An Overview of Risk-Based Explosives Safety Siting for
The 2018 International Explosives Safety Symposium & Exposition

Michael Oesterle, PhD, PE
Ruby Domingo
NAVFAC EXWC, Port Hueneme, CA

Jon Chrostowski
Ryan Schnalzer
ACTA, Torrance, CA
Introduction

• Problem:
  – Explosives storage and handling facilities require site plan approval from Department of Defense (DoD) Explosives Safety Board (DDESB) to operate
  – Quantity-Distance (QD) violations can be mitigated through risk acceptance by the component Military Service
  – Quantitative information on hazards and consequences is needed by officials who accept risk for explosive facilities not meeting QD criteria.

• Solution:
  – Make use of Explosives Safety Siting (ESS) software, which is a GIS based automated site planning tool that is used DoD-wide for generation of site plan packages
  – Incorporate hazard-consequence analysis tools into ESS:
    • Tier 1- ASAP-X based on DoD 6055.09M consequences
    • Tier 2a- HAZX based on DDESB TP-14 revision 4 algorithms
    • Tier 2b- DDESB Risk Based Explosives Safety Analysis based on DDESB TP-14 revision 4 algorithms using numerical event probabilities and acceptance criteria (i.e. SAFER)
Overview

- Introduction
- Background
- Technical Approach
- Verification Results
- RBESS Demonstration
- Conclusions and Path Forward
Background- What is ESS?

• DoD sponsored software developed for use by all DoD services.
• Software developed and maintained by NAVFAC EXWC on behalf of the DDESB
• Used for:
  – Automated calculation and display of explosives safety quantity distance (ESQD) arcs
  – Automated and standardized Site Plan Package development
  – Automated and standardized Potential Explosion Site (PES) data
Background - Tier 1 ASAP-X

- Consequences are based on damage descriptions for hazard zones in 6055.09-M
- Simple input consisting of cost and number of occupants
- Consequences based on ES location within hazard zone
- ESS QD engine used in implementation to calculate hazard zones

Fatalities:
Zone 1 = 100%
Zone 2 = 90% - (0.1(K9-ES distance)/(K9-K6)+.90)
Zone 3 = 80% - (0.1(K11-ES distance)/(K11-K9)+.80)
Zone 4 = 20% - (0.6(K18-ES distance)/(K18-K11)+.20)
Zone 5 = 2% - (0.18(PTRD-ES distance)/(PTRD-K18)+.02)
Zone 6 = 1% - (0.01(IBD-ES distance)/(IBD-PTRD)+.01)

Building Damage:
Zones 1, 2 and 3 = 100%
Zone 4 = 50% - (0.5(K18-ES distance)/(K18-K11)+.5)
Zone 5 = 20% - (0.3(PTRD-ES distance)/(PTRD-K18)+.2)
Zone 6 = 5% - (0.15(IBD-ES distance)/(IBD-PTRD)+.05)
Background- Tier 2a HAZX

- Defines accident probabilities in qualitative terms
- Translates consequences into severity categories
- Consequence algorithms based on DDESB TP-14, Rev. 4

**PES Input Requirements:**
- Facility Information
  - Height
  - Structure Type
- Replacement Cost
- Occupants
- PES Activity

**ES Input Requirements:**
- Facility Information
  - Height
  - Structure Type
  - Roof Type
  - Window
- Replacement Cost
  - Building
  - Windows
- Occupants
- Traffic Information
- Barricade Polygons
RBESS Verification

• Focus of verification was to demonstrate that RBESS was implemented as intended
• Phase I concentrated of comparing Tier 1 results for ASAP-X, HAZX (Tier 1) and RBESS
• Phase II focused on comparing Tier 2a results between HAZX and RBESS
• Each phase consisted of multiple scenarios that varied:
  – NEW
  – PES type and size
  – ES location
  – PES orientation for ECM
## Phase I Verification Scenarios

<table>
<thead>
<tr>
<th>PES Type</th>
<th>Charge</th>
<th>ID</th>
<th>PES Orientation</th>
<th>IMD-B</th>
<th>ILD-B</th>
<th>IMD-U</th>
<th>ILD-U</th>
<th>PTR</th>
<th>IBD</th>
<th>&gt; IBD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM</td>
<td>Small [1000 lb]</td>
<td>S1</td>
<td>Front</td>
<td>50</td>
<td>75</td>
<td>100</td>
<td>150</td>
<td>600</td>
<td>1000</td>
<td>1400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S2</td>
<td>Side</td>
<td>40</td>
<td>65</td>
<td>95</td>
<td>140</td>
<td>500</td>
<td>1050</td>
<td>1300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S3</td>
<td>Rear</td>
<td>30</td>
<td>70</td>
<td>105</td>
<td>115</td>
<td>400</td>
<td>850</td>
<td>1255</td>
</tr>
<tr>
<td></td>
<td>Medium [70,000 lb]</td>
<td>S4</td>
<td>Front</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>800</td>
<td>1400</td>
<td>1600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S5</td>
<td>Side</td>
<td>230</td>
<td>350</td>
<td>450</td>
<td>650</td>
<td>700</td>
<td>1300</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S6</td>
<td>Rear</td>
<td>150</td>
<td>250</td>
<td>325</td>
<td>425</td>
<td>480</td>
<td>700</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S7</td>
<td>Front</td>
<td>450</td>
<td>700</td>
<td>800</td>
<td>1300</td>
<td>2000</td>
<td>3800</td>
<td>4500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S8</td>
<td>Side</td>
<td>400</td>
<td>600</td>
<td>750</td>
<td>1400</td>
<td>1600</td>
<td>3000</td>
<td>5000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S9</td>
<td>Rear</td>
<td>475</td>
<td>500</td>
<td>870</td>
<td>1250</td>
<td>1500</td>
<td>2500</td>
<td>4000</td>
</tr>
<tr>
<td>Open</td>
<td>Small [500 lb]</td>
<td>S10</td>
<td>Front</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>120</td>
<td>400</td>
<td>500</td>
<td>1300</td>
</tr>
<tr>
<td></td>
<td>Medium [30,000 lb]</td>
<td>S11</td>
<td>Front</td>
<td>150</td>
<td>250</td>
<td>300</td>
<td>500</td>
<td>650</td>
<td>1000</td>
<td>1400</td>
</tr>
<tr>
<td></td>
<td>Medium [20,000 lb]</td>
<td>S12</td>
<td>Front</td>
<td>100</td>
<td>225</td>
<td>275</td>
<td>450</td>
<td>700</td>
<td>1200</td>
<td>1255</td>
</tr>
<tr>
<td></td>
<td>Large [100,000 lb]</td>
<td>S13</td>
<td>Front</td>
<td>250</td>
<td>400</td>
<td>500</td>
<td>700</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
</tr>
</tbody>
</table>

**Note:** IMD-B and ILD-B denote inserts, IMD-U and ILD-U denote upper inserts, PTR denotes progress, and IBD denotes insert back.
Phase I Verification Results

- Nearly full agreement between HAZX and RBESS
  - Common Library implement properly

- Disagreement between ASAP-X and RBESS/HAZX for ECMs
  - Hazard zone calculated with QDE in RBESS/HAZX
  - Hazard zone calculated with simplified QD engine in ASAP-X

- Disagreement between ASAP-X and RBESS/HAZX for Injuries
  - Interpolation scheme for ASAP-X is not consistent for all hazard zone due to different rounding rules
Phase II Verification Scenarios

- 100 runs performed to test PES, NEW, and ES parameters
- Runs also used to test functionality
- Problem setup identical to Phase I runs
- Runs compared results between RBESS and HAZX
- Runs included effects of barricades and roads
Phase II Verification Results

- Complete agreement between RBESS and HAZX
- RBESS calculated a higher expected value loss than HAZX by a factor of 10 for all roads, but issue was corrected
- RBESS functioned as expected
• Demonstration of Tier 1 and Tier 2a follows

• Alameda Naval Air Station used for example

• Barricade was included
RBESS Tier 1 AGM 1041 Project
RBESS Tier 1 Demonstration

PES Selection Screen

Scenario Selector Screen
RBESS Tier 1 Scenario Setup Screen
(Scenario Tab)

Scenario ID: 20
Selected PES: 1041 | Ammò Stor Inst | AGM
Analysis Name: Risk Analysis for PES 1041
Date Created: 12/26/2017 6:06:13 PM
Notes:

Add text to define scenario

From ESS DB

Instruction Panel

Save Information  >  Run QD  >  Run Scenario
RBESS Tier 1 Scenario Setup Screen
(PES Tab - IBD Distance & Hazard Zone Distances Sub-Tabs)

From ESS DB if available
Auto Select determines which HD has largest IBD
User can edit
Click on “Save Info” then on “Run QD”

Once “Run QD” is clicked, the hazard zones can be displayed on the Hazard Zone Distance tab. Also, the Non-Transient ES Tab will be populated.
RBESS Tier 1 Scenario Setup Screen
(Non-Transient ES Tab)

User can edit the radius within which ES’s will be evaluated: a factor on IBD

User can select which ES’s within evaluation zone will be included in analysis

Instruction Panel

When done, click on “Run Scenario”

If data are available from ESS DB, the ES attributes will be filled in; otherwise, default values are displayed. User can also edit the values
RBESS Tier 1 Analysis Results
RBESS Tier 2a AGM 1041 Project

- The same project developed for Tier 1 can be used to do a Tier 2a analysis
- Simply select: run a Tier 2a analysis
- Selecting a PES & scenario are identical to Tier 1 (so not shown)
For Tier 2a, the PES activity type determines the P(event) that is used to develop a Risk Matrix [P(e) vs. Severity]
RBESS Tier 2a Scenario Setup Screen
(Non-Transient & Transient ES Tab)

User can enter TP14 ES attributes or accept defaults.

Instructions:
1. Review Non-Transient ES to be included in scenario.
2. Non-Transient ES tab is selected by default.
3. Update ES information where necessary (only cells in yellow can be edited).
4. Click on 'Next' to continue.

RBEES Tier 2a Scenario Setup Screen
(Non-Transient & Transient ES Tab)

Roads, runways, shipping lanes can be defined at the Tier 2a level.
RBESS Tier 2a Scenario Setup Screen (Barricade Tab)

TP14 barricades, berms, etc. that can block PES debris/fragment throw can be defined at the Tier 2a level
RBESS Tier 2a Results

Tier 2a has numerous displays and reports including the Risk Matrix shown below. Consequences are available for each ES and a DARAD form can be generated.
Conclusions

• RBESS Tier 1 and Tier 2a modes have been implemented in ESS.
• Output for both Tier 1 and Tier 2a RBESS include color-coded maps that display information on replacement cost, fatalities, and injuries.
• Output also displays consequence information for individual ES’s as well as summary information for all the ES’s affected by the PES.
• Both tiers of RBESS automatically populate the Department of Army (DA) Form 7632 which is known as the Deviation Approval and Risk Acceptance Document (DARAD).
• RBESS has been validated through comparisons with ASAP-X and HAZX for Tier 1 and 2a and has been shown to generate the expected results.
• RBESS is being released in ESS v6.1.4 and will be available to ESS users in the near future.
Questions?