he assumed management responsibility for the EFV program. This policy statement directs all employees that there are "...six main ESOH areas that must be considered in decision making: Compliance, the National Environmental Policy Act (NEPA), Safety and Health, Hazardous Materials, Pollution Prevention and Explosives Safety." Furthermore, "if these considerations are not part of your decision making process, you have not made a fully informed recommendation or decision." The Program Manager continues to foster an environment that puts ESOH as a top priority and it is clearly reflected in personnel at all levels of the program from the engineers and designers to the manufacturing, maintenance and test personnel. This integration has and will continue to help reduce life-cycle costs, as well as help maintain a high state of operational readiness for the EFV in the field.

The PESOHI Division consists of a team of ESOH specialists that participate in all design Integrated Product Teams (IPTs). This provides the ability to plan for and implement ESOH considerations in the design stages of the weapon system prior to building it. ESOH considerations are also a key portion of all acquisition documentation, such as Management Plans and Contracts. Recent development of the Statement of Work and Specification for the production of the EFV (pending our successful Milestone decision and entry into the Low Rate Initial Production acquisition phase) included ESOH considerations and requirements, specifically in the Systems Engineering Management and vehicle Manufacturing sections, as well as stand-alone ESOH requirements.

A Programmatic Environmental, Safety and Health Evaluation (PESHE) was implemented in the early stages of program acquisition. The strategy for the PESHE includes various ESOH functional analyses and is implemented primarily through a system engineering approach to ensure compliance with and integration of applicable ESOH federal, state, and local laws, regulations and directives. DRPM AAA ESOH efforts are implemented through a series of program plans that are all summarized in the ESOH Master Plan (ESOHMP). The ESOHMP also defines ESOH risk identification and assessment, in accordance with DoD Regulation 5000.2 dated May 2003. Risks are managed through a balanced approach of ensuring that "...DoD incurs the lowest cost required to protect human health and the environment over the system's life cycle...". The two major risk categories addressed by the DRPM AAA are the ESOH risks that program-related actions have on the user over the life cycle of

the system and the risks imposed on the program from non-compliance to ESOH laws, regulations and directives.

One of the key roles of the Division is to ensure ESOH hazards and their associated risks are eliminated from the EFV design whenever possible, and to track any hazards that remain to ensure they are mitigated to the lowest level possible. Over the last two years, huge strides have been taken in hazard elimination and reduction, with the total number of catastrophic and critical hazards reduced from 93 to 41, and overall number of hazards reduced from 408 to 302.

The PESOHI Division is a key part of the EFV Test and Evaluation (T&E) team, providing input to test plans and procedures, and providing on-site support for testing events. The team has a proven record of compliance with National Environmental Policy Act (NEPA) documentation, working with military installations and Federal Government Environmental agencies and organizations to provide all documentation on time, and ensure that effects on the environment and surrounding communities where testing or other operations are taking place is minimized or eliminated. In assisting the T&E team in developing test plans, the Division has been able to successfully coordinate an unprecedented amount of Occupational Health testing, with data being used to further implement design changes and therefore further mitigate the hazardous conditions that potentially may exist. Occupational Health analyses are also used to support efforts to determine how the mitigations of occupational health hazards could significantly reduce the medical costs and overall life cycle costs associated with the program.

Although efforts have been on-going since program initiation, the amount of hazardous material substitution, elimination and minimization that the DRPM AAA has accomplished is again unprecedented. Some specific examples are: approval by the Navy Environmental Health Center (NEHC) for using of FM-200 instead of Halon in the fire suppression system for occupied spaces of the EFV (this later led to EPA approval of FM-200 as a confined space fire extinguishing agent); use of a water-reducible Chemical Agent Resistant Coating (CARC) instead of existing formulations of CARC containing Hexavalent Chromium, which in 1996 was categorized as a suspected human carcinogen; the elimination of all Ozone-Depleting Substances at all levels of the program (fabrication construction, processing, storage and handling) including government, contractor, sub-contractor and vendor levels); use of Trivalent Chromium Protection (TCP) coating for an anti-corrosion pre-treatment of metal instead of the industry-standard Hexavalent Chromium; the ability to track the amounts of all existing hazardous chemicals such as Teflon and Cadmium across the entire vehicle down to grams; and working with the prime contractor in minimizing the use of carcinogens and other restricted/prohibited chemicals by reviewing and approving every material used in the production, operation, and maintenance of the EFV.

The Division has worked closely with a large number of defense programs and offices in order to coordinate mitigation efforts, learn from programs that have already fielded weapon systems, and ensure that Navy and Marine Corps overseeing agencies are included and aware of the decisions being made and efforts being taken by the EFV Program. Some of those programs and offices include the office of the Navy Surgeon General, the US Army Center for Health Promotion and Preventive Medicine, the Navy Environmental Health Center, the US Army Bradley Fighting Vehicle Systems, the US Army Abrams Tank Program, the US Naval Surface Warfare Centers at Carderock and Dahlgren, the Virginia Department of Environmental Quality, the US EPA, the Norfolk Naval Shipyard, the US Air Force research center, the Wright-Patterson Air Force Base, Ohio, and Sandia National Laboratories. In April 2004, the division hosted an Independent Assessment Team, which consisted of personnel from Marine Corps, Air Force, and Navy installations, as well as ESOH Specialists from Defense Contractors. The team was asked to review and assess the EFV Program's preparedness to safely enter its upcoming Milestone C Operational Assessment (OA). Their actions included assessment the EFV System Safety procedures and processes, identification of any potential shortcomings in current safety procedures and processes, and recommendations of safety procedure and process enhancements. After one week of review, the team identified no major shortcomings in procedures and processes, and concluded that all items reviewed were acceptable to safely OA.

Members of the DRPM AAA PESOHI Division are as follows:

**Sandra G. Fenwick:** Programmatic Environmental, System Safety and Occupational Health Integration Division Head, DRPM AAA. Ms. Fenwick is responsible for the overall integration of ESOH considerations, assessments, and guidance into the DRPM AAA Systems Engineering process, per DoD Instruction 5000.2. She has oversight of the entire ESOH Program, including budget planning; interface point of contact with outside agencies regarding all ESOH concerns, policies and procedures; providing guidance and recommendations to the DRPM AAA regarding emerging laws and regulations that have the potential to impact the life cycle cost of the EFV; and validation of all ESOH requirements for the EFV (it's System/Subsystem Design and Functional Specification).

**Joseph R. Finch:** Environmental Specialist, DRPM AAA. Mr. Finch is responsible for all Environmental activities associated with the life cycle of the EFV. He provides oversight, guidance, and analysis of the following areas: National Environmental Policy Act (NEPA) Compliance for Developmental and Operational Testing, System Fielding and Military Construction; Planning for and Costs of Disposal of the EFV and all it's systems/subsystems; Hazardous Material Assessments and Management; Production & Manufacturing Environmental Issues; and Pollution Prevention (P2).

**Garry N. Klaus:** System Safety Program Manager, DRPM AAA. Mr. Klaus is responsible for implementing the requirements of Military Standard 882 (MIL-STD-882) into the Systems Engineering process and ultimately the EFV itself. He works with design engineers to identify, evaluate, and ultimately eliminate safety hazards associated with the systems and subsystems of the EFV, the MK46 Weapon System, and MK44 Weapon. For those hazards that can not be eliminated, he works with the engineers to develop and implement engineering activities necessary to reduce their risk to acceptable levels through out the system life cycle. He is also the DRPM AAA Point of Contact for the Navy's Weapon System Explosives Safety Review Board (WSESRB) and Software System Safety Technical Review Panel (SSSTRP).

**Linda A. Poston:** Occupational Health Program Manager, DRPM AAA. Ms. Poston is responsible for all aspects of Occupational Health for the EFV Program, including research, testing, assessments and engineering support. Specific areas of responsibility include Health Hazard Assessment Reports, Medical Monitoring Program Oversight, Evaluation/Mitigation of Occupational Health Program Risks (Noise, Whole Body Vibration, Toxic Fumes, and Temperature Extremes), and Closed Bomb Testing and Analysis. She also works with program engineers in the reduction and ultimate elimination of Occupational Health hazards associated with the EFV and its internal systems/subsystems, including the MK46 Weapon Station and MK44 Weapon.

**Christina R. Roll:** System Safety and Occupational Health Program Manager, DRPM AAA. Ms. Roll is responsible for all ESOH activities for the EFV Training Systems currently in development, including contractual work (i.e. Statements of Work, Design Specifications, etc.), design analysis, and general ESOH oversight. She has developed and implemented Program-level procedures for ESOH Hazard/Risk closeout/acceptance and Mishap Reporting, and provides/coordinates ESOH inputs into various Program-level documents, including Statements of Work, Vehicle System/Subsystem Specifications, Supportability Plans and Funding Documents.

**Karen Spraggins:** ESOH Program Support Specialist, EG&G Corporation. Ms. Spraggins provides assistance to each of the areas within ESOH, including research, documentation preparation, tracking of progress and actions taken during hazard mitigations, maintaining and documenting changes in the ESOH program, and providing general administrative support.

All the members of the PESOHI Division have been recognized for outstanding achievements over the last two fiscal years. Mr. Finch and Ms. Fenwick were recently recognized by the DRPM AAA for completing an Environmental Assessment for test operations in Hawaii in less than half the normal time required for such an action. Ms. Fenwick was recently asked to speak at the 8<sup>th</sup> Annual National Defense Industrial Association (NDIA) Systems Engineering Conference, and presented the EFV ESOH Program as an example of how

ESOH can be integrated successfully into the Systems Engineering process. Mr. Finch, a member of the American Society of Naval Engineers (ASNE) has provided two briefings on the EFV ESOH Program to the ASNE and a breakout session seminar at Virginia Military Institute for student environmental and civil engineers during the annual Environment Virginia Symposium. Ms. Roll, a member of the System Safety Society, co-authored an article for the Marine Corps' "Ground Warrior" Magazine, the quarterly ground safety publication of the Corps, which highlighted the Safety Program and its successes. The article was published in the Summer 2005 edition. Ms. Roll was also recently recognized by the DRPM AAA for her efforts in planning, coordinating and completing on schedule the Program Office's Integrated Logistics Supportability Plan, which will be used in support of the Program's upcoming Independent Logistics Assessment and Milestone C Decision. Ms. Poston was recognized by the DRPM AAA for coordinating activities between two outside agencies that were providing Occupational Health assessments for the EFV Program. Thanks to her efforts, test data collected by both agencies was subsequently analyzed using similar techniques, thereby allowing it to be used by the Program in hazard/risk mitigations. Mr. Klaus has been recognized by the DRPM AAA for his outstanding efforts in software safety (timely concurrence of the SSSTRP to allow the program to proceed with training of Marines for the Program's upcoming Operational Assessment) and safety certifications (issuance of Safe and Ready for Test/Operation letters to all test sites).