THALES NDIA Briefing

Hard Target Reliability for MAFIS
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Company Background in Fuzing & Shock Hardening

1918 - Shell Fuzing
1940s - Airborne Radar, Shell Fuzing, Proximity Fuzing (Rockets) Bomb Fuze for “Bouncing Bomb” etc.
1950s - Naval Proximity Shell Fuzing
1960s - No.907 RF Proximity Fuze for Bombs.
1970s - No.952 RF Proximity Fuze for Bombs. Multi Role Shell Fuze (MRF)
1980s - SG357 Runway Cratering Weapon MFBF (No.960) Multi-Function Bomb Fuze
1990s - Intelligent Hard Target Fuzing Research
2000s - Intelligent Hard Target Fuzing Production and Research, MAFIS, HTSF & AURORA.

Pioneer in hardened fuze electronics
TME Fuzing Family Tree

- MFBF
- MAFIS
- STRIFE
- MEHTF
- HTSF
- FIBDID
- PSFT
- AURORA
- HARDBUT
- JSOW
- Storm Shadow

IF research since 1995

Thales Missle Electronics

THALES MISSILE ELECTRONICS LIMITED
TME Hard Target Fuzing

- MFBF
- AURORA for PGB (Paveway IV)
- MEHTF & PSFT
- MAFIS for Storm Shadow & JSOW
MAFIS (Multi Application Fuze Initiation System)

Modular 3” fuze
- Shock hardened core electronics
- Application specific interface module

High shock survivable for MWS
Out-of-Line arming system

Missile fuze (including reliability requirements)
Initially developed for Storm Shadow with BROACH warhead
Modularity permits ready adaptation to other applications

In full production for:
- Raytheon AGM-154C (JSOW)
- MBDA Storm Shadow
MAFIS (FSU-26/B) in JSOW (AGM-154C)
Reliability in High “g” Domain

- Hard Target Fuzing
- Severe Environment for survivable electro-mechanics
- Multiple shock effects
  - High “g” levels
  - Multiple Impulses
  - Weapon Attack Angles & Angle of attack
    - Fuze x 3 Axis – Longitudinal and Lateral
  - Frequency range
    - Excitation levels within fuze
  - All over Temperature Extremes
- Real impact data difficult to collect
- Even more difficult to replicate for test
TME Shock Test Methodology

- Trials or modelling
- Hydrocode CFD modelling

PC/AC shock time signature
Target impact time signature

Candidate equivalent shock time signature

Composite shock time signature

Spectral analysis
Compare

Hydrocode CFD modelling
Compare

Physical trial
Compare

Similar SRS?
Similar strain levels?
Similar damage?
## Trials / Evaluation Approach

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<th>Computational Fluid Dynamics Simulation</th>
<th>Sled Trials</th>
<th>Catapult Trials</th>
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<td><strong>Advantages</strong></td>
<td>• Inexpensive</td>
<td>• All up round physical test</td>
<td>• Inexpensive</td>
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<td>• Repeatable</td>
<td>• Closely replicate the tactical environment</td>
<td>• Repeatable</td>
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<td>• Rapid</td>
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<td>• Adjustable shock environment</td>
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<td></td>
<td>• Temperature Extremes</td>
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<td><strong>Disadvantages</strong></td>
<td>• Difficult to Validate</td>
<td>• Expensive</td>
<td>• Requires Validation</td>
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<td>• Easy to misinterpret the results</td>
<td>• Non-Repeatable</td>
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<td>• Infrequent</td>
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<td>• Ambient Temp</td>
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Basis for SRS Analysis and Test

Shock Response Spectrum

- Applicable for material transient responses with complicated waveforms
- Enables the tailoring of shock excitations from actual data for the operational environment
- Proven technique for shock simulation testing of complex waveforms
- Identified in UK (DEF STAN 00-35) and US standards (MIL-STD-810)
- Purpose of test to demonstrate the adequacy of material to resist degradation of functional / structural performance
Typical Sled Trial Signatures

Time History - Typical Sled Trial - X axis

Time History - Typical Sled Trial - Z axis

SRS - Sled Trial

Q = 10
\( f_0 = 20 \text{ Hz} \)
\( sr = 200 \text{ kHz} \)
Typical CFD Simulations

CFD Model construction can affect simulation

Time History - Simulation 3.29, x axis

Time History - Simulation 3.29, z axis

SRS MAXI-MAX - SIMULATION 3.29 X and Z axes

Q = 10
f_0 = 20 Hz
sr = 200 kHz

Thales Missile Electronics
Typical Catapult Trials Data

**Time History - Catapult, Longitudinal, 80k g (nominal)**

![Graph showing time history data](image)

**SRS MAXI-MAX - Catapult, Longitudinal, 80 k g**

Q = 10  
\( f_{n} = 20 \text{ Hz} \)  
\( sr = 200 \text{ kHz} \)

![Graph showing SRS MAXI-MAX data](image)
Sled / CFD / Catapult Comparison

SRS MAXI-MAX - Composite Sled, Simulation & Catapult

$Q = 10$
$\omega_n = 20 \text{ Hz}$
$sr = 200 \text{ kHz}$

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**Graph Details:**
- **Y-axis:** Peak Acceleration (g)
- **X-axis:** Frequency (Hz)
- Lines represent:
  - Simulation - X
  - Simulation - Z
  - Sled - X
  - Sled - Z
  - Catapult - Longitudinal

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**Legend:**
- Simulation - X
- Simulation - Z
- Sled - X
- Sled - Z
- Catapult - Longitudinal
Achieving comparable damage

Sled Trial Damage

Catapult Test Damage
Achieving comparable damage

Sled Trial Damage

Catapult Test Damage
Achieving comparable damage

Damage to silicon component die

Sled Trial Damage

Catapult Test Damage
Catapult & Shock / Counter Shock Test Facilities

- Selected for capability to generate comparable SRS levels
- Creates ‘equivalent damage’
- Quick testing turnaround
- Multiple Test configurations
- Longitudinal
  - Predominately axial shock application – Multiple impacts
  - Variable shock parameters – “g” x Duration
  - Selectable Fuze roll orientation
  - Temperature extremes
- Lateral
  - As above plus simultaneous lateral and axial shock application – Multiple impacts
Testing for Survival and Function – Catapult

Test vehicle:
- Mass: 22 kg max
- Velocity: 50 m/s max
- Shock: 100,000 g

![Test vehicle image]

Duration

Shock Level

100,000 g 50 us
41,000 g 120 us
16,000 g 300 us

Typical shock signature
Testing for Survival and Function - Guns

 Shock counter shock (SCS) facility
 - High speed impacts
 - Multiple shocks
   - (typically +50kg for 700µs, -20kg for 600 µs)
 - High off-axis angles (Sub Modules)

Shock-Counter-Shock High Impact gun tests

Off axis test vehicle
Conclusions

• MAFIS Hard Target Fuze
  • Successfully tested in excess of 50 K”g”
    • Multiple effects, 3 Axis, temperature extremes etc.
    • High reliability – Missile levels
  • In full scale production
  • In service with RAF and USN
    • Storm Shadow & JSOW
  • Growth path
    • Void & Layer insertion
    • BDI/BDA
    • In-Line Technology
    • Supersonic Applications

MAFIS Proven Hard Target Fuze