



Ministry
of Defence



The Brimstone 2 Missile: IM technology insertion and the benefits for UK MOD

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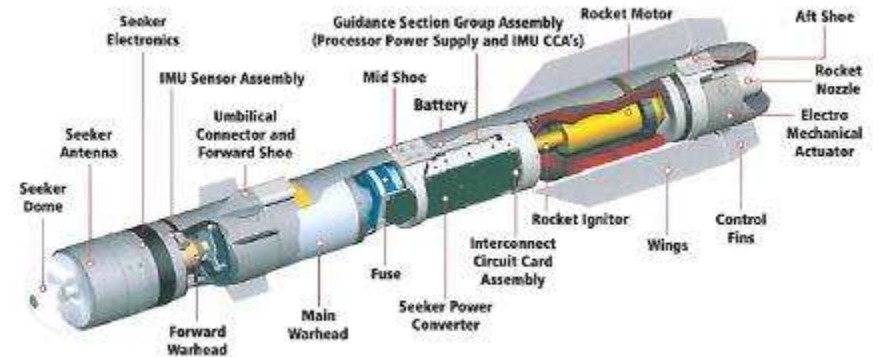
IMEMTS Rome May 2015

Summary

- Legacy Brimstone – Where we started
- Brimstone 2 Overview
- Small scale testing
- Full scale system & component testing
- Summary of results
- Questions

Legacy Brimstone

- Legacy Brimstone – What is it?
 - Fixed wing
 - Air to Ground
 - Anti-Armour
 - Low Collateral
- Legacy Brimstone IM characteristics
 - Pre dates current UK IM Policy
 - Rocket Motor:
 - Cast Double Base – Poor mechanical properties
 - Nitramine loaded – Required for performance
 - Warhead
 - LX-14, HMX 95.5% Estane 4.5%



Small Scale Testing – LX14

EMTAP 35 TEST RESULTS: Composition LX-14						
Firing ID	HE Density (g/cc)	Recovered Fragments			%HE Recovered	Degree of reaction
		Total	Body	%wt		
ES140522A-219	1.76±0.003	>100	>100	100	0	4
ES140522A-225	1.76±0.003	>100	>100	100	0	4
ES140522A-226	1.76±0.003	>180	>180	100	0	4
ES140522A-222	1.76±0.003	>200	>200	100	0	4
ES140522A-220	1.76±0.003	>200	>200	100	0	4
ES140522A-192	1.76±0.003	>180	>180	100	0	4
ES140522A-223	1.76±0.003	>130	>130	100	0	4
ES140522A-227	1.76±0.003	>170	>170	100	0	4
ES140522A-221	1.76±0.003	>170	>170	100	0	4
ES140522A-224	1.76±0.003	>170	>170	100	0	4



EMTAP 41 TEST RESULTS: Composition LX-14							
Firing ID	HE Density (g/cc)	Recovered Fragments			%HE Recovered	Degree of reaction	Time to Event(s)
		Total	Body	%wt			
ES140522B-690	1.76±0.01	41	39	99	0	3	232
ES140522B-691	1.76±0.01	155	153	100	0	4	210
ES140522B-692	1.76±0.01	36	34	97	0	3	276
ES140522B-693	1.76±0.01	34	32	100	0	3	241
ES140522B-694	1.76±0.01	90	88	99	0	3	219
ES140522B-695	1.76±0.01	>142	>110	97	0	4	233
ES140522B-685	1.76±0.01	127	124	100	0	4	257
ES140522B-683	1.76±0.01	78	76	100	2	3	212
ES140522B-686	1.76±0.01	75	73	100	6	3	248
ES140522B-682	1.76±0.01	58	56	99	0	3	237

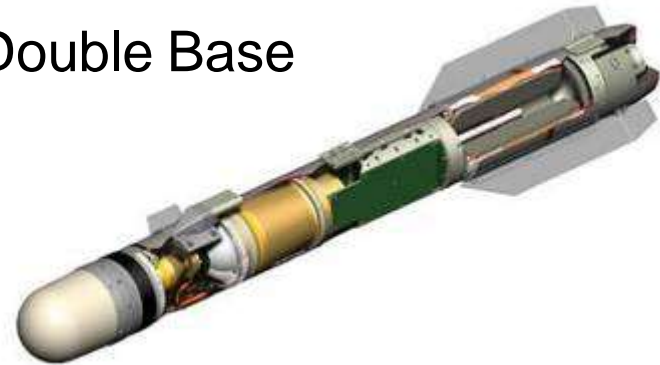


EMTAP 42 TEST RESULTS: Composition LX-14						
Firing ID	HE Density (g/cc)	Recovered Fragments			%HE Recovered	Degree of reaction
		Total	Body	%wt		
ES140523C-708	1.76±0.01	129	127	98	0	4
ES140523C-705	1.76±0.01	142	140	98	17	4
ES140523C-706	1.76±0.01	123	109	93	0	4
ES140523C-707	1.77±0.01	>153	>130	95	0	4
ES140523C-703	1.77±0.01	>182	>150	98	0	4



Brimstone 2 Overview

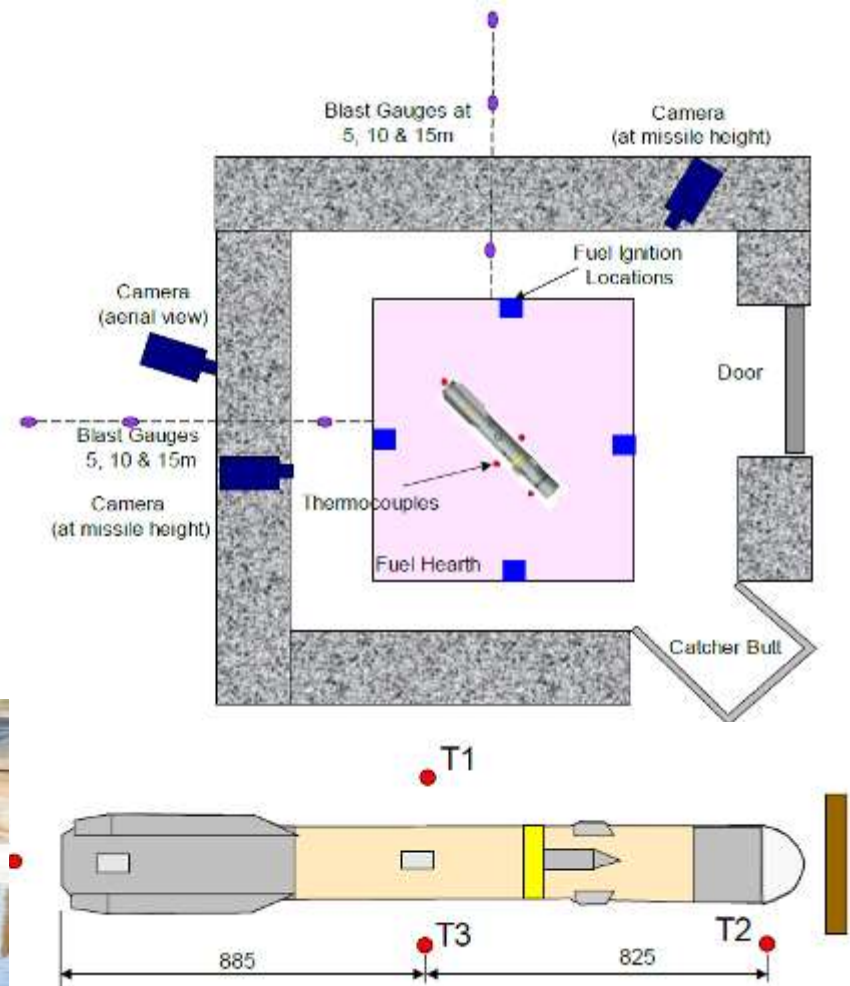
- Tandem Warhead
 - Precursor Charge (Includes shape charge) – KS33
 - Main Charge (Includes shape charge) – KS33
- Rocket Motor – Vulcan
- KS33: PBX with a HMX filler
- Vulcan: Elastomer Modified Cast Double Base
 - Both low explosiveness



Full Scale – Fast Heating (1)

Trial Setup:

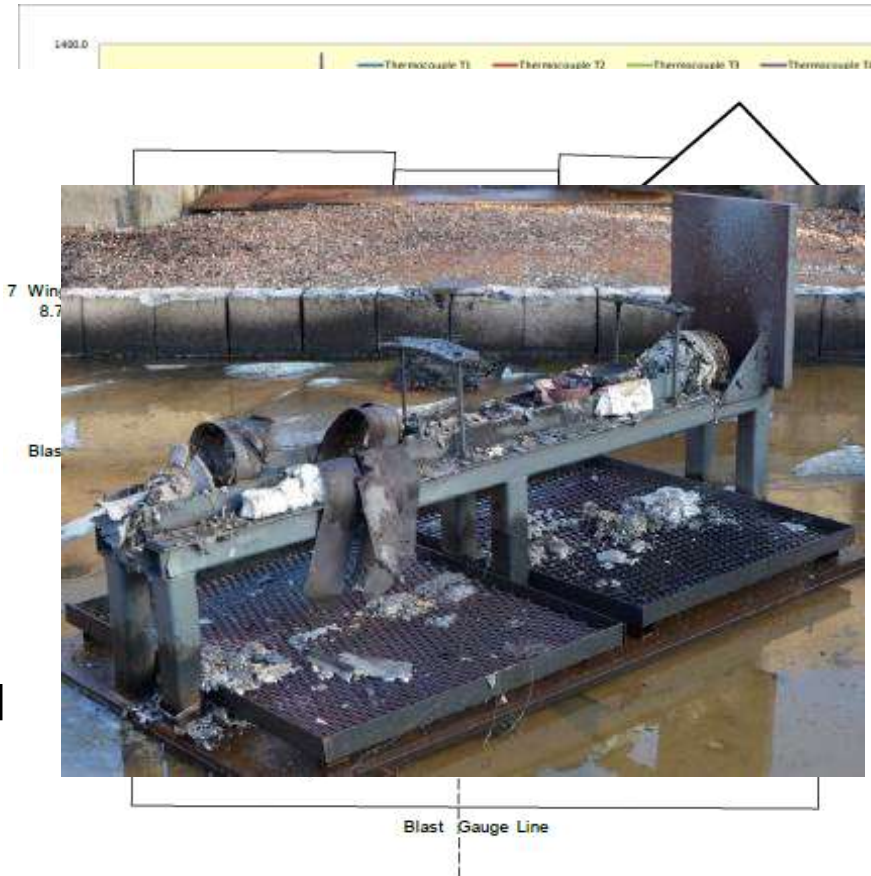
- Unpackaged
- All energetics included
- 4 Thermocouples located along the length of the system
- Catcher butt located on axis with the system



Full Scale – Fast Heating (2)

Results

- Thermal
 - Test compliant.
 - Some measurable input from system
- Fragmentation
 - Minimal. Contained within 9 metres
- Propulsion
 - No evidence of an propulsive event
- Over Pressure
 - No significant over pressure recorded
- [Video](#)
- Response:
 - Evaluated as a type V burning



Full Scale – Slow Heating (1)

Trial Setup:

- Packaged
- All energetics included
- 16 thermocouples located along the length of the system
- Additional witness plate in front of system

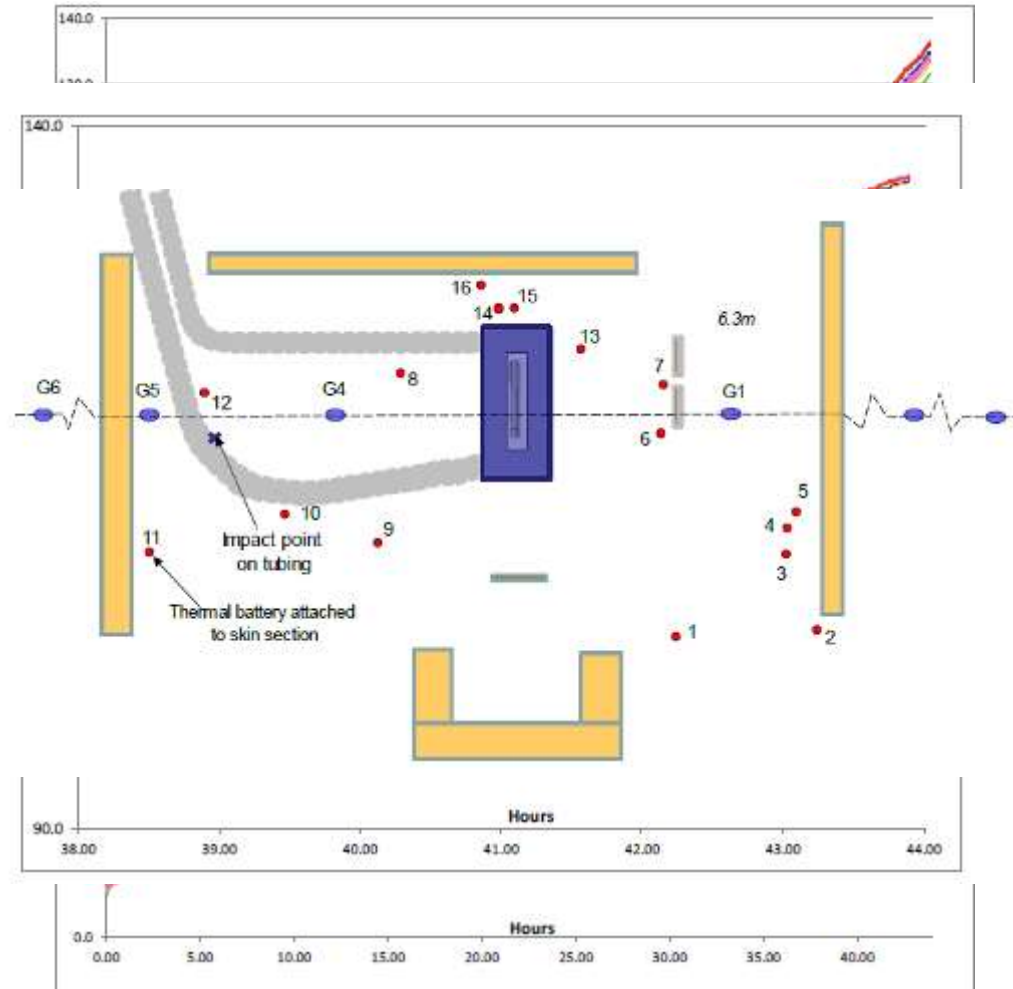


Full Scale – Slow Heating (2)

Results:

- 39 hours – Ramp in temperature recorded near Rocket Motor
- 42 hours – Ramp in temperature recorded near Thermal Battery
- 44 hours – Event
 - Over pressure 2.4 kPa at 5m
 - No damage to witness plate
 - Warhead burnt post event
 - Large amounts of RM recovered
- Response:
 - Evaluated as a type IV deflagration

Note: Component level results demonstrated a Type III response.



Full Scale – Sympathetic Reaction (1)

Trial Setup:

- 1 x Donor (Red)
- 2 x Live Acceptor (Blue + White)
- 1 x Inert Acceptor (Green)
- Donor RM initiated with SCJ
 - 45° from horizontal
 - 45° from vertical
- All systems facing same direction



Full Scale – Sympathetic Reaction (2)

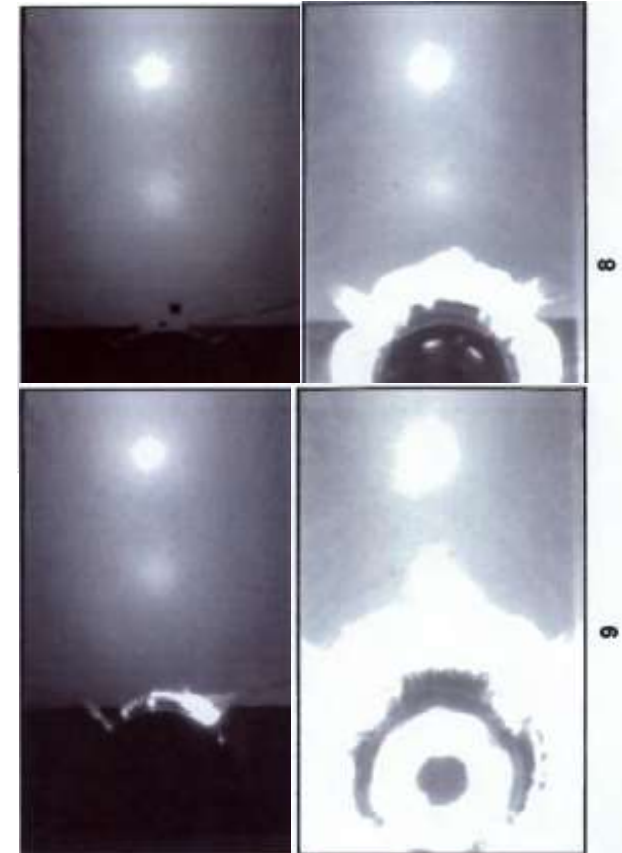
Results

- Donor RM detonated as intended
- All warheads recovered.
- Large amounts of Rocket Motor recovered.
 - Some post event burning occurred.
- Over pressure readings indicate that the acceptor Rocket Motors did not contribute to the event
- [Video 1](#)
- [Video 2](#)
- Response:
 - Evaluated as a Type V burning event



Component level – Fragment Impact 2560 m/s

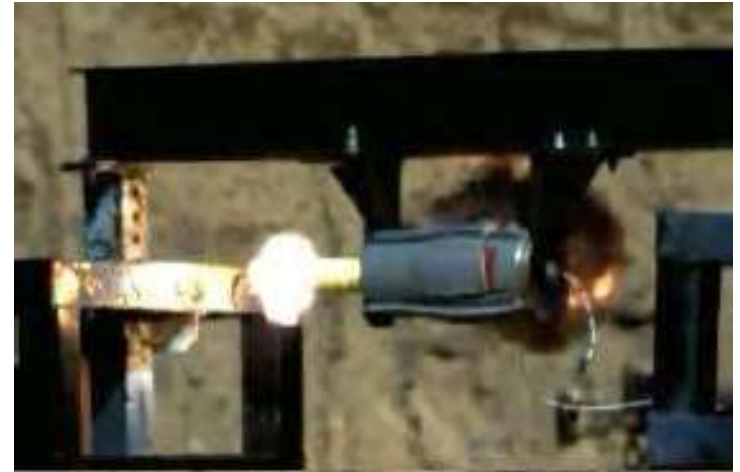
- Warheads:
 - SDT threshold found between 1950 m/s and 2250 m/s.
 - Deemed likely to detonate from fragment impact
- Rocket Motor:
 - Testing conducted in representative body
 - Detonation occurred.
 - Inconclusive if SDT or XDT



Component level – Fragment Impact 1830 m/s (1)

Warheads:

- Multiple firings conducted to confirm SDT threshold
- Warhead Type V
 - Rocket Motor Type IV
 - Between 1950 m/s and 2250 m/s.
- 1830 m/s confirmation firings conducted against both warheads.
- **System response evaluated to be a Type IV response**
- Evaluated as a Type V Mild burning response recorded.



Rocket Motor

- Rocket Motors in representative bodies
 - Debris projected, including unburnt propellant
 - Mild burning event recorded. Calculated to be below requirement for propulsive
- Evaluated as a Type IV deflagration response



Component level – Bullet Impact

Warheads

- Assessed based on fragment impact data and small scale data.
- Threat below SDT threshold
- Low explosiveness (small scale testing) removes DDT threat
- Evaluated as Type V



Rocket Motor

- Rocket Motors in representative bodies
 - Negligible debris projection
 - 25 second mild burning event recorded. Calculated to be below requirement for propulsive
- Evaluated as a Type V burning response

System

- Warhead Type V
- Rocket Motor Type V
- **System response evaluated to be a Type V burning response**

Summary of Results

Munition	Configuration	FH	SH	BI	FI 2560	FI 1830	SR	SCJ
Brimstone 2 Missile	Un-packaged	V	III(A)	V(A)	I	IV		I
Brimstone 2 Missile	Packaged	V(A)	III(A)	V(A)	I(A)	IV(A)	V	I(A)

Impact

- State of the art IM characteristics
- Cost savings:
 - Manufacture
 - Storage
 - Transport
- Improved flexibility for operational usage.
- Additional applications under investigation:
 - Rotary wing
 - UAS
 - Naval environment.

Acknowledgments

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