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The Design and Test of a new Insensitive Munitions (IM) Booster for the UK Paveway IV Weapon System.

NDIA FUZE CONFERENCE MAY 2016

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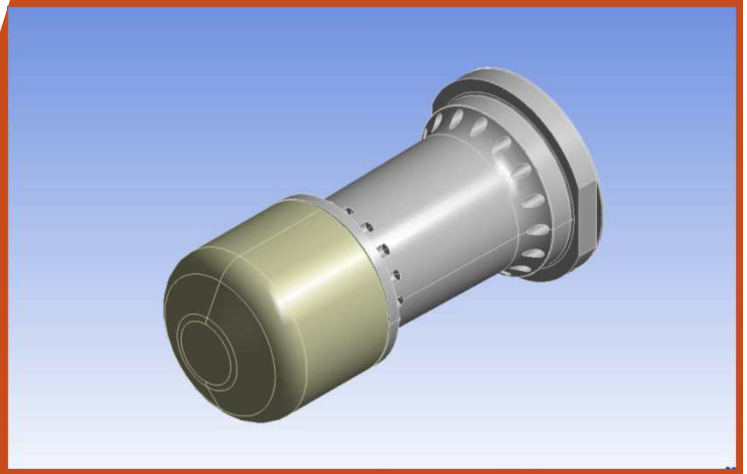
Technical Authority for Ordnance Systems

Missile Electronics

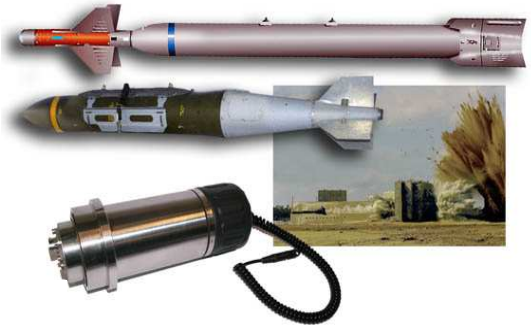
Thales(UK)



Thales Ordnance Systems / SAFU Product Group

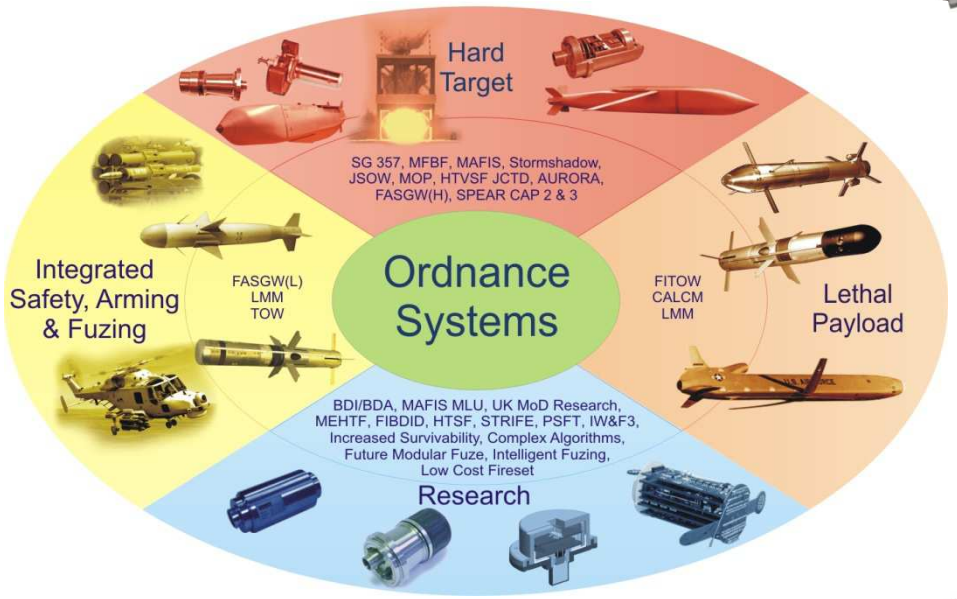
Paveway IV
Aurora

JSOW
FSU-24B



HTVSF FMU-168/B

Export IESAD



MF

MFBF

LMM ISAU

Storm Shadow
MAFIS

Ordnance Fuzing Systems World Leader

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Background

Synopsis

- The Paveway IV weapon system uses the Thales Aurora "In-Line" fuze
- The current Aurora Fuze programme was accelerated to meet an Urgent Operational Requirement (UOR)
- To enable this PBXN-5 material was used for the booster with a simple detonator to booster interface
- This resulted in the current weapon being non-compliant to IM requirements
- A 2* waiver is in-place, which is scheduled to expire in November 2016
- The Programme requirement was to redesign this booster to meet I/M requirements and remove the waiver
- There were additional requirements to improve survivability and service life for this Fuzing system

I/M Status for Paveway IV with PBXN-5 booster

Test	Fast heating	Slow heating	Bullets	Fragments	Shaped Charge	Propagation
Requirement	No worse than Type V	No worse than Type V	No worse than Type V	No worse than Type V	No worse than Type III	No worse than Type III
Outcome	Type I (A)	Type I (A)	Type I (A)	Type I (A)	Type I (A)	Type I (A)

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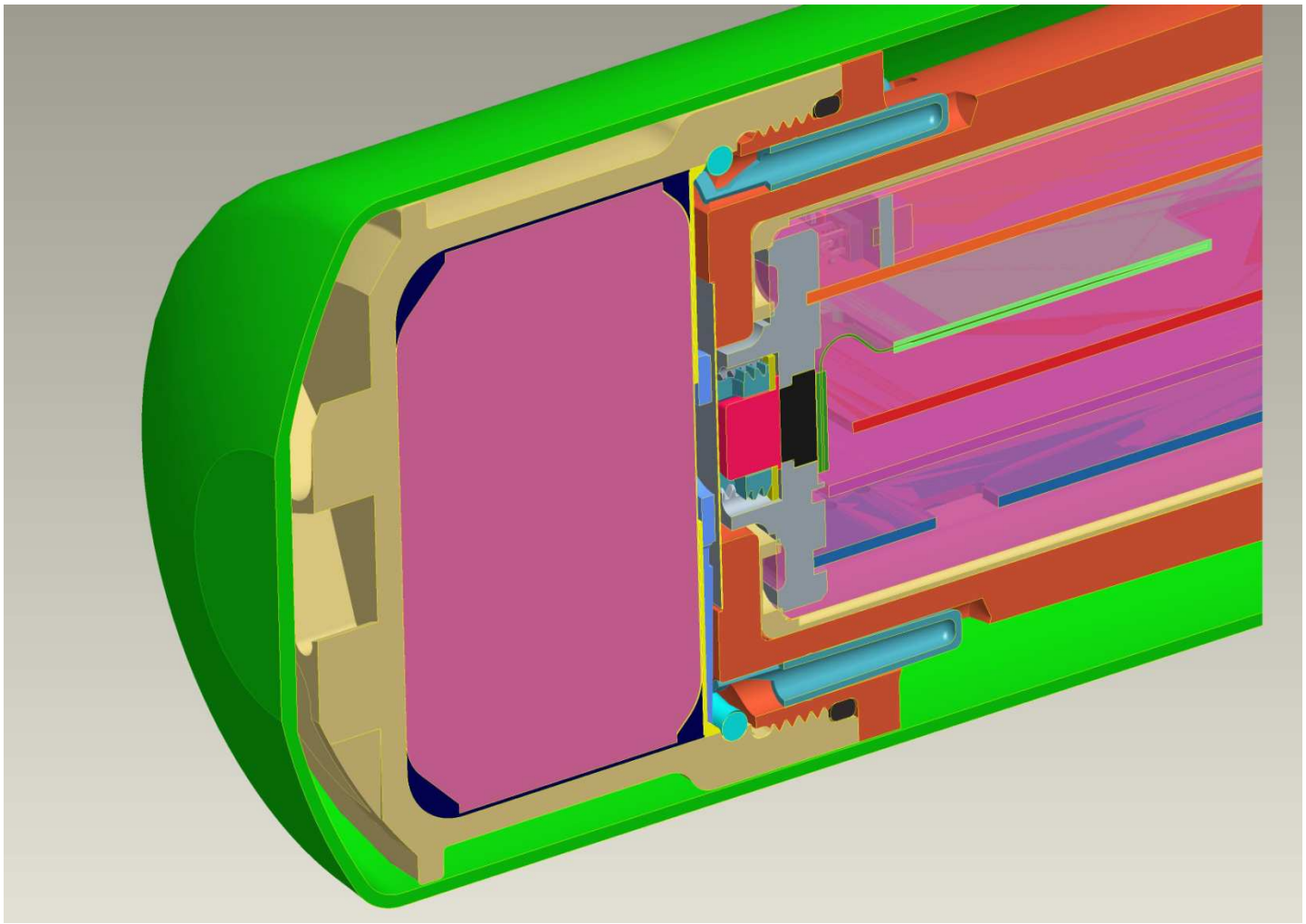
Design

Current Booster Design



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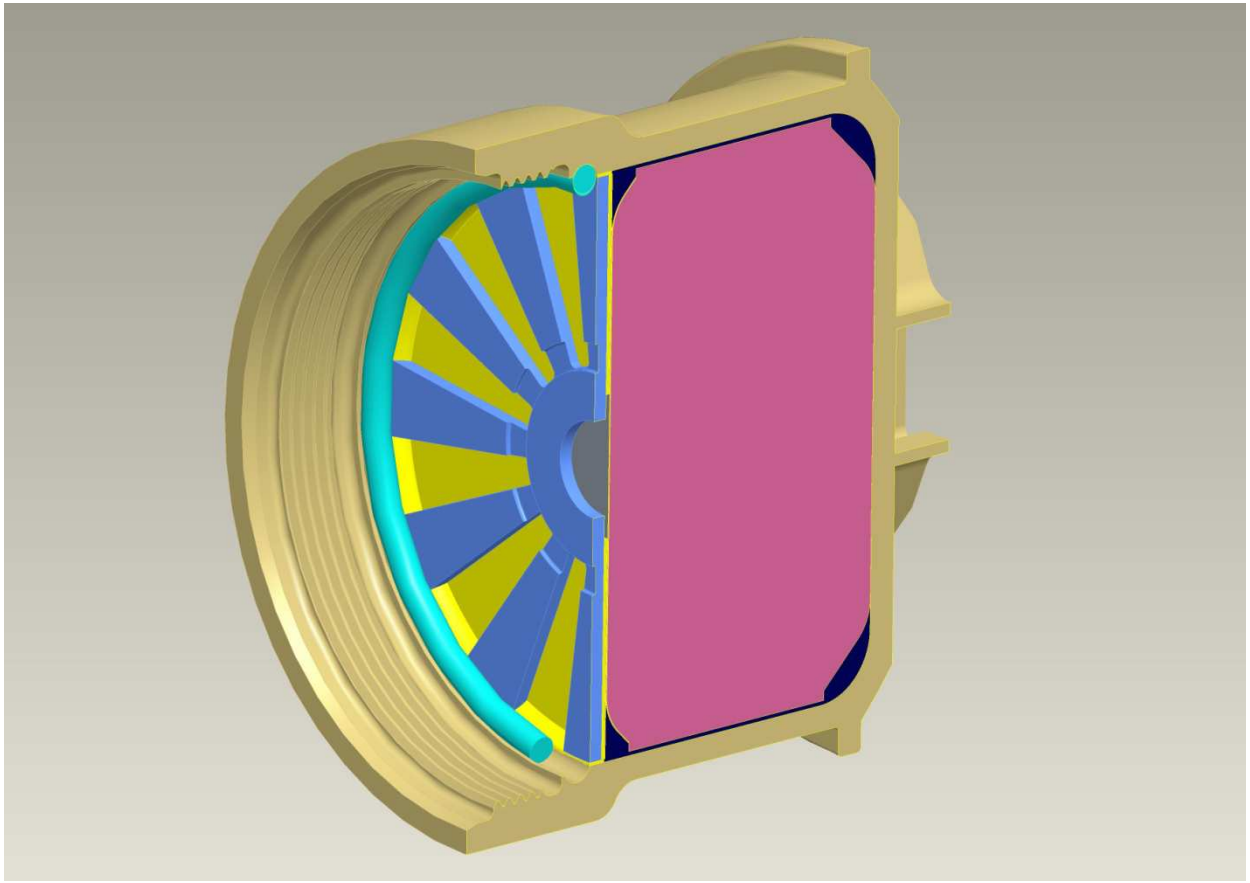
Design

Current Booster Design



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Programme Objectives

Activities for an I/M Booster for the Aurora Fuze

- Define Options for IM compliant Technologies
  - Design Options
  - Available energetic materials
- Requirements for High "g" Survivable solution
  - Variable air gap under high "g" loads
  - Mass reduction to improve survivability
- Extended Life – Fuze & Booster
  - 300 Hours service life
- Qualification activities
  - IM Performance & Safety trials
  - Survivability testing
  - Takeover Reliability
  - Environmental tests
  - Compatibility testing

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Assumptions

Requirements for Material Selection

Qualification & IM Compliance

- Material to be STANAG 4170 qualified for UK by the time of insertion
  - PBXW-11 STANAG 4170 data available
  - Data assessment conducted by DOSG
  - Additional EMTAP trials required

Robustness / Survivability

- Material to withstand Hard Target impact forces

Takeover

- Obtaining material properties has been challenging
  - Material properties of selected W11 material defined by Cranfield
  - Inserted into Thales Hydrocode modelling
  - Modelling indicates a stemming will be required for reliable takeover
- Where shock sensitivity and other material parameters are unavailable, judgements were made based on similarity with known materials

Retrofittability

- No change to Fuze is a key design driver

Trade Study Results – Booster Pellet

Potential Materials (For I/M compliant booster) (In order of scoring)

P16945	Modern NTO Based / Dedicated I/M material Lacking qualification evidence / Shock Sensitivity 2.56GPa
PBXW-11	In UK & US Service / Proven in Hard Target applications as a Booster / Dedicated I/M material / Shock Sensitivity 1.8GPa
Rowanex 3601 (N7)	In UK Service / Commercial availability issues identified Shock sensitivity 2 Gpa / Expensive
DPX-2 (N9)	Dedicated IM material / Limited available data for assessment / Shock sensitivity 2GPa
DPX-1	In UK Service / Dedicated I/M material / Shock sensitivity 3.4GPa / Used as a Main Charge material
Fox-7/binder	Modern material / Dedicated I/M material / Lacking qualification evidence / Shock sensitivity 3.1GPa

PBXN-7 & PBXN-11 were both equal in measured results

- The supply and manufacture of PBXN-7 was restricted
- PBXW-11 was freely available
- Thales had experience of PBXW-11 in similar hard target applications

PBXW-11 recommended

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Trade Study Results - Stemming Materials

Potential Materials (For I/M compliant Stemming)(In order of Scoring)

- PBXW-11
  - UK 4170-Qualified / Proven in Hard Target applications
  - Good I/M characteristics - Existing product = SCO, type V, Drop tests OK, Frag, aging OK
  - Shock Sensitivity 1.8GPa
- HNS-II
  - Used in existing products (MAFIS) / Structural issues under high "g"
  - Good I/M characteristics / Shock sensitivity 1.8GPa
  - Small critical diameter – good for detonator acceptance
- PBXN-5
  - Old material / High sensitive non I/M material
  - Shock sensitivity 1.4GPa

PBXW-11 recommended

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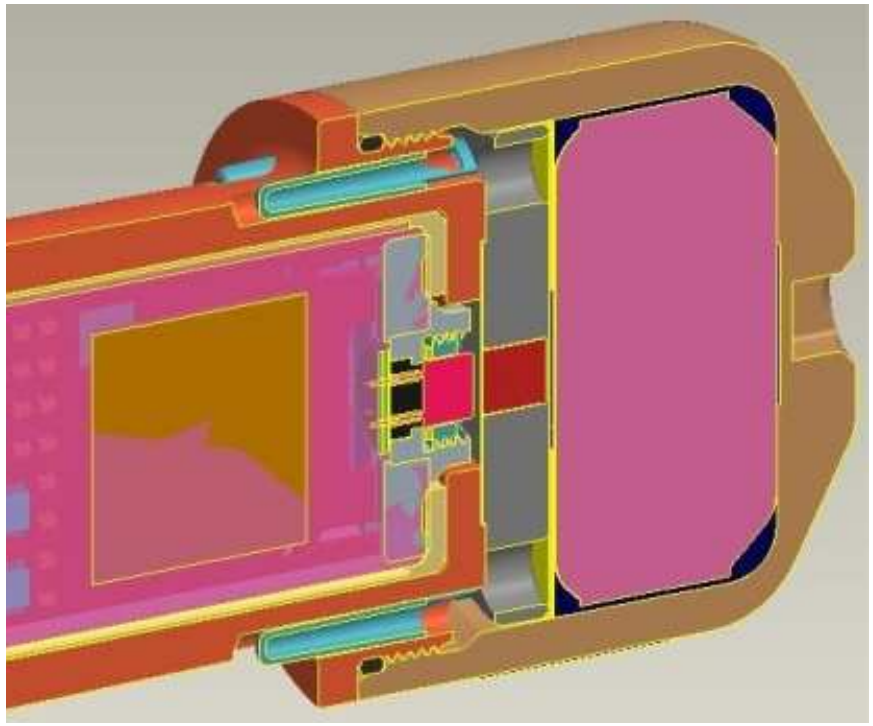
Recommended Solution

Selected Design solution comprising PBXW-11 Stemming Pellet and PBXW-11 Booster Pellet



IM booster assembled to fuze

- **PROS**
- Insensitive Booster Pellet
- IM capable Stemming
- Retrofittable
- Robust – Hard Target Capable
- Lightweight Housing
- **CONS**
- A480 furniture would need to be modified to accept two assembled Fuzing Systems (in a horizontal configuration)
- **Benefits**
- This option requires the Fuze and Booster to be assembled together as a single unit which simplifies handling in service

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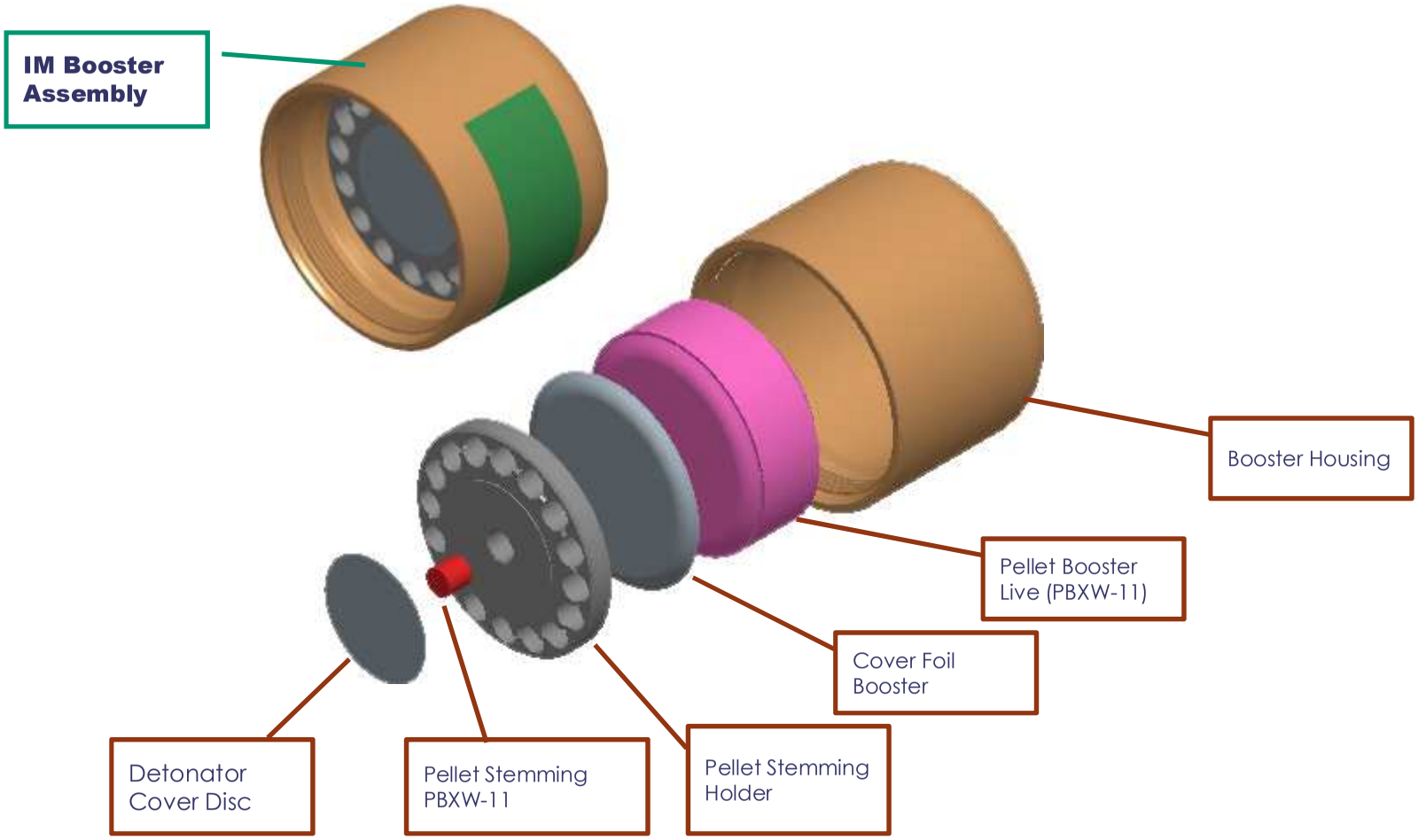
IM Booster Assembly

Principal Components of Booster



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Qualification

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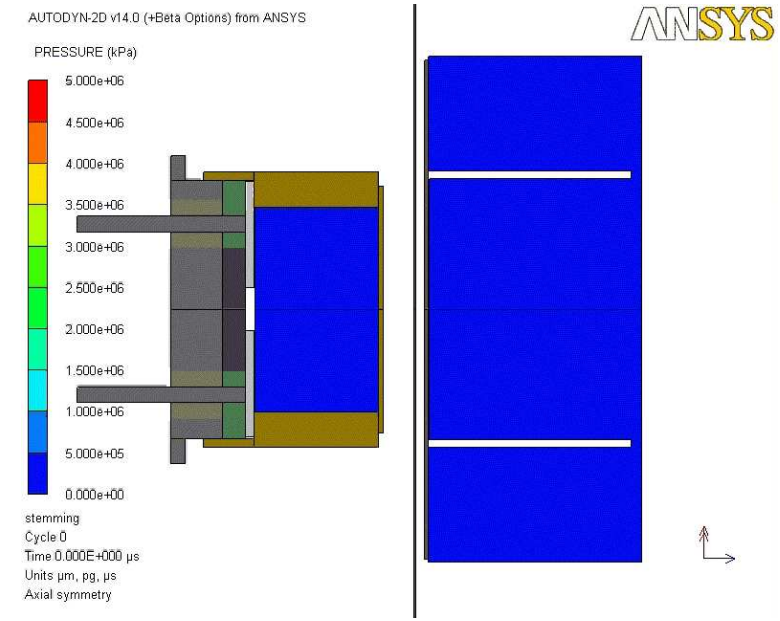
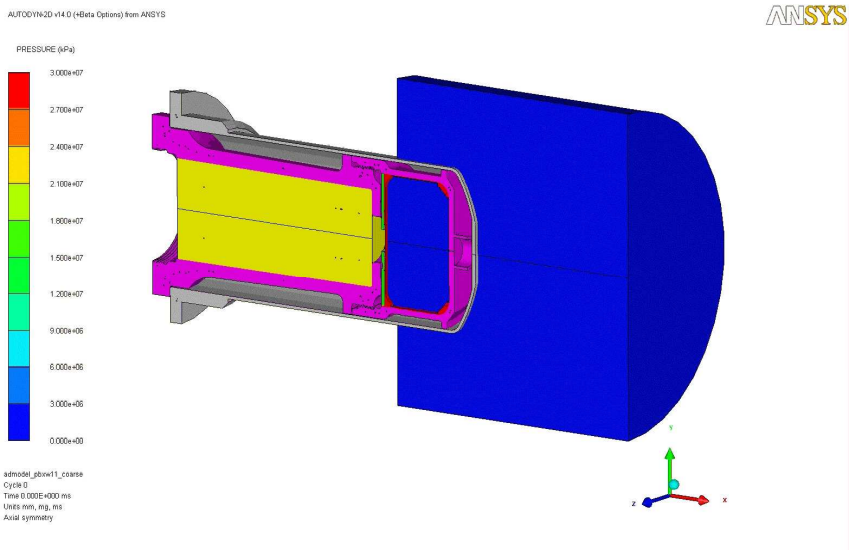
Qualification

Tests & Trials

Takeover Analysis

- Hydrocode modelling conducted
- Allowance for variable air gap
- Motion under shock loads
- 25 Takeover trials completed successfully
- Det to stemming / Stemming to booster
- Maximum air gap at temp extremes





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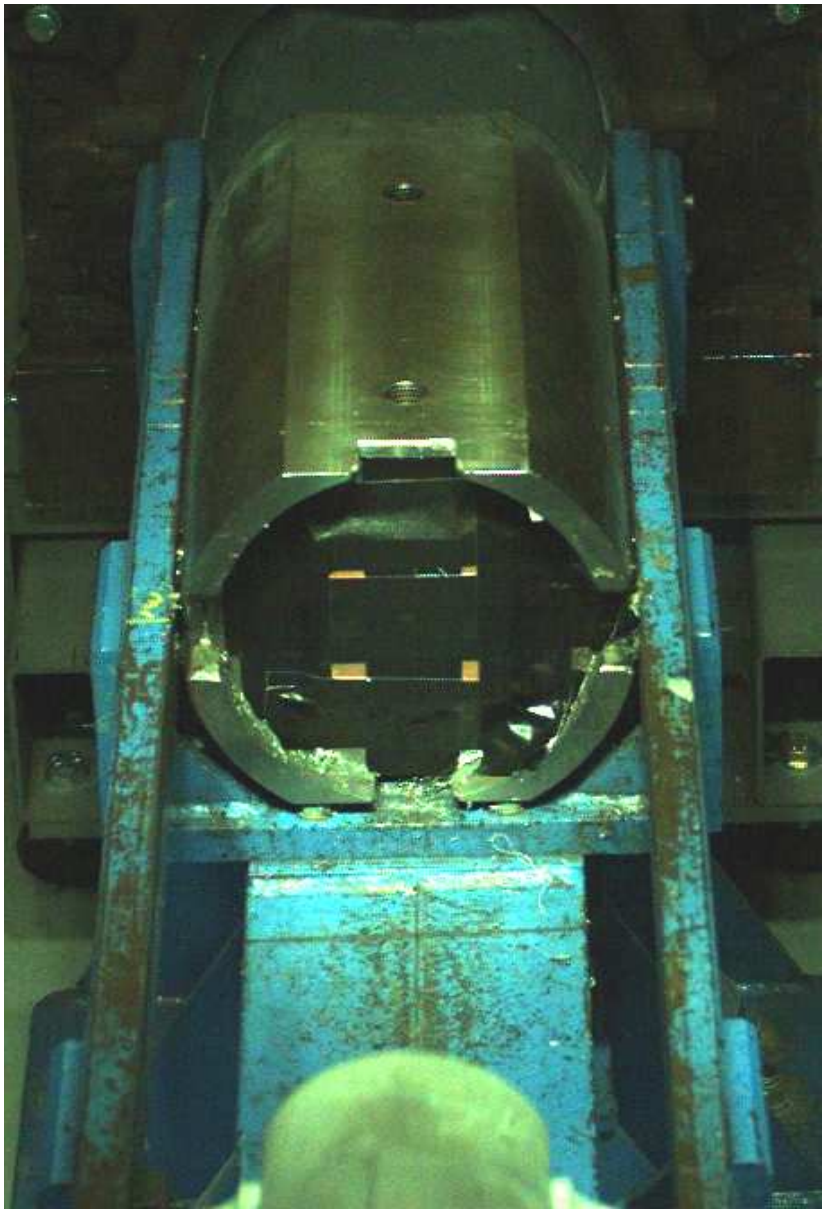
Qualification

Tests & Trials

- High "g" Shock Loads
  - 12 successful Catapult firings
    - Inert boosters
- Environmental Tests
  - To current System TRS and STANAG 4157
  - Trials completed
    - Boosters under assessment
    - Fuze life assessment
  - X Rays at each environmental phase
    - No anomalies found
  - Small scale testing in progress
    - Vac Stab & DSC
    - F of I
    - Rotary Friction
    - Temp of Ignition



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Qualification

Tests & Trials

- Drop Tests
  - 1.5 Metre un-packaged fuze
    - One fuze dropped five times
    - Five different orientations
    - No Reaction
    - Passed STANAG 4157 criteria

- 25m Drop Trial – Def Stan 00-35
  - Palletised Load of 30 x A480s
  - 1 Live makeweight fuze & 1 Live booster
  - Placed in 2 x A480 packages
    - 2 x A480s placed in worst case positions
    - Bottom Tier Corners
  - Remaining positions filled with ballast items
    - Mass & C of G representative
  - Passed – No reaction

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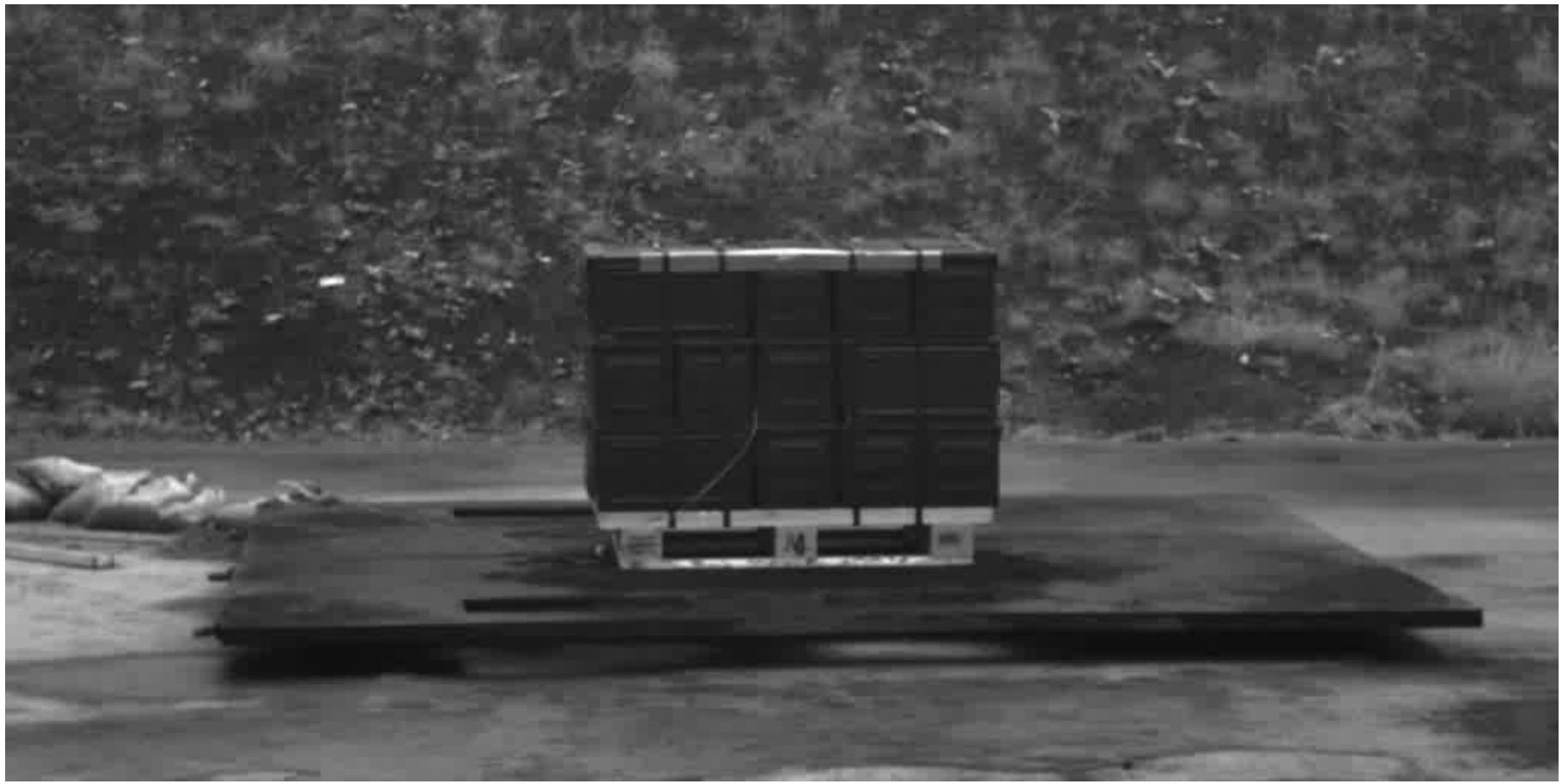
Qualification

Tests & Trials

- Sympathetic Detonation – Packaged Fuze
  - Passed – No reaction



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Qualification

Tests & Trials

- AUR Fast Heating Trial – Un-Packaged Weapon
  - Passed – No reaction – Type V

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Qualification

Tests & Trials

- Compatibility Analysis
- Water Gap test – STANAG 4363
  - Initial test on the current design
    - Significant failure
  - Followed up with new design
    - Passed with a score better than 28 threshold
- Safety Tests
  - Additional EMTAP Characterisation tests – UK DOSG Sub-Scale Safety Tests
    - 22A Large scale gap test
    - 35 internal ignition test
    - 41 Fast Heating test
    - 42 Electrical Heating
  - Full suite of I/M Trials on Packaged fuze

Packaged Fuze with new W11 Booster - IM Status						
Test	**Fast heating**	**Slow heating**	**Bullets**	**Fragments**	**Shaped Charge**	**Sympathetic Reaction**
Requirement	No worse than Type V	No worse than Type V	No worse than Type V	No worse than Type V	No worse than Type III	No worse than Type III
Outcome	Type V	Type IV	Type V	Type III	Type 1	Type IV

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Final Paveway IV I/M Assessment

Paveway IV with current Aurora fuze - IM Status						
Test	**Fast heating**	**Slow heating**	**Bullets**	**Fragments**	**Shaped Charge**	**Sympathetic Reaction**
Requirement	No worse than Type V	No worse than Type V	No worse than Type V	No worse than Type V	No worse than Type III	No worse than Type III
Outcome	Type I (A)	Type I (A)	Type I (A)	Type I (A)	Type I (A)	Type I (A)

Paveway IV with New W11 Booster - IM Status						
Test	**Fast heating**	**Slow heating**	**Bullets**	**Fragments**	**Shaped Charge**	**Sympathetic Reaction**
Requirement	No worse than Type V	No worse than Type V	No worse than Type V	No worse than Type V	No worse than Type III	No worse than Type III
Outcome	Type V	Type IV (A)	Type V (A)	Type V (A)	Type 1 (A)	Type 1 (A)

- The Aurora Fuze is still not fully compliant with the full I/M requirements of STANAG 4439
- The I/M response is a significant improvement over the previous system
- This system is ALARP for a munition of this nature with available technology
  - As Low As Reasonably Possible
- 300 Hours service life proven
- Improved Hard Target Capability Proven

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