Storm Shadow: Achievement of an IM Compliant Lethal Package

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Introduction

- Air-launched, long-range cruise missile
- Attack of high value, hardened targets
- BROACH multiple warhead system (Bomb, Royal Ordnance, Augmenting Charge)
  - Precursor Charge (PC) pre-damages the target structure
  - Follow-Through Bomb (FTB) perforates the target and detonates within it
- The design of an effective Lethal Package inevitably conflicts with IM compliance
BROACH Concept

BROACH SEQUENCE OF OPERATION

Concrete  Soil

1. Sensor detects target

2. Precursor Charge detonates
   Blast & fragmentation outside target
   Jet penetrates target

3. Follow Through Bomb
   separation from missile
   and penetrates target

4. Detonation of Follow Through Bomb within target structure
BROACH Concept
Missile components
Requirements

- Functional requirement
  - Target penetration
  - Reliable detonation
  - Range of target constructions
  - Range of impact conditions:
    - Velocity, impact angle, incidence angle (AOA)

- IM Requirement
  - Ordnance Board Proceeding 42657

<table>
<thead>
<tr>
<th>Threat</th>
<th>Required reaction</th>
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<tbody>
<tr>
<td>Fast Cook-off (FCO)</td>
<td>Type V</td>
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<tr>
<td>Slow Cook-off (SCO)</td>
<td>Type V</td>
</tr>
<tr>
<td>Bullet Impact (BI)</td>
<td>Type V</td>
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<tr>
<td>Sympathetic Reaction (SR)</td>
<td>Type III</td>
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LP Functional Design

- **PC**
  - High performance explosive (brisant)
  - Optimised shaped charge
  - Airframe & forebody integration

- **FTB perforation**
  - High strength
  - High mass (KE)
  - Minimised cross section
  - Airframe integration

- **FTB behind target effect**
  - High performance explosive (blast / fragmentation)
  - Fragmenting case
  - Fuze reliability
IM development programme

- Concept
  - Bench tests
  - Modelling
    - Concept downselect
  - Pre-qualification
    - Risk reduction
    - Modelling
    - Data gathering
- Qualification
  - Modelling
  - Fast Cook off
  - Slow Cook off
  - Sympathetic Reaction
  - Bullet Impact
- Production
PC IM Design

• Trade-offs
  • Performance of explosive conflicts with insensitivity

• Energetic materials
  • Cast PBX material main filling – no DDT, low explosiveness
  • Proven insensitive booster pellet and pyro cord compositions

• Venting
  • Closure fixings designed to detach as temperature increases beyond environmental limits
  • Steel & aluminium case construction

• Thermal management
  • Body lined with insulating material
  • Thermal modelling conducted to build confidence before trials
FTB IM Design

- **Trade-offs**
  - High strength and mass conflict with need for venting
  - Small cross section means large aspect ratio
  - Performance of explosive conflicts with insensitiveness

- **Energetic materials**
  - Cast PBX material main filling – no DDT, low explosiveness
  - Proven insensitive booster pellet composition
  - EMTAP fast heating tube tests conducted to aid selection

- **Venting**
  - Vent holes incorporated in rear closure for main fill and boosters

- **Thermal management**
  - Body lined with insulating material
  - Controlled ignition site position – supported by modelling
PC Bullet impact
PC Bullet impact
Fast Cook Off
Sympathetic Reaction
Sympathetic Reaction
## Qualification trial results

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<tr>
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<th>Acceptable reaction</th>
<th>Result</th>
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Fragment impact assessment – type V
Operational Effectiveness
Summary

- Full compliance with IM requirements was achieved
  - FCO, SCO, SR and BI demonstrated
  - Assessment conducted on Fragment Impact threat

- Performance requirements not compromised
  - Despite functional requirements acting against IM compliance

- In service with UK MoD
  - First IM compliant system of its size
  - Proven effective in Operation Telic