# TNT Hazard Response & Applicability to Counter-Rocket, Artillery and Mortar

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# 1
# Introduction

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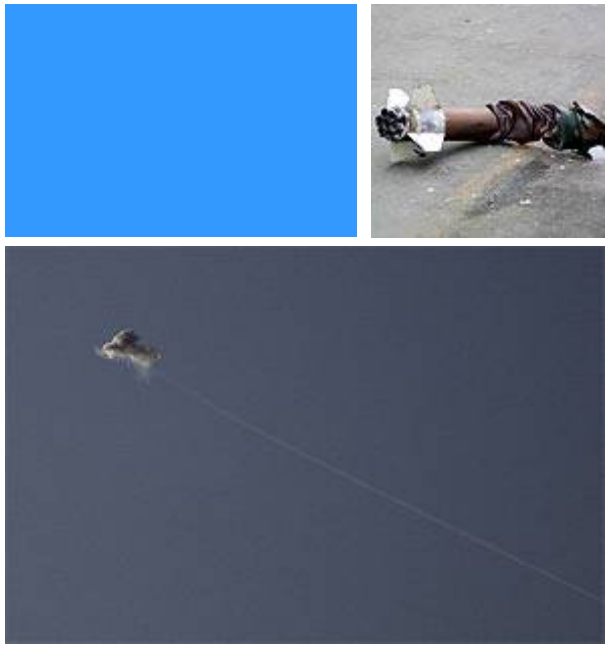
# 1 Introduction

## Background

- UK military operations have shown the requirement to protect against Rocket, Artillery & Mortar (RAM)
  - Effective mitigation strategy requires understanding of *Prevent*, *Warn*, *Intercept*, *Respond* & *Protect*
- Work Presented on Understanding Intercept 'Pillar'
  - Characterisation of likely RAM threats
    - Thickly cased with steel and TNT filled – parallels with modern Insensitive Munitions variants
  - Identification and verification of lethal mechanism options for compact warheads
    - Integration into small to medium ammunition or missiles
    - Original requirement for a prompt detonation reaction in threat
  - Use of modelling and experimental tools for design and assessment
    - Hazard assessment using e.g. Jacobs-Roslund
    - Live firing verification trials

# 2
# TNT Characterisation

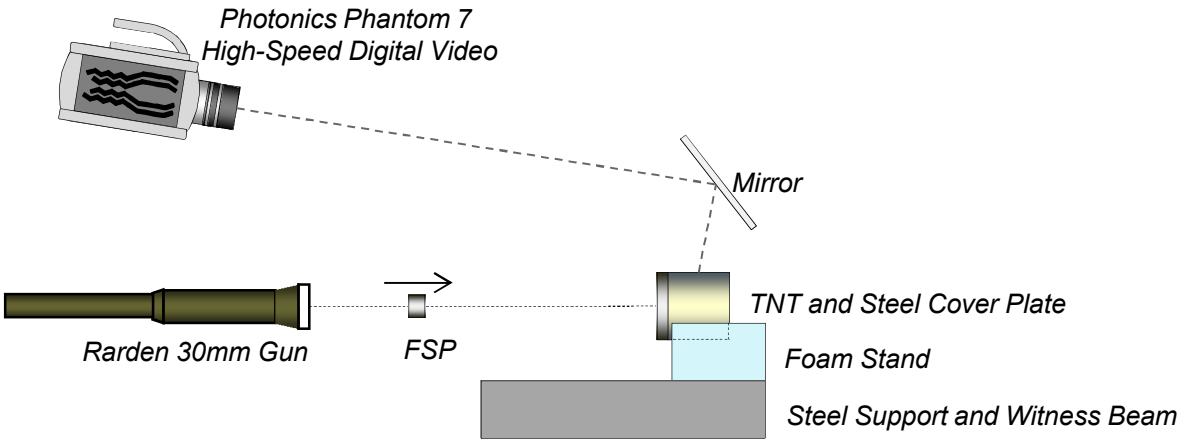


# 2 TNT Characterisation

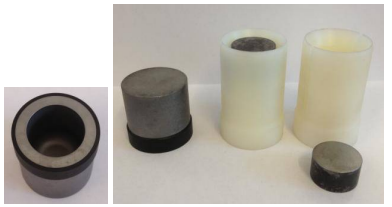
## High Explosive Filling

- Melt-cast ‘Creamed’ TNT of interest to study
  - Prepared by melting TNT in steam heated vessel, stir in flaked TNT to produce slurry
  - Density 1580kg.m$^{-3}$
- Single fragment attack used to characterise material
  - Rarden 30mm gun to launch 20 and 30mm projectiles up to ~2000m.s$^{-1}$
  - Calibrate hazard response models

*TNT Casting*




*FSP Impactors*



*TNT & Cover Plate*

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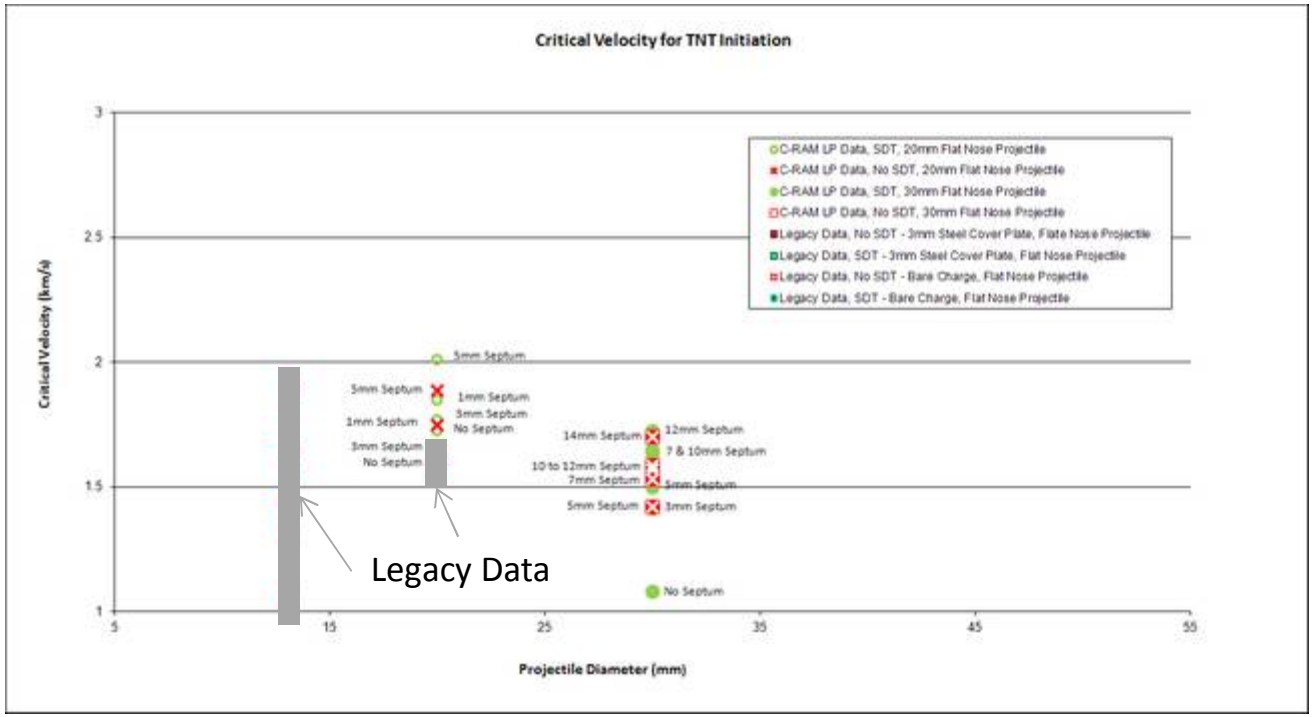
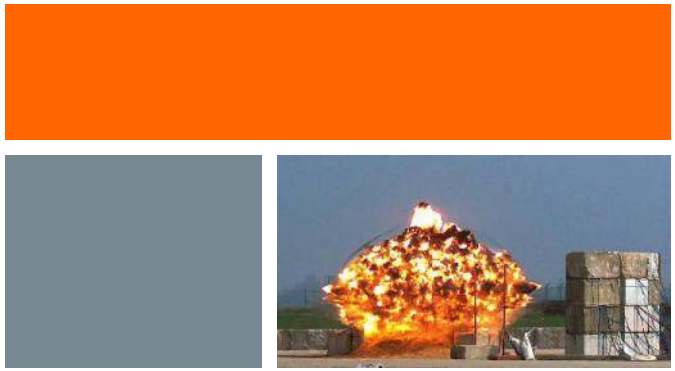
# 2 TNT Characterisation

## Gun-launched Fragment Attack Results

- Legacy data for bare TNT or very thin steel barrier only
  - Limited SDT ‘go’ data
- Current data covers a wide range of barrier thicknesses
  - Identification of highest ‘no-go’ and lowest ‘go’ velocities
- To produce ‘go’ response in thicker barrier target configurations, necessary to use larger 30mm diameter projectile
- Data allows recalibration of hazard models to fit thick septum data



# 3
# Explosively Generated Lethal Mechanisms

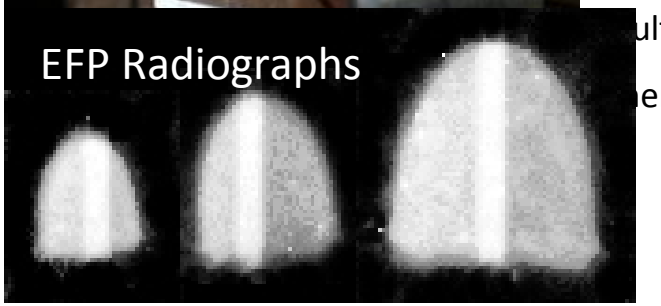


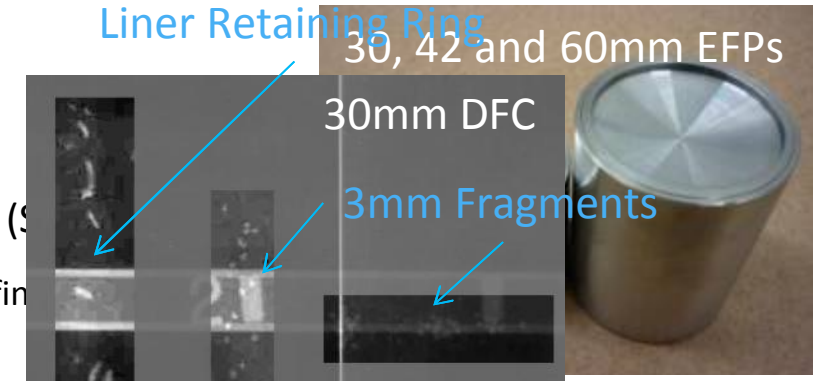
# 3 Explosively Generated Lethal Mechanisms

Live Firing Tests Objective

- Verification and Validation Data
  - Tests c… …k to detonation (S…
    - Ope… …rather than confin…
  - Iron Ex… …single impacts






# 3 Explosively Generated Lethal Mechanisms

## Explosively Driven Mechanisms (TNT Sensitivity)

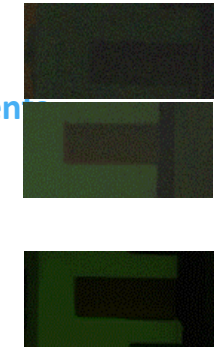
Hard kill requirement for detonation implies bulky LP solutions arising from deployment of larger elements

Potentially relax this requirement so that acceptable outcome is TNT integrity loss

- TNT relatively intact; wholly unreacted
- Small TNT pieces recovered; some reaction possible
- No TNT recovered; pulverisation or consumed

Initial Requirement →

| Hazard Response Levels | |
|---|---|
| 0 | No Reaction |
| 1 | Ignition; no propagation |
| 2 | Burning |
| 3 | Deflagration |
| 4 | Detonation |



| Hazard Response | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Target (thickness steel covering TNT) | EFP | | | DFC (charge and fragment diameter) | | | | | |
| | 30mm | 42mm | 60mm | 30mm | | 42mm | | 60mm | |
| | | | | 3mm | 5mm | 3mm | 5mm | 3mm | 5mm |
| 9mm | Pulverisation → Detonation | | | | | | | Pulverised | |
| 5mm | | | | | | | Burning Response | | |
| 15mm | | | | | | | | | |

Black fill denotes untested scenarios

# 3 Explosively Generated Lethal Mechanisms

Jacobs – Roslund Hazard Response – Rail Projectile Impact

Small scale Projectiles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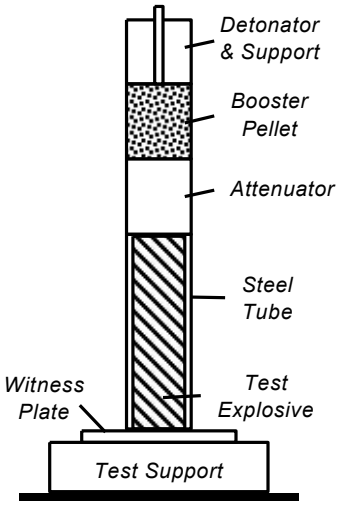
# 4
# High Explosive Shock Initiation

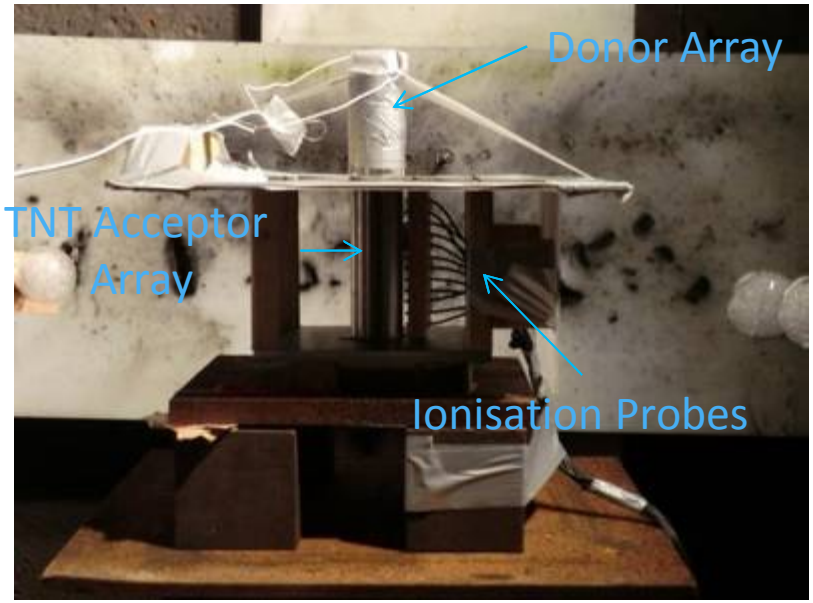
# 4 High Explosive Shock Initiation

## Large Scale Gap Test (LSGT)

- Shock loading of TNT to establish SDT threshold
  - Inform assessment of HE in contact lethal mechanism
- 'Bare' TNT and TNT with additional 15mm steel barrier (to represent threat casing)
  - 15 tests with bare, 15 with steel barrier





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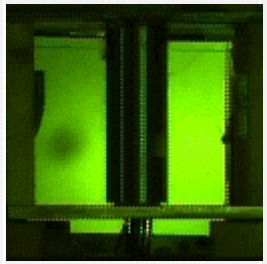
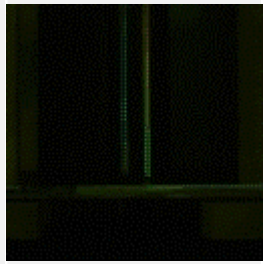
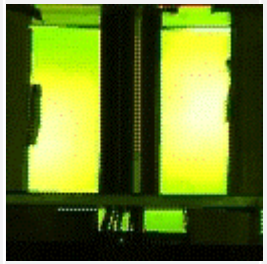
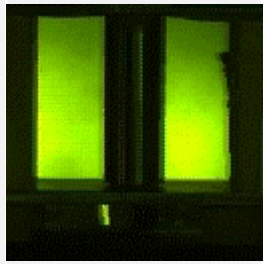
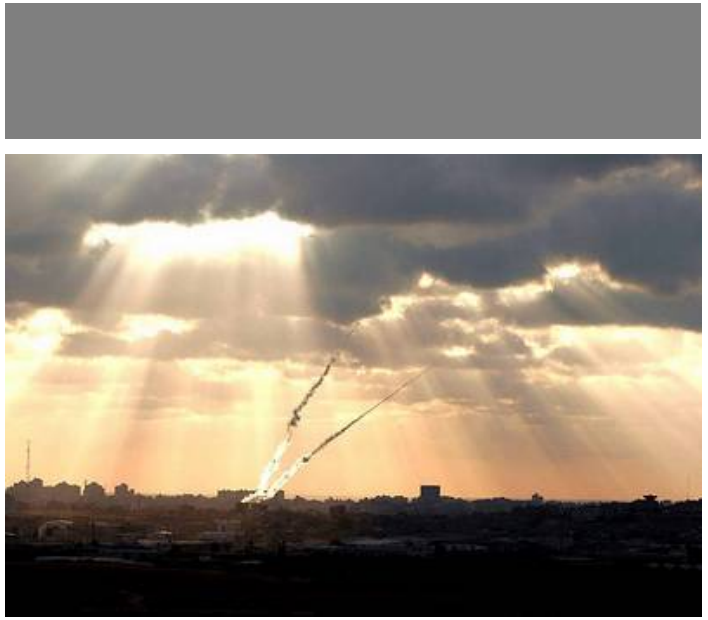
# 4 High Explosive Shock Initiation

Large Scale Gap Tests

- Conventional LSGT
  - No steel in front of acceptor explosive
  - No takeover for PMMA gaps > 39mm
  - Takeover < 39mm
- Modified LSGT
  - 15mm septum covering acceptor explosive
  - No takeover for PMMA gaps > 13mm
  - Takeover < 12mm

| LSGT Response | No Steel Barrier | | Steel Barrier | |
|---|---|---|---|---|
| | Thickness (mm) | HSV | Thickness (mm) | HSV |
| No Takeover | > 39 |  | > 13 |  |
| Takeover | < 39 |  | < 12 |  |

# 5
# Summary & Conclusions



# 5 Summary & Conclusions

- Experimental tests show difficulty in producing prompt SDT using small-scale projectile attack
  - Challenge to design suitably compact lethal effectors
- Less violent response and defeat modes could be exploited
  - HE filling structural integrity loss readily achievable by small-scale EFPs
- Hazard response tools designed to determine SDT outcomes only
  - Other responses (such as XDT or burning) cannot be predicted
  - Valid in regimes with experimental validation – not readily extrapolated
  - Broad range of experimental data required to seed models

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