IM State of the Art

2013 INSENSITIVE MUNITIONS & ENERGETIC MATERIALS TECHNOLOGY SYMPOSIUM

8 Oct, 2013
CORONADO BAY, SAN DIEGO, CA

Manfred “Fred” Becker
Warhead Technology TSO
Tel ++32 2 707 5426
M.Becker@msiac.nato.int

Munitions Safety Information Analysis Center
Supporting Member Nations in the Enhancement of their Munitions Life Cycle Safety

Approved for Public Release – Distribution Unlimited
Presentation will describe IM State of the Art and trends with respect to IM Technology

Available to members  http://www.msiac.nato.int/

Changing Nature of Technology, Munitions and Threats
IM International Success Stories

• Many examples of IM compliant / near compliant systems

**Misconception – IM means reduced performance**

- IM definition; Munitions which reliably fulfill their **performance**, readiness and operational requirements on demand
  - There are examples of IM rounds with increased performance against the target set
  - And, there are examples where a reduced performance requirement was deemed acceptable to achieve increased IMness

- Munitions can significantly impact the survivability of platforms in operational scenarios

MSIAC IM SOTA project captures information on latest munition developments
IM SOTA Trends

HIG

120mm HE Mortar

Min Smoke Rocket Propellant

60mm MAPAM

Gun Launched Cast Cure Formulations

Gun Launched Melt Cast HE

Gun Launched Pressed HE

IM Performance

Large Calibre Gun Propellant

Metal Accelerating HE Cast Cure Formulations

Metal Accelerating Pressed HE

Underwater Explosives

M795 155mm

LU 211 155mm

Excalibur 155mm

M0125 105mm

RH30 155mm

105mm

155mm

155mm

155mm

120mm HE Mortar

Approved for public release - Distribution Unlimited
## Gun Launch Trends

<table>
<thead>
<tr>
<th>Munition</th>
<th>PBXN-110</th>
<th>M934A2</th>
<th>M0125</th>
<th>RH30</th>
<th>M795</th>
<th>LU211-IM</th>
<th>XM-982</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FCO</strong></td>
<td>V</td>
<td>IV**</td>
<td>IV</td>
<td>IV/V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td><strong>SCO</strong></td>
<td>V</td>
<td>IV**</td>
<td>IV</td>
<td>IV/V</td>
<td>V</td>
<td>V</td>
<td>III</td>
</tr>
<tr>
<td><strong>BI</strong></td>
<td>V</td>
<td>IV**</td>
<td>IV</td>
<td>IV/V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td><strong>FI</strong></td>
<td>V*</td>
<td>III</td>
<td>IV</td>
<td>IV/V</td>
<td>V</td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td><strong>SR</strong></td>
<td>IV*</td>
<td>IV***</td>
<td>IV</td>
<td>IV/V</td>
<td>Pass</td>
<td>IV</td>
<td>IV</td>
</tr>
<tr>
<td><strong>SCJ</strong></td>
<td></td>
<td>IV</td>
<td>IV</td>
<td>IV/V</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **60mm MAPAM**
- **120mm HE Mortar**
- **M0125 105mm**
- **RH30 155mm**
- **M795 155mm**
- **LU 211 155mm**
- **Excalibur 155mm**

Approved for public release - Distribution Unlimited

Supporting Munitions Safety
Changing Nature of Munitions

IM reality

Search Results for 155 mm Shells that Pass Sympathetic Reaction Test
(MSIAC Tool SYR v1.2)
## Gun Launch Trends

### IM Maturity and IM Performance Assessment

- IM rounds are in Service e.g. RH30 deployed with the Dutch in Afghanistan.
- Systems close to IM compliance (some require package mitigation)
- Recent experience introducing rounds has led to some issues; in particular gun launch survivability hence higher technical risk.

<table>
<thead>
<tr>
<th>Munition Type</th>
<th>FCO</th>
<th>SCO</th>
<th>BI</th>
<th>FL</th>
<th>SR</th>
<th>SCJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBXN-110</td>
<td>V</td>
<td>V</td>
<td>V*</td>
<td>V*</td>
<td>IV*</td>
<td></td>
</tr>
<tr>
<td>M934A2</td>
<td>IV**</td>
<td>IV**</td>
<td>IV***</td>
<td>IV***</td>
<td>III</td>
<td></td>
</tr>
<tr>
<td>M0125</td>
<td>IV</td>
<td>IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RH30</td>
<td>IV/V</td>
<td>IV/V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LU211-IM</td>
<td>V</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XM-982</td>
<td>V</td>
<td>III</td>
<td>V</td>
<td>V</td>
<td>III</td>
<td></td>
</tr>
</tbody>
</table>

- 60mm MAPAM
- 120mm HE Mortar
- Excalibur 155mm
IM SOTA Trends

Technical Risk

LOW

HIGH

IM Performance

LOW

HIGH

Supporting Munitions Safety

Approved for public release - Distribution Unlimited
# Underwater Explosives

<table>
<thead>
<tr>
<th>Weapon</th>
<th>FCO</th>
<th>SCO</th>
<th>BI</th>
<th>FI</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP-2000</td>
<td>V</td>
<td>V</td>
<td>IV</td>
<td>IV</td>
<td>III*</td>
</tr>
<tr>
<td>FOXIT</td>
<td>V</td>
<td>V</td>
<td></td>
<td></td>
<td>III*</td>
</tr>
<tr>
<td>Mk 46</td>
<td>V</td>
<td>IV</td>
<td>IV</td>
<td>F</td>
<td>III*</td>
</tr>
<tr>
<td>DM2A4 SeaHake&lt;br&gt; PBXN-111 Warhead&lt;br&gt; DM29 Booster</td>
<td>FCO</td>
<td>SCO</td>
<td>BI</td>
<td>FI</td>
<td>SCJ</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>IV</td>
<td>IV</td>
<td>IV</td>
<td>III</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>I</td>
</tr>
</tbody>
</table>
**IM Maturity and IM Performance Assessment**

- TP2000 in service
- Underwater optimised formulations PBXN-111 or B-2211D has excellent IM properties and improved underwater performance
- Mitigation required to pass SR for large warheads
IM SOTA Trends

- High Performance Rocket Propellant
- Gun Launched Pressed HE
- Gun Launched Melt Cast HE
- Gun Launched Cast Cure Formulations
- Large Calibre Gun Propellant
- Underwater Explosives
- Typical AP/HTPB Composite Propellant
- Metal Accelerating HE Cast Cure Formulations
- Metal Accelerating HE
- General Purpose HE Cast Cure & Melt Cast Formulations
- Min Smoke Rocket Propellant
- Small Calibre Gun Propellant
- Gun Launched Pressed HE
- Low Risk
- High IM Performance
- High Technical Risk
- High IM Performance
- Low Technical Risk

Approved for public release - Distribution Unlimited
Supporting Munitions Safety
IM SOTA Trends

Technical Risk

HIGH

General purpose bomb
BLU-111/B

Lowest Calibre
Gun Launched Cast
Cure Formulations

Metal Accelerating
Pressed HE

Large Calibre
Gun Launched Pressed
Cure Formulations

Gun Launched Melt
Cast HE

Underwater
Explosives

Precision Guided Bomb
Paveway IV

Lowest Performance
Propellant

CBEMS/BANG 250 kg

Highest Performance
Propellant

General Purpose HE
Cast Cure Formulations

Approved for public release - Distribution Unlimited

Supporting Munitions Safety
## General Purpose Bombs

<table>
<thead>
<tr>
<th>Bomb Type</th>
<th>FCO</th>
<th>SCO</th>
<th>BI</th>
<th>FI</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLU-111C/B</td>
<td>V</td>
<td>IV</td>
<td>V</td>
<td>IV</td>
<td>I*</td>
</tr>
<tr>
<td>BLU-117C/B</td>
<td>V</td>
<td>V</td>
<td>III</td>
<td>III</td>
<td>I*</td>
</tr>
<tr>
<td>CBEMS/BANG</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>III</td>
</tr>
<tr>
<td>PGB</td>
<td>V</td>
<td>V</td>
<td>V*</td>
<td>V</td>
<td>I*</td>
</tr>
</tbody>
</table>

**General purpose bomb**

**BLU-111C/B**

**CBEMS/BANG 250 kg**

**Precision Guided Bomb Paveway IV**
General Purpose Bombs

<table>
<thead>
<tr>
<th></th>
<th>FCO</th>
<th>SCO</th>
<th>BI</th>
<th>FI</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLU-111C/B</td>
<td>V</td>
<td>IV</td>
<td>V</td>
<td>IV</td>
<td>I*</td>
</tr>
<tr>
<td>BLU-117C/B</td>
<td>V</td>
<td>V</td>
<td>III</td>
<td>III</td>
<td>I*</td>
</tr>
<tr>
<td>CBEMS/BANG</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>III</td>
</tr>
<tr>
<td>PGB</td>
<td>V</td>
<td>V</td>
<td>V*</td>
<td>V</td>
<td>I*</td>
</tr>
</tbody>
</table>

IM Maturity and IM Performance Assessment

- IM rounds are in Service (PGB dropped in Libya)
- Systems close to IM compliant
- Sympathetic reaction difficult to pass for large diameter warheads
Rocket Motor Design plays a major role in Reducing IM signature:

- Case selection
- Mitigation features and devices
Changing Nature of Munitions

MSIAC GAPS workshop (The Hague, The Netherlands June 2011)
  IED threats
  Shaped Charge Jet threats – unlike a 50mm Rockeye
  Nations identified need for standard SCJ threat for test and analysis

I-AMMO Working group addressing Marking of Munitions
  IM rounds  more resilient to destruction
  EOD  desire for stamp / Stencil Explosive fill
  NATO AOP-2(c) will be amended
Changing Nature of Munitions (ours…)

It’s cheap, it’s safe, it’s the future . . . and the future is here.

“Ours” and “Theirs”

Pictures from recent MSIAC newsletters & workshops
Technology Gaps

• Designing gun propellants for IM not funded in most countries
  ▪ Gun propellant response to FI and SCJ generally resulting in a pass with most recent gun propellants
  ▪ System design critical

• Rocket Propellant
  ▪ High energy min signature rocket motor
    ✷ Low temp capability, performance, signature, higher requirements not yet achieved by reduced vulnerability propellant.
  ▪ High Performance Propellant
    ✷ Type III response may present unacceptable collateral damage

• Design Toolkits required
  ▪ Codes and Models, small scale predictive tests…
Knowledge Transfer

- **Common Standards**
  - Common Procedures

- **Compete reporting**
  - Processes
  - Results
    - Successes
    - “Failures”

- **Information**
  - Accurate
  - Standardized
  - Disseminated
Summary - IM Technology

• Significant progress has been made in terms of technology availability

• An increasing number of reduced vulnerability systems are now in service or are in development

• Recent conflicts have emphasised importance of IM in the operational environment

Request information on systems not included
QUESTIONS?

Thank you