DDESB Software & Tools – Planning for the Future

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Abstract

Over the years, the Department of Defense developed and fielded a number of automated tools to address various aspects of explosives safety. Some are very comprehensive; some are very basic but all serve a useful purpose. Among these are: Explosives Safety Siting (ESS), Safety Assessment for Explosives Risk (SAFER), Automated Safety Assessment Protocol – Explosives (ASAP-X), FAST-Site, Blast Effects Computer (BEC), Buried Explosion Module (BEM), Confined Blast (CONBLAST), Fragment Trajectory Analyzer (TRAJ_CAN), and Munitions Risk Assessment System (MRAS), to name just a few. The DoD Explosives Safety Board (DDESB) is embarking on an effort to collectively manage and maintain these applications. This paper will describe the multi-phase/multi-year effort to integrate, modernize and maintain the suite of DDESB explosives safety automated tools and applications.

Introduction

As the science and standards of explosives safety evolved, so did the "tools of the trade." For example, pioneers in explosives safety like Dr. Jerry Ward developed tools and methods to solve problems and provide data related to the expected blast effect damage from explosions in above ground and earth-covered magazines. He began his work using a circular slide rule called the "blast effects computer," a tool he continued to develop and refine with improved airblast algorithms for a wide variety of ammunition types in multiple storage configurations. Over the years, the circular slide rule became the Blast Effects Computer spreadsheet tool now in its seventh version.

Since explosives safety is a relatively small and specialized field, especially as applied in the Department of Defense (DoD), many of our tools evolved from "home grown solutions." These applications generally address a small niche of analysis work. The increased efficiency gained from these systems is substantial, but it is not that easy to keep track of and maintain them all.

The U.S. Government Accountability Office (GAO) provides a list of Best Practices and Leading Practices in Information Technology Management.[1] Although explosives safety technical tools are but a drop in the "DoD information technology (IT) enterprise" ocean, many IT management tenets would be useful in managing the wide array of explosives safety software and tools.

Most notable of these tenets is to prepare an enterprise-wide IT strategic plan. At a minimum, this plan should describe how IT activities will be used to accomplish the mission and operations to support the mission. Recognizing that advances in technology have changed and continue to change the way we do business, this tenet emphasizes the need to plan strategically to manage software applications.

This paper documents the raw materials for this strategic plan. The DDESB technical software collection is divided into two major groups: 1) site planning support software, and 2) specialized technical tools. The sections below describe our current and planned DDESB software and tools, as well as the actions underway to maintain them, with a focus on our efforts to continuously improve the quality of our products. DDESB is also developing processes and tools to govern the development, maintenance, and use of our software and tools.

Site Planning Support Software

Explosives Safety Siting (ESS). ESS is DoD's automated explosives safety site planning tool. This application integrates an installation's Geographic Information System (GIS) map data, Real Property Inventory (RPI) data and Potential Explosion Site (PES) data to analyze compliance with the explosives safety standards of DoD Manual 6055.09, *DoD Ammunition and Explosives Safety Standards*. The program produces drawings and forms illustrating the relationship between a PES and surrounding exposed buildings and areas, referred at as Exposed Sites (ES). The drawings and forms constitute the bulk of an explosives safety site plan submittal package. The current version of ESS is V6.1.3, a desk-top based application generally implemented and managed at the installation level.

The analysis of PES-ES pairs and their compliance with DoD explosives safety standards within ESS is accomplished through a module called the Quantity-Distance Engine (QDE). The QDE, used in preparing the forms and drawings used for site plans, is also accessible as a stand-alone application called the ESS QD Calculator. The ESS QD Calculator allows users to enter information for a single PES-ES pair to determine the required separation distance. There are currently three QDEs being managed under the ESS program: 1) one that implements the DoD criteria, also used by the Army, 2) one that implements Navy explosives safety siting criteria, and 3) one that implements the Air Force explosives safety siting criteria.

Currently, ESS is used by DoD Components and their contractors. DoD installations are facing increasing difficulty in obtaining licenses for the ArcGIS software needed to run ESS on a desk-top computer. It is unclear whether International Traffic in Arms Regulations (ITAR) apply to ESS. It is also difficult to share ESS outside of the DoD because of the required technical support. The DDESB staff is working to address these issues.

Risk-Based ESS (RBESS). In 2013, the DoD explosives safety community decided to pursue integration of various explosives safety risk-based tools into the ESS software suite. This expansion in capability is referred to as RBESS.

The DDESB-developed risk-based siting software, Safety Assessment for Explosives Risk (SAFER), is a high-fidelity quantitative risk assessment tool based on DDESB Technical Paper (TP) 14, *Approved Methods and Algorithms for DoD Risk-Based Explosives Siting*. SAFER is currently a standalone software tool that can be used to prepare risk-based site plans in accordance with DoDM 6055.09's risk-based siting criteria. SAFER does not have a GIS-based map interface capability.

There is significant input data overlap between SAFER and ESS. Given that ESS already contained a map-based interface, and both programs produce explosives safety site plan packages, the DDESB in concert with Service representatives, embarked on integrating risk-based siting into ESS.

Additionally, to enhance the risk-based utility of ESS, HAZX will also be integrated. HAZX, an Army-developed high-fidelity qualitative risk analysis tool, implements DDESB TP-14 consequence algorithms. Both SAFER and HAZX lack the necessary DoD IT certifications required to be installed on most DoD computers and face significant barriers to implementation because of this. RBESS also integrates the Automated Safety Assessment Protocol – Explosives (ASAP-X) spreadsheet tool into ESS. ASAP-X, a low-fidelity consequence assessment tool, is based on DDESB TP-23, *Assessing Explosives Safety Risk, Deviations, and Consequences*, and DoDM 6055.09, Volume 1 Enclosure 8.

The suite of risk-based tools that will comprise RBESS, are to be implemented in ESS in order of fidelity (and complexity) in a tiered approach as follows:

- RBESS Tier 1. A simplified, low-fidelity tool that could be used by the Services for qualitative explosives safety consequence assessments in support of risk assessments for deviations from DoD explosives safety standards, or other Service-driven consequence assessment needs. Tier 1 will be based on ASAP-X.
- RBESS Tier 2a. A high-fidelity tool that could be used by the Services for qualitative risk assessments for deviations from DoD explosives safety standards, or other Service-driven risk assessment needs. Tier 2a will be based on HAZX.
- RBESS Tier 2b. A high-fidelity tool that meets DoD criteria for performing quantitative risk-based siting analysis for explosives safety site plans meeting DoD risk-based siting criteria. Tier 2b will be based on SAFER but with significantly updated algorithms being developed as part of the projected Revision 5 of DDESB TP-14.

Tier 2a and Tier 2b will use the same explosion effects consequence engine, in a similar manner to how ESS and the ESS QD Calculator both use the QDE. This consequence engine will be known as the Blast Consequence Engine (BCE).

Munitions Risk Assessment Software (MRAS). Subsequent to the initial formulation for the RBESS suite of tools, it was decided that it would also be beneficial to incorporate the DDESB's Consequence & Risk Identification (C&RI) tool into ESS. The C&RI tool, used predominantly by the DDESB's Military Operations Division, is a tool to perform risk assessments in support of US and NATO operational planning. The C&RI tool combines ASAP-X (as the basis for its consequence assessments) with a hardware/software solution that allows data input from hand-

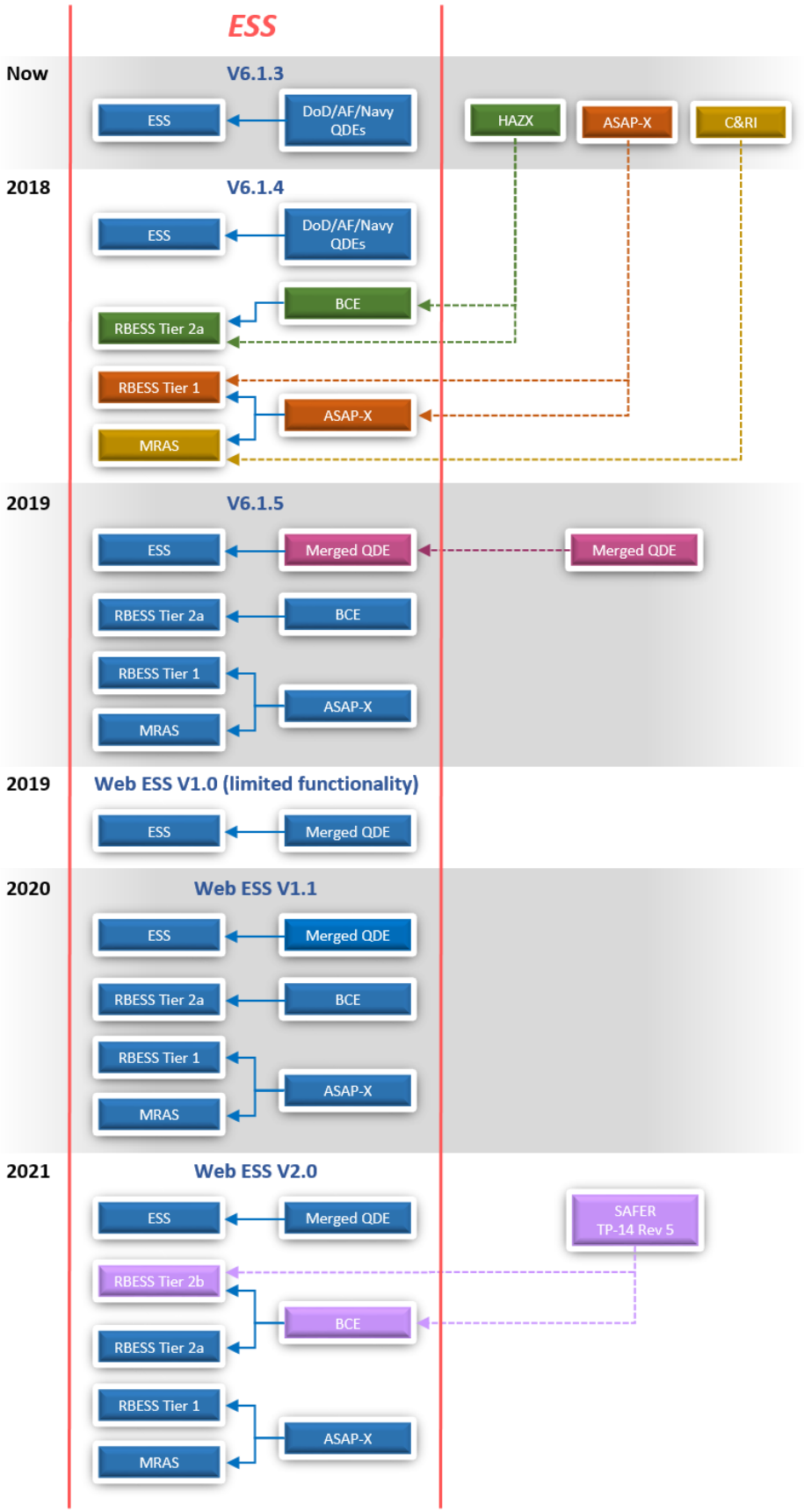
held GPS units. The C&RI tool uses the GPS data to provide automated data input to ASAP-X, adds more fidelity for property loss estimations, and produces output tables required for munitions risk assessment reports. Once integrated into ESS, the C&RI tool will be known as the Munitions Risk Assessment Software (MRAS), and will use the same ASAP-X algorithms used for RBESS Tier 1.

Field Assessment Spreadsheet Tool for Operational Munitions Risk Management in Explosive Safety Site Planning (FAST-Site). FAST-Site provides the convenience of a spreadsheet tool with minimal user input (like ASAP-X) with the high-fidelity consequence algorithms of the SAFER software. Within ESS, FAST-Site's functionality will be replaced by RBESS Tier 2a.

Merged QDE. In 2015, the ESS Service representatives agreed to pursue the development of a "merged" QDE. The merged QDE will incorporate a common set of QD criteria that is applicable to all Services, and identify any unique Service criteria if needed. The merged QDE will greatly facilitate explosives safety site planning for joint garrison bases and joint contingency bases and operations. It will also reduce the ESS maintenance costs by reducing the documentation, programming and testing from that required for three QDEs to that required for just one QDE.

Web ESS. In 2015, the DDESB and ESS Service representatives agreed to pursue transition of the ESS software from a desk-top application to a web-based system, to be hosted with the Defense Installations Spatial Data Infrastructure (DISDI) Portal. Web-based hosting on a DoD system will eliminate the burden on Services to obtain Service-level IT certifications of the ESS software, and also eliminate continuing issues they have with obtaining the necessary ArcGIS software licenses that are required for desk-top use of ESS. Web-based hosting of ESS will also provide a centralized location for the hosting of a suite of other explosives safety-related software and tools. This arrangement could potentially allow for automatic sharing of input and output information between tools when required, which should facilitate ease of use.

ESS Software Integration & Web ESS Software Suite Timeline. The figure below shows the timeline for integration of the software described above into ESS.


ESS
Now
V6.1.3
ESS
DoD/AF/Navy QDEs
HAZX
ASAP-X
C&RI
2018
V6.1.4
ESS
DoD/AF/Navy QDEs
BCE
RBESS Tier 2a
RBESS Tier 1
ASAP-X
MRAS
2019
V6.1.5
ESS
Merged QDE
Merged QDE
RBESS Tier 2a
BCE
RBESS Tier 1
ASAP-X
MRAS
2019
Web ESS V1.0 (limited functionality)
ESS
Merged QDE
2020
Web ESS V1.1
ESS
Merged QDE
RBESS Tier 2a
BCE
RBESS Tier 1
ASAP-X
MRAS
2021
Web ESS V2.0
ESS
Merged QDE
SAFER TP-14 Rev 5
RBESS Tier 2b
BCE
RBESS Tier 2a
RBESS Tier 1
ASAP-X
MRAS

Specialized Technical Tools

Confined Blast (CONBLAST). CONBLAST is a new software program currently in development, with a projected release date of 2018. It will incorporate updated versions of the SHOCK and FRANG software used to determine internal shock and gas impulse loads for the design of structures to resist blast loading in accordance with UFC 3-340-02. It will also include an updated version of the Multiple Debris Missile Impact Simulation Model (MUDEMIMP) software for the prediction of debris hazards. MUDEMIMP is based on DDESB TP-13, *Prediction of Building Debris for Quantity-Distance Siting*, and uses SHOCK and FRANG to determine the internal blast loads on the donor structure.

MUDEMIMP and DDESB TP-13 were developed in 1991 and have significant limitations on applicability. In the past 15 years, there has been a large-scale international effort to improve our collective explosives safety knowledge of debris hazards from many types of buildings. The DDESB determined that development of a new debris prediction tool based on the extensive test data and modeling now available would be more beneficial than trying to modify MUDEMIMP and DDESB TP-13 in the future. Planning for the development of this new software will begin in 2019.

DDESB TP-16 Tools. Over the past 10 years, a significant effort has been expended to improve and expand the spreadsheet tools associated with DDESB TP-16, *Methods for Calculating Primary Fragment Characteristics*. This effort involved rewriting the programming behind the spreadsheets for clarity, and ensuring consistency among all the tools and with DDESB TP-16.

The distribution and use of DDESB TP-16 and most of its associated tools are restricted to DoD and DoD contractors. There are currently six DDESB TP-16 tools:

- Generic Equation Calculator (GEQ)
- Buried Explosion Module (BEM)
- Barricade Angle Calculator (BAC)
- Modified Pseudo Trajectory Normal Calculator (MPTNC)
- Jacobs-Roslund Calculator (JRC)
- Stacked Munition Article Calculator (SMAC)

The SMAC tool was added in the most recent version of DDESB TP-16, and replaces the legacy Fragment Hazard Computer Program (FRAGHAZ) and Method for Calculating Range to 1 Hazardous Fragment per 600 Square Feet for Stacks of Munitions (HFSTACK) software.

Pipe Bomb Tool. DDESB is developing a spreadsheet tool for determining fragment and overpressure distances from pipes filled or partially filled with explosives, called the Pipe Bomb Tool (PBT). The original intent for this tool was to support determination of required safety distances during demolition of explosives-contaminated piping. However, since an explosives-filled pipe is essentially a “pipe bomb,” the tool will have wider applicability than originally planned. DDESB expects to release the PBT by end of 2018.

Intentional Burn/Detonation Criteria Management Tool. DDESB initiated a project in 2018 to develop an Intentional Burn/Detonation Criteria Management Tool. This tool is expected to be similar to the ESS QD Calculator in functionality and will be based on the recently updated intentional burn and detonation criteria in DoDM 6055.09. It will enable the user to determine the required non-essential personnel separation distance based on the many variables associated with the new DoDM 6055.09 criteria, to include use of mitigation options such as burial in earth.

The tool will allow "backward" calculations for some scenarios where the user enters an available non-essential personnel separation distance and is provided with limitations that must be met to stay within that distance. This "backwards" calculation capability will require development of a solution to back-calculate the results of the BEM such that the user can enter an available distance and the tool will determine the required explosives burial depth. Development of this tool will be a multi-year project with release of the final software in 2020.

Blast Effects Computer (BEC). Similar to the effort associated with the DDESB TP-16 spreadsheet tools, significant effort in the past 5 years resulted in improvements to the BEC spreadsheet associated with DDESB TP-17, *DDESB Blast Effects Computer (BEC) Version 7 User's Manual and Documentation*. Distribution and use of DDESB TP-17 and BEC are restricted to DoD and DoD contractors.

Because of the wide spread utility of BEC, demand is high from users outside of the DoD. To be responsive to non-DoD users and to minimize the burden of managing numerous waivers of distribution limitations, DDESB recently released an open distribution version of DDESB TP-17 and the BEC; these are DDESB TP-20, *DDESB Blast Effects Computer – Open (BEC-O) Version 1 User's Manual and Documentation*, and the BEC-O spreadsheet.

Hazard Division (HD) Mixing Rules Tool. Explosives safety site plans are typically approved with maximum explosives weights allowed for each explosives HD if stored individually. If the facility user would like to store explosives items from more than one HD together, they must apply the HD mixing rules specified in DoDM 6055.09, Volume 1 Enclosure 7, to determine if the mixed HD storage is allowed per the approved explosives safety site plan. The DDESB is developing a spreadsheet tool, the HD Mixing Rules Tool, to automate this determination for a facility user. Expected to release of this tool is in 2019.

DDESB QD Calculator. The DDESB QD Calculator is a spreadsheet tool developed by DDESB staff as an in-house tool for performing QD calculations. It provides the required QDs (i.e., intermagazine distance, intraline distance, public traffic route distance and inhabited building distance) based on user inputs for net explosives weight and the HD. It also performs the reverse calculation (i.e., allowable net explosives weight based on the user inputs for HD and available QD). This "home-grown" tool is now widely used by Service and installation explosives safety personnel. DDESB plans to update to this tool in 2019, rewriting the programming for clarity, improving the user interface, and developing documentation and a validation process for it.

Mobile Application Development. The DDESB is exploring the feasibility of converting some commonly used tools into mobile applications. For example, work is underway on an executable

version of the BEM, an intermittent step toward developing the tool as a mobile app. Other tools, ideal for conversion to apps include the ESS QD Calculator and the DDESB QD Calculator.

TRAJ_CAN. There are many legacy DOS executable programs that the explosives safety community relies on heavily for explosion effects and protective construction analyses. These programs were typically developed by individuals in the 1970's and 1980's to meet specific needs of time, using the then-current programming approach of writing DOS executable files. These programs were not typically managed or maintained. They lack version control, supporting technical basis and user guide documentation, and long-term planning for continued maintenance and upgrades. With the advent of the Windows 7 and higher operating systems, many of these programs have become functionally obsolete because they no longer run on most government computers. In many cases, the original developers of these programs have retired and the developer's organization (presuming it still exists) does not maintain the software.

In 2013, the DDESB sponsored development of an updated version of the legacy DOS software program TRAJ, used for analyzing fragment trajectories. This program is critical to apply the primary fragment prediction methodologies and tools established in DDESB TP-16. This effort resulted in the TRAJ_CAN software (and associated white paper) that can be run on current government computers. The DDESB plans to continue maintain the TRAJ_CAN software in the future. DDESB may pursue modernization of other legacy DOS programs as requirements dictate.

2019 Requirements Definition Process

In 2019, the DDESB will begin an information gathering and requirements definition phase for the next generation of DDESB-sponsored explosives safety software and tools, both from a capabilities standpoint and from a format and delivery standpoint. Potential capability focus areas include:

- Blast design tools
- Explosives safety-related tools for the expeditionary environment or "lite" versions of existing tools
- "Interface" tools which would help bridge the gaps between explosives safety and other disciplines that are affected by or affect explosives safety (i.e., acquisition, master planning, real property processes, explosives logistics processes, and radio-frequency analysis)
- Explosives safety-related databases

Potential format and delivery focus areas include:

- Mobile device applications
- Stand-alone software and executable files
- Spreadsheet tools
- Integration into ESS due to data overlap or need for mapping capability

We welcome input from the Military Services at any time, but will formally solicit input through the DoD Explosives Safety Board in 2019.

Conclusion

The DDESB maintains several different software and tools, all designed to fulfill specific needs at the time they were developed. Some have overlapping data entry requirements. Some perform the same function, but to a higher or lower level of fidelity based on more or less input data requirements. Integration of some of these software and tools into ESS will not only benefit our users, but will also reduce DDESB resource requirements for software maintenance and IT certifications.

As this paper illustrates, the DDESB has made a concerted effort over the past decade to improve, document, validate, and expand the suite explosives safety-related software and tools our Military Services need to perform their explosives safety mission, and to plan for the next generation of software tools to support the future needs of the DoD explosives safety community.

References

1. US Government Accountability office, *Best Practices and Leading Practices in Information Technology Management* https://www.gao.gov/key_issues/leading_practices_information_technology_management/issue_summary#t=0 (accessed July 11, 2018)