Part I/Risk-Based Siting Criteria – Current and Future Efforts in Risk Management and Siting Applications

J Covino, PhD DDESB
2018 International Explosives Safety Symposium and Exposition
San Diego, Ca
7-9 August 2018
Program Partnership/Co-authors

Ming Liu; Naval Facilities Engineering & Expeditionary Warfare Center; Port Hueneme, California, USA

Brandon Fryman; John Tatom and Jorge Flores A-P-T Research, Inc.; Huntsville, Alabama, USA

Jon Chrostowski, ACTA, Inc.; Torrance, California, USA

Mr. Robert Conway and Dr. Michael Oesterle of NAVFAC EXWC have been making significant contributions to the Program

PART II: Will go into further details on the future development of Risk Methodology for Siting

Other papers in this Symposium will discuss science improvements
Quantity-Distance (QD) criteria have been used as the primary means for the safe siting of facilities for more than 70 years.

20+ years of DDESB involvement in Risk-Base for Explosives Safety

Other governing and policy setting entities that are continuing to collaborate with the DDESB:
- Range Commanders Council (RCC)
- Institute of Maker of Explosives (IME)
- North Atlantic Treaty Organization (NATO)
- National Aeronautics and Space Administration (NASA)
- The Bureau of Alcohol, Tobacco
- Firearms and Explosives (ATF)
- Coast Guards and even in the United Nations
- The Department of Homeland Security
ESMRM Policy Implemented

- DoDD 6055.09E Explosives Safety Management
- DoDI 6055.16 Explosives Safety Management Program
- DoDM 6055.09 Ammunition and Explosives Safety Standards
- Joint Staff Policy on ESMRM
- ESMRM Implementation
- DODD 5000 The Defense Acquisition System
- Mil-STD 882E Department of Defense Standard Practice – System Safety
- DoD Instruction 6055.01, DoD Safety and Occupational Health (SOH) Program, 14 October, 2014
Considerations of QD and Risk-Base for Siting

- Quantity Distance (QD) criteria consider:
  - Explosives quantity
  - Hazard Division (HD), and
  - Facility type to determine QD
- Risk-Base for Siting Requires:
  - more input and the
  - answer is a significant improvements

\[
Risk = Probability \ of \ Event \times Consequences \times Exposure
\]

\[
Risk = P_f = P_e \times P_{f|e} \times E_p
\]

- \( P_e \) = probability that an explosives mishap will occur at a potential explosion site (PES) in a year
- \( P_{f|e} \) = probability of fatality given an explosives event and the presence of a person
- \( E_p \) = the exposure of one person (as a fraction of a year) to a PES on an annual basis

For Risk-base siting see Technical Paper 14 DDESB web site [https://ddesb.altess.army.mil/](https://ddesb.altess.army.mil/)
OMB vs DOD Risk Management Process

Identify Hazards ➔ Assess Hazards ➔ Implement Controls ➔ Mitigate Risk ➔ Supervise and Evaluate Risk Mitigation
ESMRM Considerations Throughout the Acquisition Lifecycle

- Materiel Solution Analysis
- Technology Maturation and Risk Reduction - Siting
- Production and Deployment
- Operations and Support
- Disposal

Siting Facilities TP-14 ↔ Risk Management TP-23
### Risk Assessment Matrix

#### Mil-STD 882E

<table>
<thead>
<tr>
<th>Probability</th>
<th>SEVERITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Catastrophic (1)</td>
</tr>
<tr>
<td>Frequent (A)</td>
<td>High</td>
</tr>
<tr>
<td>Probable (B)</td>
<td>High</td>
</tr>
<tr>
<td>Occasional (C)</td>
<td>High</td>
</tr>
<tr>
<td>Remote (D)</td>
<td>Serious</td>
</tr>
<tr>
<td>Improbable (E)</td>
<td>Medium</td>
</tr>
<tr>
<td>Eliminate (F)</td>
<td>Eliminate</td>
</tr>
</tbody>
</table>
## Probability Levels Specific for Munition Related Mishaps

<table>
<thead>
<tr>
<th>Description</th>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burning Ground / Demilitarization / Demolition / Disposal / EOD</td>
<td>OCCASIONAL</td>
<td>Mission Failure</td>
</tr>
<tr>
<td>Assembly / Disassembly / LAP / Maintenance / Renovation</td>
<td>REMOTE</td>
<td>Mission Interrupted</td>
</tr>
<tr>
<td>Lab / Test / RDTE</td>
<td>REMOTE</td>
<td>Mission Degraded</td>
</tr>
<tr>
<td>Training</td>
<td>REMOTE</td>
<td>Mission Unaffected</td>
</tr>
<tr>
<td>Missile System in Static Mode</td>
<td>IMPROBABLE</td>
<td></td>
</tr>
<tr>
<td>Manufacturing / Production</td>
<td>IMPROBABLE</td>
<td></td>
</tr>
<tr>
<td>Inspection / Painting / Packing</td>
<td>IMPROBABLE</td>
<td></td>
</tr>
<tr>
<td>Loading / Unloading / Handling (Ships, Aircraft, Vehicles, Container Stuffing / Unstuffing)</td>
<td>REMOTE</td>
<td></td>
</tr>
<tr>
<td>Short Term Storage (hrs – few days)</td>
<td>IMPROBABLE</td>
<td></td>
</tr>
<tr>
<td>Temporary Storage (1 day - 1 month)</td>
<td>IMPROBABLE</td>
<td></td>
</tr>
<tr>
<td>Deep Storage (1 month - year)</td>
<td>IMPROBABLE</td>
<td></td>
</tr>
<tr>
<td>Munitions and Explosives of Concern</td>
<td>OCCASIONAL</td>
<td></td>
</tr>
</tbody>
</table>

### Severity Categories

- **Catastrophic**
  - Category: 1
  - Definition: One or more deaths and/or serious injuries of individuals not meeting quantity-distance criteria.

- **Critical**
  - Category: 2
  - Definition: Multiple serious injuries of individuals not meeting quantity-distance criteria.

- **Marginal**
  - Category: 3
  - Definition: Minor injuries of individuals not meeting quantity-distance criteria.

- **Negligible**
  - Category: 4
  - Definition: No anticipated injuries and/or other effects for individuals not meeting quantity-distance criteria.
RBESS Software

Tiered Approach to Risk-Based Explosives Siting Analysis

1. Hazard - Overpressure/Frag Analysis
2. Consequence Analysis
3. Risk Analysis

TIER 3
- Conseq/Qual Risk
- Quantitative Risk
Advanced hazard, consequence & risk tools

(Use DDES approved models)

TIER 2
- Consequence/Qualitative Risk
- Quantitative Risk
Improved hazard, consequence & risk tools

Min to moderate inputs
Medium fidelity models

TIER 1
- Hazard/Consequence
Simple hazard & consequence tools

Minimum input
Low fidelity models

Siting Facilities TP-14 ↔ Risk Management TP-23
# DDES B Risk Tools

<table>
<thead>
<tr>
<th>Analysis Level</th>
<th>Tool</th>
<th>App Type</th>
<th>Resp Org</th>
<th>Documentation</th>
<th>Analysis Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tier 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consequences based on 6055.9M damage descriptions</td>
<td>ASAP-X</td>
<td>Spreadsheet</td>
<td>DDES B</td>
<td>TP23</td>
<td>Sloss, #injuries/fatalities</td>
</tr>
<tr>
<td></td>
<td>CNRI</td>
<td>Spreadsheet</td>
<td>DDES B</td>
<td>???</td>
<td>Sloss, #injuries/fatalities</td>
</tr>
<tr>
<td></td>
<td>S/CNRI</td>
<td>GUI/Spreadsheet</td>
<td>???</td>
<td>???</td>
<td>Sloss, #injuries/fatalities</td>
</tr>
<tr>
<td></td>
<td>HAZX/ASAP-X</td>
<td>GUI/GIS</td>
<td>ACTA</td>
<td>Users Guide with tech info</td>
<td>%damage, Sloss,%/# minor/major injuries, DARAD, various GIS</td>
</tr>
<tr>
<td></td>
<td>RBESS/ASAP-X</td>
<td>GUI/GIS</td>
<td>EXWC</td>
<td>RBESS Draft?</td>
<td>%damage, Sloss,%/# minor/major injuries, DARAD, various GIS</td>
</tr>
<tr>
<td></td>
<td>RBESS/MRAS/ASAP-X</td>
<td>GUI/GIS</td>
<td>EXWC</td>
<td>RBESS Draft?</td>
<td>%damage, Sloss,%/# minor/major injuries, DARAD, various GIS</td>
</tr>
<tr>
<td><strong>Tier 2a</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consequences based on DDES B TP14</td>
<td>HAZX/TP14</td>
<td>GUI/GIS</td>
<td>ACTA</td>
<td>Users Guide with tech info</td>
<td>%damage, Sloss,%/# minor/major injuries, DARAD, Risk Matrix/RAC, various GIS displays</td>
</tr>
<tr>
<td></td>
<td>RBESS/TP14</td>
<td>GUI/GIS</td>
<td>EXWC</td>
<td>RBESS Draft?</td>
<td>%damage, Sloss,%/# minor/major injuries, DARAD, Risk Matrix/RAC, various GIS displays</td>
</tr>
<tr>
<td></td>
<td>FASTSITE</td>
<td>Spreadsheet</td>
<td>APT</td>
<td>Users Guide</td>
<td>%damage, Sloss,%/# minor/major injuries, other graphic displays</td>
</tr>
<tr>
<td></td>
<td>SAFER V3.2</td>
<td>GUI/GIS</td>
<td>APT</td>
<td>TP19</td>
<td>%damage, Sloss,%/# minor/major injuries, other graphic displays</td>
</tr>
<tr>
<td><strong>Tier 2b</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consequences based on DDES B TP14</td>
<td>SAFER V3.2</td>
<td>GUI/GIS</td>
<td>APT</td>
<td>TP19</td>
<td>%damage, Sloss,%/# minor/major injuries, other graphic displays</td>
</tr>
<tr>
<td></td>
<td>HAZX</td>
<td>GUI/GIS</td>
<td>ACTA</td>
<td>Users Guide with tech info</td>
<td>%damage, Sloss,%/# minor/major injuries, other graphic displays</td>
</tr>
<tr>
<td><strong>Tier 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consequences based on PES/Weapon specific data</td>
<td>HAZX</td>
<td>GUI/GIS</td>
<td>ACTA</td>
<td>Users Guide with tech info</td>
<td>%damage, Sloss,%/# minor/major injuries, other graphic displays</td>
</tr>
</tbody>
</table>
Risk-Based Explosives Safety Siting (RBESS) Module

- QD engine modules
- ASAP-X (Tier 1),
- MRAS (Tier 1),
- Fast-Site (Tier 1),
- TP-14 type tool (Tier 2a) HAZX Risk Tool (Tier 2a),
- **Quantitative Risk Analysis TP14-based – SAFER**
## TP-14 Six Functional Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Steps</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>1-4</td>
<td>Situation Definition, Event and Exposure Analyses. Includes user inputs that describe the situation (PES and ES) and calculates Pe, exposure, and yield.</td>
</tr>
<tr>
<td>Group 2</td>
<td>5-8</td>
<td>Pressure and Impulse Branch. Calculates the magnitude of the fatality mechanisms of pressure and impulse.</td>
</tr>
<tr>
<td>Group 3</td>
<td>9-10</td>
<td>Structural Response Branch. Calculates the magnitude of the fatality mechanisms of building collapse and broken windows (overall building damage).</td>
</tr>
<tr>
<td>Group 4</td>
<td>11-18</td>
<td>Debris Branch. Calculates the magnitude of the fatality mechanisms for multiple types of flying debris.</td>
</tr>
<tr>
<td>Group 5</td>
<td>19-22</td>
<td>Thermal Branch. Calculates the magnitude of the fatality mechanism heat for HD 1.3 scenarios only.</td>
</tr>
<tr>
<td>Group 6</td>
<td>23-26</td>
<td>Aggregation and Summation. Aggregates the total magnitude and risks of all fatality mechanisms, calculates the desired measures of risk, and assesses overall uncertainty.</td>
</tr>
</tbody>
</table>
Time Line for Science Improvements for TP-14

- SAFER Maturity Matrix Developed - March
- RBESCT ESKIMORE Testing Program Proposed - April
- SciPan 2 - July
- Australian Defense Force (ADF) – 5 tonne - April
- SPIDER 1B - October
- SciPan 1 - February
- SciPan 3 - April
- SPIDER 1A - June
- ISO 1 – May
- ADF 859 Trial 4 - March
- Project ESKIMORE Formalized - February
- ISO 2 - March
- ADF 859 Trial 5 - April
- ISO 3 – September
- SciPan 4 - August
- ISO 4 (re-test) – December
- SPIDER 2 – June - September
- ISO (KG) - August
- SciPan 5 - June
- IME Testing Program Proposed - October
- ISO 4 – September
- RBESS Release
- Iron Warrior IV - July
- Derailed Test - April/May
- SPIDER 3 Testing - January
<table>
<thead>
<tr>
<th>Risk to:</th>
<th>DDESB Criteria</th>
<th>Service Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any 1 worker(^a) (Annual P(_f))</td>
<td>Risks below (1 \times 10^{-4}) are acceptable</td>
<td></td>
</tr>
<tr>
<td>All workers (Annual E(_f))</td>
<td>Risks below (1 \times 10^{-3}) are acceptable (advisory)</td>
<td>If risks are above (1 \times 10^{-3}) apply ALARP principle(^c) Accept above (1 \times 10^{-2}) with significant national need only(^c)</td>
</tr>
<tr>
<td>Any 1 person (Annual P(_f))</td>
<td>Risks below (1 \times 10^{-6}) are acceptable</td>
<td></td>
</tr>
<tr>
<td>All public(^b) (Annual E(_f))</td>
<td>Risks below (1 \times 10^{-5}) are acceptable (advisory)</td>
<td>If risks are above (1 \times 10^{-5}) apply ALARP principle(^c) Accept above (1 \times 10^{-3}) with significant national need only(^c)</td>
</tr>
</tbody>
</table>

\(\text{\(^a\) Worker criteria apply to people that are associated with the explosives activity, but not directly involved (hands-on).}\)
\(\text{\(^b\) Public criteria apply to government employees working on the installation but not related to the explosives activity, and the general public.}\)
\(\text{\(^c\) For Service's waivers and exemptions ALARP is the safety principle whereby risks are reduced "as low as reasonably practicable."}\)
The ALARP principle
(As low as reasonably practicable)

- Unacceptable or intolerable region
- Broadly acceptable region (No need for detailed work to demonstrate ALARP)
- Negligible risk

The ALARP or Tolerability region (Risk is accepted only if a benefit is desired)

- Risk cannot be justified except in extraordinary circumstances
- Tolerable only if risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained
- Tolerable if the cost of reduction would exceed the improvement gained

- Avoid avoidable risks
- Need to maintain assurance that risk remains at this level

Moving Forward - Possible Modification of Criteria
Risk-Base Program Improvement - Short Term

- Updating the probability of event (Pe) used in TP-14 methodology
- Implementing a “warning system” as the criteria for a TP-14 QRA analysis
- Updating the Universal Risk Scale (URS)
- Updating the uncertainty methodology used in TP-14 methodology
- Removing undue conservatism in TP 14 methodology to create a more realistic model
- Creation of RBESS v1.0 for incorporation into Explosive Safety Siting (ESS) to be released in late 2018.
• Implement an “As Low as Reasonably Possible” (ALARP) methodology into the criteria used for a TP-14 QRA analysis
• Implement an F/N process to consider catastrophic risk criteria for a TP-14 QRA analysis
• Remove undue conservatism in TP-14 methodology
• Make tools easy to use
• Continue to support future versions of RBESS and web based RBESS
• Assist DoD Components in utilizing Risk Analysis and Risk Management principles thought-out a munition system lifecycle.
• Develop practical tools in support of DoD Components ESMRM process and life cycle management.
• Incorporate new science to include new test data
• Continue to socialize with DoD Components
Conclusion

- Move into ESS and become Web Based – Allows for switching between conventional QD and Risk Base
  - Improves risk management
  - Increases visibility of critical facilities
  - Improve informed risk decision process– inform key decision makers
  - Quantify the risks at QD

- Continue to improve Risk Analysis tools and methods for explosives safety
  - Risk management in operations
  - Munition lifecycle
  - Combustion processes

- Share findings with national and international communities of interests.