

Planning Considerations for Munitions-Related Infrastructure

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Abstract

The Department of Defense (DoD) is pursuing a number of initiatives aimed at better integration of explosives safety and planning. At its core explosives safety is community planning. DoD criteria require the use of explosives safety separation distances in order to provide acceptable levels of protection to personnel, property, and assets exposed to the hazardous effects from an explosives event. The application of explosives safety separation distances provides a simplified approach for providing acceptable levels of protection. The building and maintenance of protective structures can reduce these distances. A few initiatives underway are addressing these planning considerations. For example, DoD is undertaking a Structural Integrity Study to analyze its earth-covered magazines. The study will determine the physical condition, expected remaining service life, and needed maintenance for magazines, many of which were built in the World War II era. The output of the study includes an overall health rating, an updated explosives safety rating, and recommended maintenance for every magazine analyzed. An accurate explosives safety rating is critical since separation distances are based on these ratings. Additionally DoD is developing a web based application to illustrate the relationship between explosives facilities and surrounding buildings. Another study examined the integration of considering munitions-related infrastructure in the DoD acquisition program. All of these initiatives underscore the necessity of close cooperation and the value of synergy between the explosives safety and planning communities.

Introduction

U.S. military infrastructure, including munitions-related infrastructure, is critical to DoD's ability to perform ground, air, maritime, and sea-based missions in support of the national security and defense strategies. The Military Services, the Combatant Commanders, Joint and Allied Forces rely extensively on U.S. military infrastructure to train personnel, perform and sustain missions, as well as maintain quality of life for the military members and their families. Military munitions are simultaneously key strategic, operational, and tactical assets essential to mission accomplishment, and when not maintained and managed as prescribed they can become liabilities that have destroyed entire military installations and surrounding communities. In

support of the DoD mission, munitions-related infrastructure must be planned for, maintained, managed, and recapitalized. Effectively integrating munitions-related infrastructure into the planning, real property, and logistics processes will result in mission sustaining structures capable of performing as designed for the length of time envisioned.

Munitions-related infrastructure includes, but is not limited to:

- Research, development, test and evaluation facilities such as laboratories or other similar facilities where energetics, components of munitions, and complete munitions are developed, tested, or evaluated before initial operating capability
- Loading docks where munitions are loaded and offloaded
- Transportation holding yards where munitions are staged
- Classification yards where munitions are received, segregated, and prepared for follow-on movement or transportation
- Secure ammunition holding areas
- Maintenance buildings where munitions are inspected, maintained, upgraded, or prepared for shipment
- Munitions build-up facilities where munitions are prepared for employment and disassembled before return to storage after training or operations
- Hardened aircraft shelters (HAS) designed to protect aviation assets with or without munitions from potential enemy fire
- Maintenance HAS designed to prepare aviation assets and their supporting munitions for training and operations
- Combat aircraft loading areas
- Combat aircraft parking areas
- Munitions storage facilities
 - Earth-covered magazines (7-bar, 3-bar, undefined)
 - Zero quantity distance magazines
 - Aboveground magazines
 - Ready service lockers
- Aboveground structures such as operating buildings or line offices
- Open burn and open detonation areas and their supporting facilities
- Explosives operating areas

Main Body

The Challenge

Although munitions-related infrastructure is an important asset for DoD, there are a number of significant problems that require attention.

Aging Earth-Covered Magazines. Many of the DoD earth-covered magazines (ECM) still in service were built during the World War II era. They are approaching 75 years of use. The purpose of an ECM is to protect its contents and prevent propagation of an external explosion to its contents. ECMs are showing signs of age raising concerns as to their continued effectiveness.

Old Facilities vs New Weapons/Operations. As much of the weapons system infrastructure continues to age, weapons continue to evolve. The result is an increasing mismatch between facilities and the weapons they need to contain. One very obvious mismatch involves the transformation from powder based weapons to missiles. Palletized material is relatively easy to move into, out of and around a magazine with standard material handling equipment (e.g., forklifts). Missiles present a significant challenge. They are too long to fit through the doors using standard handling equipment and require different storage configurations.

Sub-Optimal Planning. The “cardinal rule” of explosives safety is to expose the minimum number of people to the minimum amount of explosives for the minimum amount of time. Many new facility designs attempt to concentrate as many operations as possible into the smallest footprint for the sake of efficiency, which violates this cardinal rule. In many cases, explosives safety is addressed much too late in the process. This results in expensive redesigns, modifications or significantly reduced capacity.

The response to these challenges is a three-pronged plan of attack.

Plan of Attack

Action 1: Determine if the current infrastructure is deficient and plan for replacement

ECM Infrastructure Assessment.^[1] The Department of Defense Explosives Safety Board (DDESB) initiated and is funding a comprehensive study of DoD military munitions ECMs to better understand risks to infrastructure, assess overall “structural health” of ECMs as related to their intended use for storage of explosives and predict the remaining service life of the ECMs. The study will inform a long-term Munitions-Related Infrastructure Recapitalization Plan for the assessment, maintenance, and replacement of ammunition and explosives (AE) storage facilities to ensure continued ability to support the mission, manage risk and protect the public. The information gained from ECM assessments can be utilized to manage risk and protect the public while ensuring the continued ability to support the mission. For FY19 to FY23, three installations were selected for the munition-related infrastructure evaluation with emphasis on ECM assessments.

The DDESB established a multi-organization team to execute the ECM assessments. This team consists of members from the DoD, Department of Army, Army Materiel Command, Joint Munitions Command, Defense Ammunition Center, U.S. Army Technical Center of Explosives Safety (USATCES), Installation Command and Personnel, U.S. Army Corps of Engineers, Naval Ordnance Safety and Security Activity (NOSSA) and Naval Facilities (NAVFAC) Atlantic.

The overall approach to accomplish the objective is to utilize three phases over a multi-year effort. The three phases, once completed, will identify the types of magazines at the installation, provide a representative structural health of the installation magazines with a

probable remaining service life, establish storage limits and allow planning/accounting for the installation's explosives stockpile.

Phase 1: ECM Structural Integrity Assessment

- Part 1 - Facilities Assessment: establish types/quantity of ECMs
- Part 2 - Structural Health Visual Inspection (SHVI): establish "structural health" Rating
- Part 3 - Concrete Coring/Testing: project remaining service life

Phase 2: Site Planning

- Accurate geo-locating and mapping
- Electronic Quantity Distance Analysis utilizing DDESB approved Explosives Safety Siting Software (addresses grandfathering)

Phase 3: Load Plan Analysis

- Account for stockpile

The three Phases shown above are related and best performed in succession. Parts 1 and 2 of Phase 1 will provide needed information for Phases 2 and 3.

Navy Explosives Facility Planning. The Navy has an internal mandate to evaluate and authorize all of their explosives facilities by 31 December 2021.^[2] This mandate is in response to the 2011 DDESB ESMP of the Navy and the 2015 NAVAUDIT SVC evaluation of Navy Ammunition and Explosives storage facilities. The objective is to ensure all explosives facilities are either properly sited, or have the required risk acceptance and corrective action plan in place by the deadline. On-site assessments will be made for all installations with 16 or more explosives storage magazines. The results from this effort will assist the Navy with their munitions infrastructure planning similar to the DDESB study described above. This effort is being conducted under the Fleet Concentration Area Magazine Study (FCAMS) and Ammunition & Explosives Facility Support (A&E FS) programs.

The goal of FCAMS and A&E FS are to provide senior Navy leadership with current and accurate information on the capability of the Navy's AE support facilities to meet not only current but future Fleet mission requirements.^[3] They entail a number of actions including:

- Baseline AE related facilities against current explosives safety and facility criteria
- Evaluate AE storage magazines against current and projected mission requirements (Global Requirements Based Load Plan-GRBLP); to do this, the Magazine Storage Requirements Calculator (MSRC) was developed
- Site/authorize all AE related facilities before 31 Dec 2021 deadline
- Update all enterprise data stores
 - GeoReadiness—geospatial data
 - iNFADS—real property data
 - EES—enterprise explosives safety database

The MSRC will provide dynamic explosives safety siting based on current mission requirements and configurations.

Explosives Safety Siting (ESS) Software and the Defense Enterprise Explosives Safety (DEES) Database. The ESS software is transitioning to a web-based application in 2019. As part of this transition, a DoD-wide database of explosives safety information as entered into ESS or calculated by ESS will be developed. The DEES database will be modeled after the Navy’s EES database. This database will allow for the first time explosives safety personnel to perform queries on DoD information critical to munitions-related infrastructure. For example, we will be able to determine the exact number of ECMs currently sited for storing DoD munitions, as well as the total sited explosives storage capacity. Analysis of this type of munitions-related infrastructure information will better enable us to focus our limited explosives safety resources on solving real-world concerns.

DDESB Technical Paper (TP) 15 & Whole Building Design Guide (WBDG) Standard Designs. Standardized designs reduce variability and promote interoperability. As designs are approved they are incorporated into DDESB TP-15, *Approved Protective Construction*. The contents of DDESB TP-15 are shown in the table below:

DDESB TP-15 (Main Body)	Revision 3	May 2010
Table AP1-1: 7-Bar and 3-Bar ECM Approved for New Construction	N/A	6 Jan 2011
Table AP1-2: 7-Bar and 3-Bar ECM No Longer Used for New Construction, But Still in Use	N/A	6 Jan 2011
Table AP1-3: Undefined ECM	N/A	6 Jan 2011
Table AP1-4: Magazines (Earth-Covered and Aboveground) and Containers with Reduced NEW and/or Reduced QD	N/A	Oct 2010

Work is underway on Revision 4 of DDESB TP-15. In this revision, ECM entries in Table AP1-1 are being pared down to only include those designs that the Military Services want to continue using for new construction. Future editions will work towards transforming DDESB TP-15 to an on-line “living document” for access by approved users, to include background information on the designs.

Standard Design Updates. The DDESB is sponsoring an FY18 project to:

- Determine and prioritize Service needs for standard ECM designs.

- Determine which standard designs are obsolete and which are currently used for new construction and must be maintained.
- Identify Service AE storage and operational requirements that aren't adequately or efficiently met by current standard designs.

The draft DDESB TP-15 Rev 4 Table AP1-1 will be the starting point for this task. Additionally, the project will:

- Implement minor corrections/modifications to recently updated Army standard ECM designs based on lessons learned and requests for information from site-adapted designs.
- Investigate development of a "small ECM" design. Apply Service input on AE storage and operational needs (minimum interior dimensions, door sizes, explosives limits, etc.) to develop definitive ECM drawings.

Action 2: Update policy and standards to improve infrastructure planning

Acquisition/Infrastructure Planning Harmonization Initiative. The DDESB led a working group to examine how explosives safety was integrated into acquisition and master planning processes. The group concluded that current DoD acquisition, real property and master planning policies do not fully integrate DoD explosives safety requirements allowing for gaps in key acquisition (including logistics), real property and master planning processes.

The group completed a gap analysis of the various policy and guidance documents and identified shortfalls that are now being addressed.

Updates to explosives safety policy. The DDESB staff is currently working on policy and guidance updates to better institutionalize and strengthen the relationship between explosives safety and munitions-related infrastructure and master planning.

DoDI 6055.16, *Explosives Safety Management Program*, implements the bulk of explosives safety policy in DoD. It prescribes procedures for the implementation and operation of the Explosives Safety Management Program (ESMP) at all management levels. A total revision of DoDI 6055.16 is currently underway. This revision emphasizes the role of munitions-related infrastructure in achieving explosives safety. It also adds munitions-related infrastructure planning, sustainment, and recapitalization management as part of the DDESB ESMP evaluation process.

Involvement in Unified Facility Criteria (UFC) documents. Unified Facilities Criteria (UFC) documents provide planning, design, construction, sustainment, restoration, and modernization criteria. They apply to the Military Departments, the Defense Agencies, and the DoD Field Activities.^[4]

The UFCs are the foundation of the design, planning and maintenance of munitions-related infrastructure. As such, there is a concerted effort to integrate explosives safety into UFC requirements. Some pertinent UFCs include:

- UFC 3-340-02, *Structures to Resist the Effects of Accidental Explosions* (formerly TM 5-1300)
- UFC 4-420-01, *Ammunition and Explosives Storage Magazine* (initial issue in May 2015)
- UFC 3-600-01, *Fire Protection Engineering for Facilities* (provided updated input for explosives facilities for the 2016 version)
- UFC 3-260-01, *Airfield and Heliport Planning and Design* (provided updated input for explosives facilities that will be incorporated in next version)
- UFC 2-100-01, *Installation Master Planning* (initial comments provided, in the process of developing additional comments)

Additionally, DDESB is conducting a review of existing planning and design documentation. This review will identify documents where explosives safety is currently addressed and determine if the information presented is current and correct. This effort will also identify any additional documents where explosives safety should be addressed.

ECM design analysis, modeling & testing. The DDESB organized an ECM Technical Exchange Forum which was hosted by USATCES at the Army Defense Ammunition Center on 13-15 June 2017 in McAlester, Oklahoma. The objectives of the forum were to 1) vocalize specific knowledge gaps and data requirements related to ECMs, and 2) make an attempt to harmonize ECM research program efforts such that they address these knowledge gaps and data requirements. The meeting was attended by a wide variety of personnel within various disciplines of explosives safety and munitions operations. As a result of the ECM Technical Exchange Forum, it was readily apparent there were four aspects of ECMs that required additional research and investigation to support further enhancement of explosives safety criteria:

- Legacy Flat-Roof ECMs. This topic addresses how to safely maximize the storage capacity of thousands of legacy flat-roof ECMs in the DoD inventory which do not meet current blast-loading criteria.
- ECM Intermagazine Distance Design Loads. This topic ensures that correct headwall and flat-roof design blast loads are being applied to all new ECM designs to satisfy the loading condition at minimum intermagazine separation distances.
- ECM Debris Hazards. This topic investigates the debris hazard generated by an ECM in the event of an accidental detonation, and the resulting debris inhabited building distance as a function of ECM direction (i.e., front, side, or rear).
- ECM Earth Cover Requirements. This topic addresses defining a reasonable path forward in the event that the earth cover on top of the ECM becomes less than the required two feet due to erosion, as well as defining erosion prevention solutions that have a negligible impact on explosives safety.

DDESB is sponsoring several research, modeling and testing projects related to addressing the issues identified above as part of our Advanced Munitions Operations – Consequence Assessment Trials (AMO-CAT) program. Initial work on the last topic is addressed below.

Other DDESB FY18 studies. DDESB is sponsoring a number of projects and studies to further the relationship between explosives safety and munitions-related infrastructure.

Development of Earth Cover Guidance for ECMs. These projects investigate potential improvements for maintenance of ECM earth cover:

- A concept for a geogrid product will be investigated and developed for use as the outermost layer of sloped earth cover over ECMs. This type of product is intended to provide slope stability and to prevent erosion by serving as reinforcement for the earth. Other slope and soil stabilization options may also be investigated, such as the tarp-type material used at McAlester Army Ammunition Plant.
- DDESB is partnering with the U.S. Army Engineer Research and Development Center (ERDC) to provide “more practical” criteria for the soil used as earth cover. The current wording in ECM standards is vague and open to interpretation, so the intent is to link the criteria to actual soil-type definitions.
- A third effort will evaluate the current drainage system (i.e. sand filter layer) shown on most recently updated standard ECM designs and consider changing it to a manufactured drainage system that is more constructible, effective, and less labor intensive.

Protective Construction Design Roadmap for AE Firms. To alleviate confusion in the design of munitions-related infrastructure, DDESB is developing a roadmap/state of practice guidance document. The target is to present this paper at the 2018 International Explosives Safety Symposium and Exhibition. The paper will include available criteria and tools for analyzing and designing protective construction for explosives safety applications. Likely points of emphasis include:

- Explaining the basis of protective construction criteria (e.g., testing of and accidents involving typical DoD explosives storage and operating configurations).
- Highlighting the challenges an Architect-Engineer may face when deviating from these configurations.
- Reviewing DDESB’s blast effects and protective construction analysis and design guidance documents and criteria, noting their permissible uses and limitations.

Protective Construction Guidance for HD 1.3. Current criteria for construction of facilities prone to accidental ignition of HD 1.3 items is very limited. DDESB is working toward improved guidance for HD 1.3 through research, testing and modeling to:

- Develop analytical procedures and guidance for assessing whether thermal hazards will be contained within a typical DoD explosives operating cell (reinforced

concrete side and rear walls extending through roof) that include some means for evaluating thermal hazards beyond doors and penetrations in the concrete walls.

- Develop design criteria for eliminating and mitigating thermal hazards at doors and other penetrations (e.g., acceptable door seal materials and configurations).

Criteria development for tomorrow's weapons. Like infrastructure, explosives safety criteria much maintain pace with the evolution of weapons. As more and more weapons achieve "insensitivity" to initiation by external threats, the probability of accidental detonation will decrease significantly. Mass fire may then become the major hazard of concern.

DDESB is currently conducting an integrated computational and testing program for development of new and enhancement of existing HD 1.3 standards for siting mass fire explosives. Current criteria is based only on fireball hazards, but this may be too simplistic. The DDESB is looking at improving these standards to:

- Better address the fireball hazard
- Address jetting effects from openings
- Address primary fragments and firebrands
- Address debris hazards from structural failure

Action 3: Improve communication

Effective communication is integral to any safety program, but has been somewhat lacking in the past in the area of munitions-related infrastructure. One can argue that all of the actions and initiatives described above are forms of communication, at least indirectly. The following initiatives are a more direct approach to communicate explosives safety and its relationship to the planning considerations of munitions-related infrastructure.

Develop informational tools and videos. Today's technology provides a wide range of means to get a specific message to a targeted audience. For example, the DDESB recently produced videos targeted at the operational commander emphasizing the importance of assessing the risk of munitions operations. These videos continue to be well-received and drive home the consequence of inadequate risk assessment.

Based on the success of these videos, additional production is in progress on a video to illustrate the need for effective master planning by showing the meaning of explosives safety separation distances. This video will illustrate the effects of an accidental detonation at various distances and emphasize the impact of poor planning on the mission and the surrounding buildings.

Other informational tools are also imperative to integrate explosives safety with the infrastructure processes. One such product, the guide for Architect-Engineer firms, was already mentioned.

Promote use of ESS by master planners. The Explosives Safety Siting (ESS) software was developed by the explosives safety community to address the complexities of site planning. At its core, ESS is a master planning application.

Continue participation in real property and master planning events. The DDESB began participating in the American Planning Association Federal Planning Division Workshop in 2016. This participation opened a line of communication between the explosives safety and master planning communities. The sidebar conversations alone proved to be invaluable. Maintaining this type of information exchange will continue as part of the DDESB outreach effort.

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