

# High Performance IM Compliant Artillery Projectile With Enhanced Throughlife Survivability

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## Introduction

- ✦ BAE SYSTEMS Land Systems is developing a range of IM compliant artillery projectiles that meet the requirements of the UK MoD's mandatory Insensitive Munitions policy.
- ✦ These ammunition natures utilise a suite of generic technologies which include a castable-curable main charge Polymer Bonded Explosive (ROWANEX 1100) filling, a reduced vulnerability booster explosive (ROWANEX 3601) and a patented liner system.
- ✦ The full benefits of these IM Technologies had been demonstrated in the 4.5" IA IM Technology Demonstrator Programme, a collaborative R&D programme involving BAE SYSTEMS, DERA and CESO(N)



**ROWANEX 1100**  
Main Charge Filling



**ROWANEX 3601**  
Reduced Vulnerability Booster Explosive

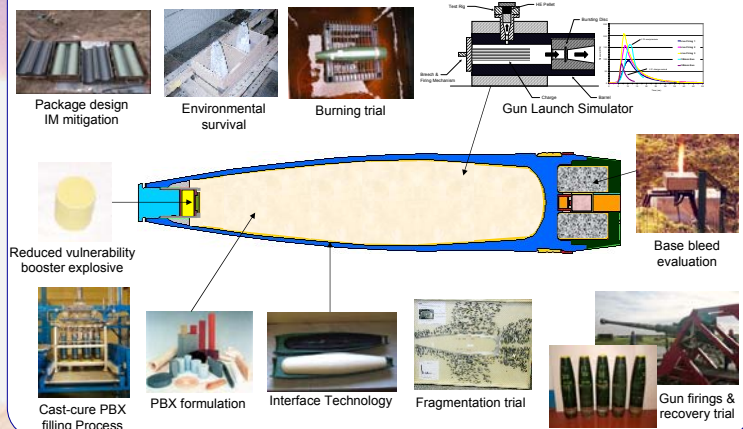
## Objectives

- ✦ To evaluate the effects of accelerated ageing and environmental testing on a range of projectile natures comprising 105mm, 4.5" and 155mm calibres.
- ✦ To monitor the status of PBX filling and Booster Pellet conditions with techniques such as radiography and visual inspection in association with sectioning, chemical analysis and assessment of hazard and mechanical properties under various accelerated ageing and environmental testing regimes.

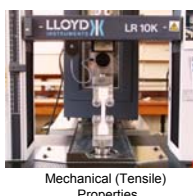
## IM Projectile Development Life-cycle

- ✦ 1. R&D of main charge and booster material → material qualification (UK MOD DOSG)
- ✦ 2. Filling and pressing process development
- ✦ 3. High-g launch of projectiles (medium / large calibre)
- ✦ 4. Assessment of filling standards (gun launch simulator)
- ✦ 5. Assessment of effect of ageing/environmental testing on main charge explosive in projectiles
- ✦ 6. High-g launch of projectiles underwent ageing / environmental testing
- ✦ 7. Performance and Hazard (IM) assessment on IM projectiles (not covered in this poster)
- ✦ 8. Demil / Disposal (not covered in this poster)

## Projectile Design - Systems Approach



Vacuum Stability



Mechanical (Tensile) Properties



Conditioning Chamber



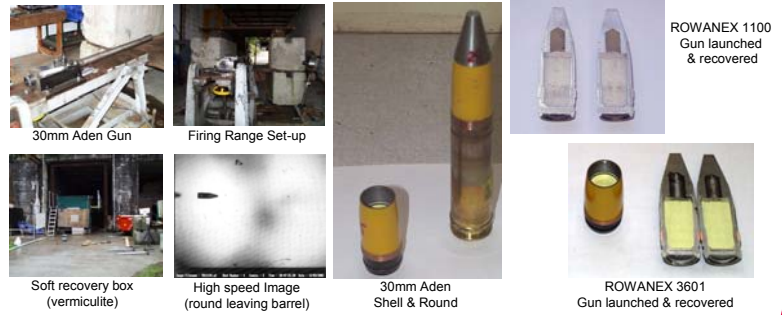
Impact Sensitiveness (Rotter Impact Machine)

## ROWANEX 1100/3601 accelerated ageing (material)

- ✦ ROWANEX 1100 is a RDX/HTPB based PBX designed specially as main charge explosives for gun-launch applications
- ✦ ROWANEX 3601 is a RDX/TATB based PBX designed as reduced vulnerability booster explosive for gun-launch applications
- ✦ A key part of the material qualification programme (for UK In-service use), is the effect of accelerated ageing (60°C for 6 months) on both main charge and booster explosive in terms of hazard and mechanical properties
- ✦ Both materials exhibited no significant deterioration after accelerated ageing and hence qualification status were granted as a result

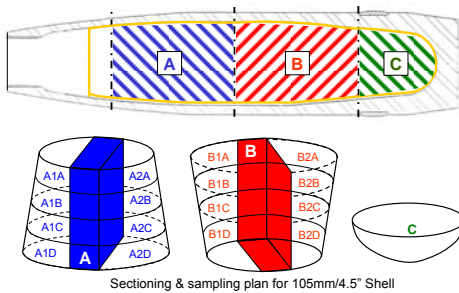
**ROWANEX 1100/3601 high-g launch (Medium Calibre)**

- ✦ ROWANEX 1100 and 3601 were subjected to high-g (60,000g nominal) gun launch survivability assessment prior to large calibre launch
- ✦ 30mm Aden ammunitions filled with both materials and fitted with inert fuze were fired into soft recovery box (filled with vermiculite), recovered & sectioned for visual analysis
- ✦ All rounds survived and no damaged were found in any rounds recovered



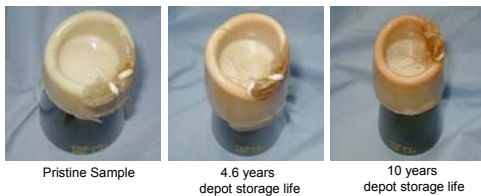
**ROWANEX 1100 high-g launch (Large Calibre Ammunition)**

- ✦ 3 off ROWANEX 1100 filled 155mm L15 shells were gun-launched at low charge (amb temp) initially and recovered at sea (39 Calibre gun)
- ✦ The shells survived without incident. They were sectioned to allow filling examination
- ✦ Further L15 shells were gun-launched at P1 pressure (52 Calibre gun) and at -46°C and +63°C – again, all shells survived without incident
- ✦ Strength of Design & Safety in Gun firing on 105mm HEIM shells (at various pressures / -46°C & +63°C). A sample of shell were recovered and sectioned – no signs of cracking, dusting and exudation of the ROWANEX 1100 main charge
- ✦ Over 100 rounds of ROWANEX 1100 filled 105mm HEIM shells were fired for ballistic matching and no incident was ever recorded



**Effect of ageing on ROWANEX 1100 in shell**

- ✦ ROWANEX 1100 filled 105mm shells were subjected to accelerated ageing (various periods) to replicate up to 10 years in-storage life
- ✦ Shells were radio-graphed and sectioned to obtain PBX samples at various part of the shell for the analysis of:
  - Visual inspection (Presence of loose RDX crystals)
  - Radio-graph inspection (For internal cracking)
  - Mechanical properties (Stress and strain at Max load)
  - Physical properties (Density and Shore Hardness)
  - Thermal properties (VS and DSC)
  - Hazard properties (Sensitiveness to Impact)
- ✦ Results were compared with unaged pristine ROWANEX 1100 sample
- ✦ No significant deterioration observed in the above analysis



**Environmental testing on ROWANEX 1100 in shell**

- ✦ ROWANEX 1100 filled shells (105mm/155mm/4.5") were subjected to environmental tests such as:
  - Bounce (Def Stan 00-35 Test M11)
  - Vibration to AOP-34
  - 2.1m drop (Def Stan 00-35 Test M5)
  - 12m un-packaged drop (Def Stan 00-35 Chapter 5-03)
  - Diurnal Cycling (A1/B3 cycle to STANAG 2895)
- ✦ Shells were radio-graphed pre and post test & "head end" area inspected. No evidence of ROWANEX 1100 cracking/dusting and exudation was found
- ✦ A number of 105mm HEIM shells underwent environmental testing were gun launched and no incident was recorded



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**Conclusion**

- ✦ The effects of accelerated ageing & environmental testing on IM projectile are minimal, which shows that explosive filling quality can be maintained after undergoing various ageing & environmental test regimes, equivalent to a significant service life