Technology Work Session for the South African Army; Hosted by the CSIR

Firepower

New Developments in Firepower

Dr Frikkie Mostert
CSIR Defence, Peace, Safety and Security

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Outline of presentation

- Changes dictating new developments in the firepower field
- New developments:
  - Energetic materials
  - Propulsion
  - New warhead developments
  - Ballistic Non-lethal weapons
- Conclusion

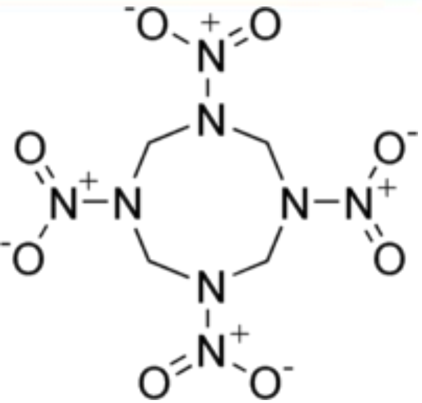
Changes dictating developments in firepower

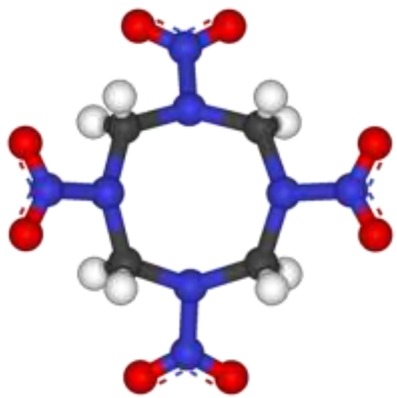
http://www.fotosearch.com/photos-images/military-tanks.html

http://www.dodbuzz.com/2008/12/12/900-ied-attacks-a-month-in-iraq-and-afghanistan-metz

- Shift from the cold war era
- Balancing conventional firepower with firepower needs for OOTW
- Common factors :
  - Rapid threat recognition and target acquisition
  - High accuracy
  - Terminal effectiveness
- Deviating factors
  - Standoff
  - Low collateral damage
  - Omni-directional engagement
  - Tunable terminal effect
  - Engagement rules

Energetic Materials





- Incremental developments during the 20th century :
  - TNT, RDX & HMX based
  - Castable & pressed PBX mixtures
  - IM formulations
- Enhancement of output with additives that reacts with atmospheric oxygen
- Emerging scientific understanding enables synthesis of new formulations
  - Nitrogen compounds (N_5)
  - Compounds with no carbon
  - High density functional groups
  - Metallic hydrogen

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Energetic Materials

Compound	Density (g/cc)	Detonation Velocity (km/s)	Detonation Pressure (GPa)	Relative Energy* (HMX=100)	Specific Impulse** (seconds)
HMX	1.89	9.3	39.3	100	266
CL-20	2.04	10.0	47.8	119	273
Boron Nitride/HNO_3	2.20	18.0	64	88	--
TTTO	2.62	10.8	133	265	288
N_{60}	1.97	12.3	65	161	331
$N_5^+N_5^-$	1.93-2.07	12.7	69	160	313
N_4 (T_d, Tetrahedral)	2.4	15.5	122	310	424
N_8	2.7	19	206	498	--
Poly-N	3.9	30	660	1058	516
Metallic Hydrogen	0.8	--	--	~3000	~1700

* Expansion energy at $V/V_o=2$

** Relevant to for gun and rocket propulsion

THE FUTURE OF WARHEADS, ARMOUR AND BALLISTICS

Bo Janzon[1], Joseph Backofen, Jr.[2], Ronald E. Brown[3], Roxan Cayzac[4], André Diederen[5], Marc Giraud[6], Manfred Held[7], Albert W. Horst[8], Klaus Thoma[9]

23rd International Symposium on Ballistics, Tarragona, Spain, 2007

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Energetic Materials – enhanced blast explosives

RDM CSIR collaboration

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* Expansion energy at $V/V_0=2$
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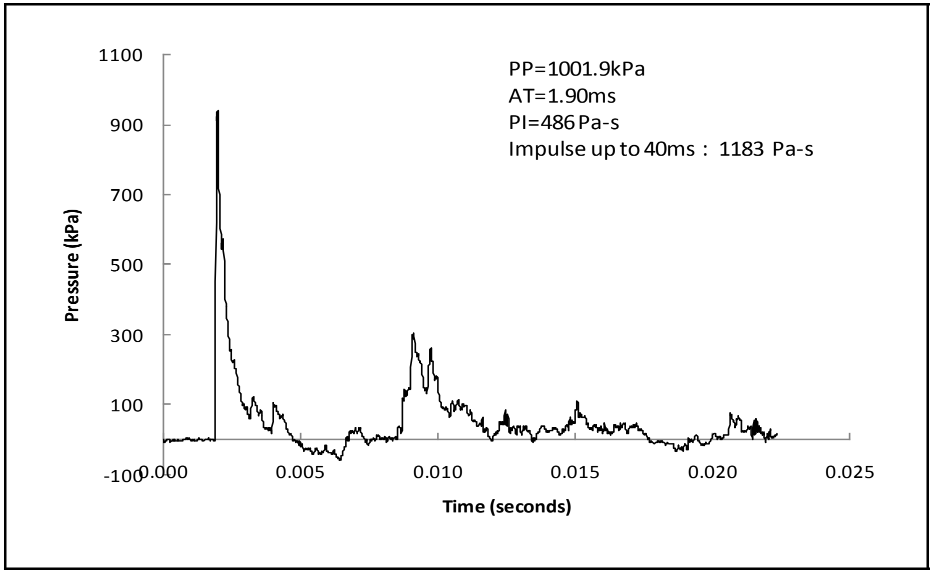
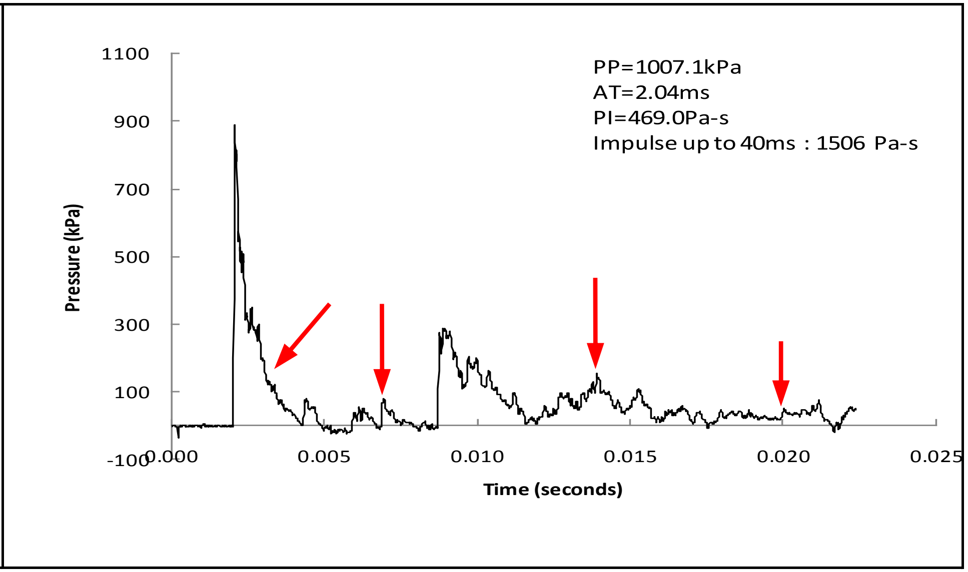
Energetic Materials – enhanced blast explosives

HMX Charge – 2kg HE no additives



RDX with 20% Al – 1.6kg HE with 400g Al



RDM CSIR collaboration

Propulsion


Credit : Somchem (RDM)


http://en.wikipedia.org/wiki/Electromagnetic_gun

- Rocket propulsion
  - Use new energetic materials for higher yield
  - Less sensitive formulations for higher survivability
- New propulsion systems
  - Ramjet, Scramjet, SOFRAM
  - Pulse detonation engine
  - Liquid propellants
  - Electromagnetic railgun
  - Electro-thermal-chemical propulsion
- Other Improvements :
  - Exterior ballistic enhancement
  - Lower signature
  - Ignition technology

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Propulsion

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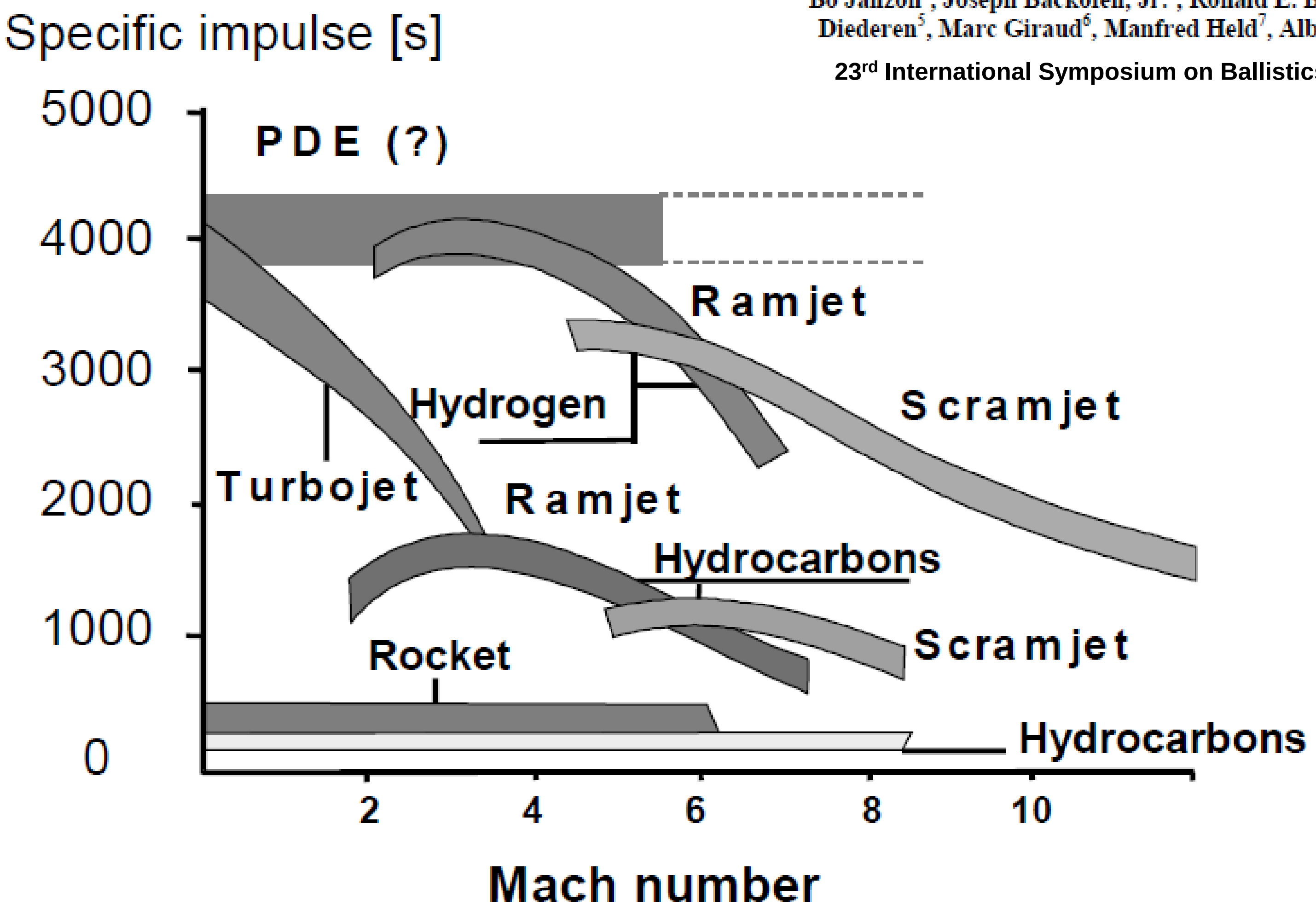

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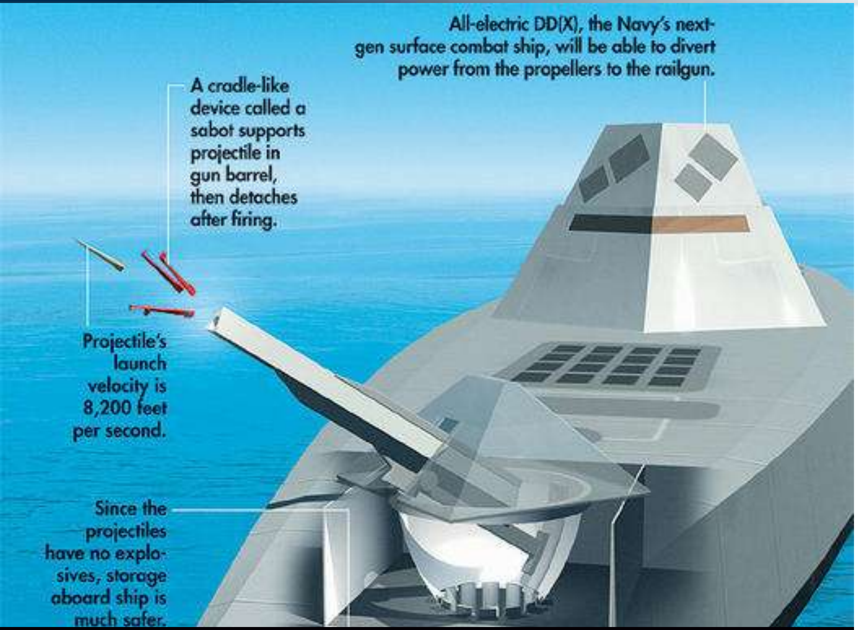
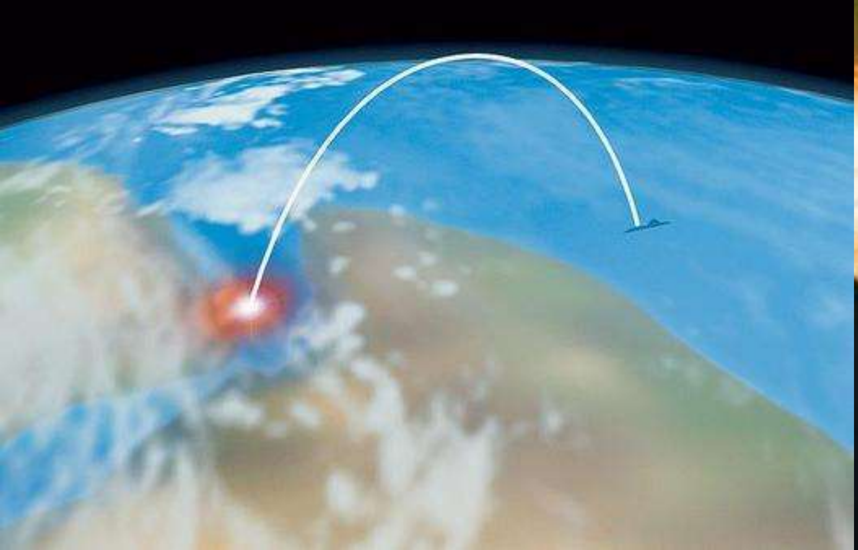
Propulsion – the future



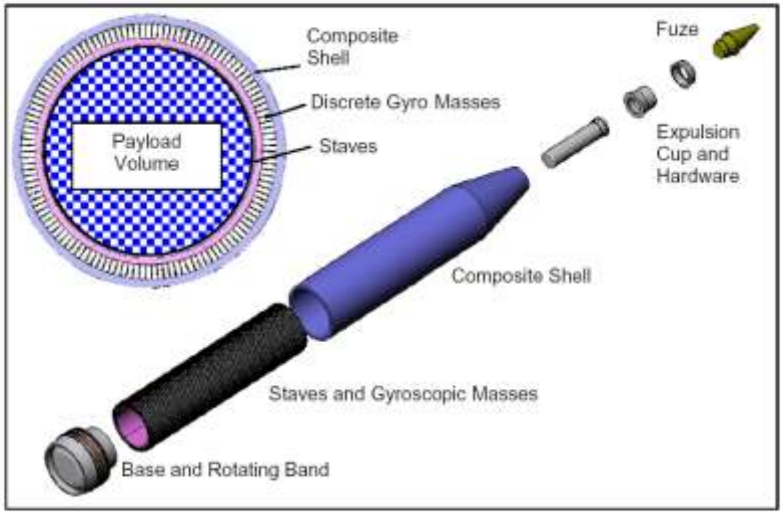
http://www.popsci.com/gear-gadgets/gallery/2004-11/electromegnetic-railgun?image=2

- NSWC – EM Railgun
  - Recent successful experiment:
    Velocity - 830m/s, Mass - 2.4kg
  - Development aim:
    Muzzle velocity – 2350m/s
    Range – 300km



http://www.foxnews.com/scitech/2011/11/02/us-navys-futuristic-railgun-passes-projectile-milestone

New Warhead Technology



Minnicino (et al) *Frangible Munition for Reduced Collateral Damage*, 24th International Symposium on Ballistics

http://www.taurus-systems.de/html/gallery.html

- Higher localised effect
- Less collateral damage
- Tunable (adaptive) warheads
  - Multi-mode (i.e. EFP, shaped charge)
  - In-situ tunable (i.e. detonate, deflagrate, blast or fragments)
- Multi-warhead (tandem, triple charge)
  - Anti-armour
  - Penetrator follow-through systems
- Intelligent fusing
  - Standoff control
  - Sequencing
  - Multi-layer count

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New Warhead Technology – EFP Evolution

Explosively moulded Fins

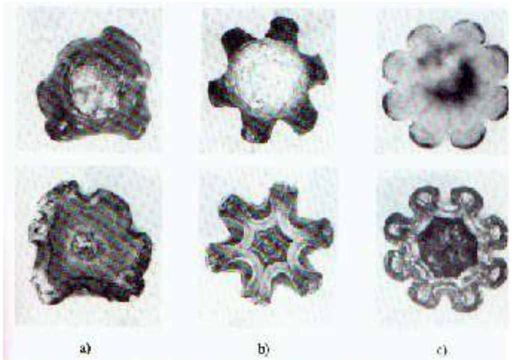
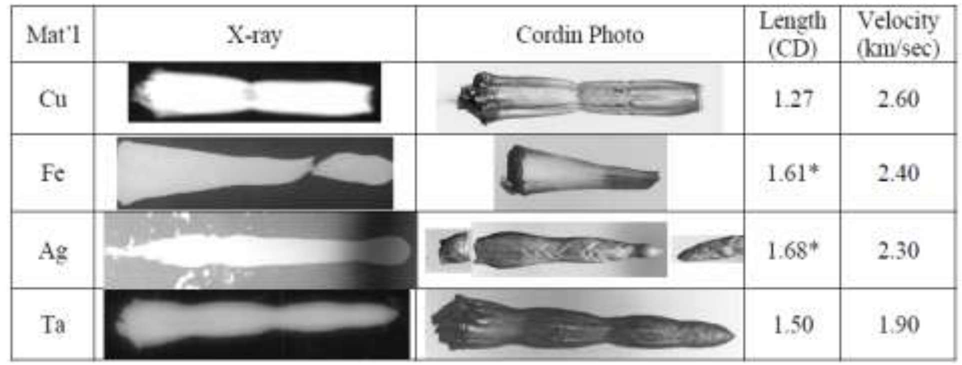


Fig. 3. Front and back view of explosively formed projectiles

Weiman (et al) The Effect of Explosive Detonation Wave Shaping on Efp Shape and Performance, 13th International Ballistic Symposium, Stockholm 1992

Materials and L/D

Fong R (et al) *Advances in Non-tantalum EFP Warhead Designs* 21st International Symposium on Ballistics, Adelaide, 2001



Mat'l	X-ray	Cordin Photo	Length (CD)	Velocity (km/sec)
Cu			1.27	2.60
Fe			1.61*	2.40
Ag			1.68*	2.30
Ta			1.50	1.90

Multiple EFPs from a single design

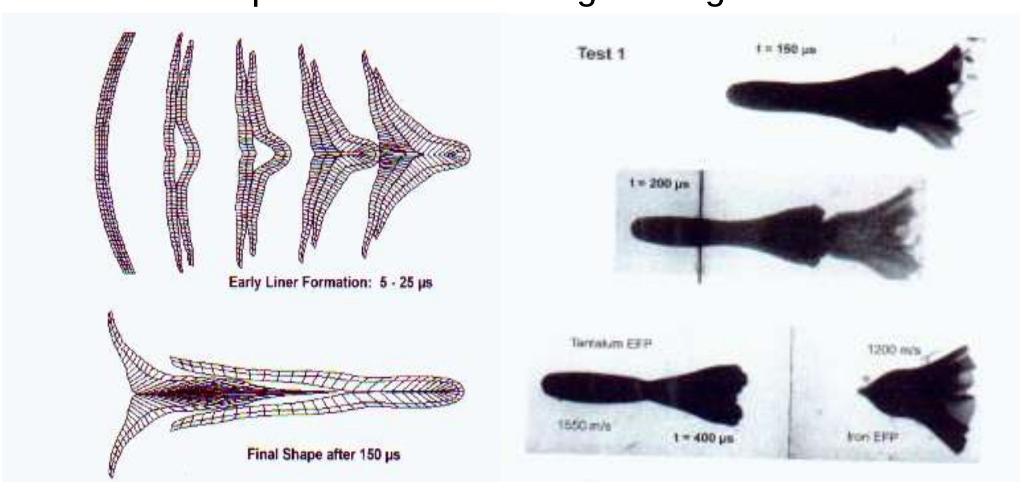
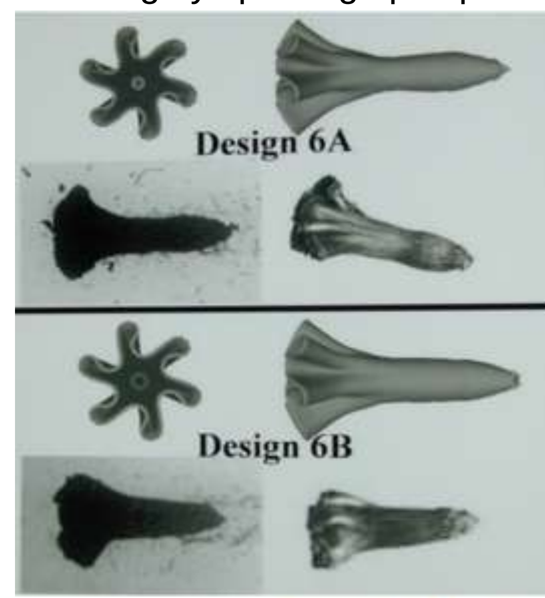


Figure 1. Simulation of EFP formation with multi liner design

Figure 2. X-rays from EFP formation with multi liner design

Weiman (et al) *Explosively formed projectile with tantalum penetrator and steel stabilization base*, 18th International symposium on Ballistics, San Antonio 1999

Stabilising by spinning up explosively



Bender (et al) *EFP with Canted Fins*, 19th International Symposium on Ballitstics, Interlaken, 2001

New Warhead Technology – Tunable effects

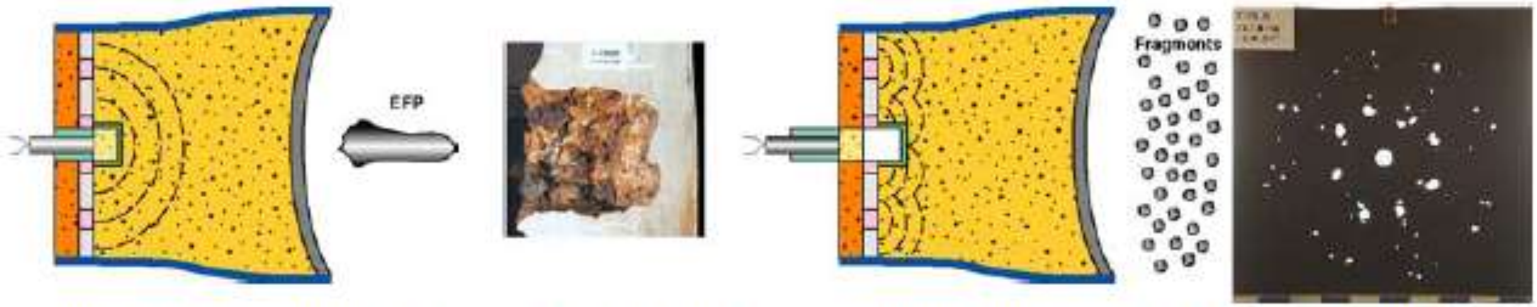


Figure 6. HEP technology to make an EFP charge switchable between an EFP projectile (left) and controlled fragments (right).

Arnold W (et al) *A Novel Technology for Switchable Modes Warheads*, 26th International Symposium on Ballistics, Miami 2011

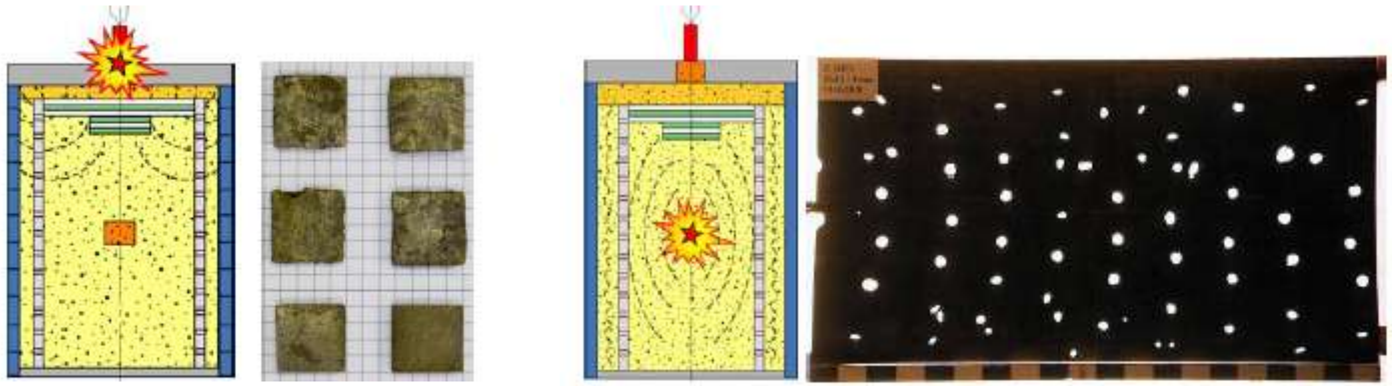


Figure 8. Switchable blast / fragment charge

Ballistic Non-Lethal Technology

Courtesy : Rheinmetall-DenelMunition

Technical data

Dimensions (mm)	Ø 40 x 90
Net Explosive Content	max. 0.2 g
Cartridge Weight	approx. 107 g
Projectile Weight	approx. 55 g
Muzzle Velocity (V_4)	approx. 80 m/sec
Engagement Range	up to 100 m
Kinetic Energy (at 20 m)	approx. 160 J
Impact Signature Color	Red
Chemiluminescent:	
-Operating Temps	-46C to +63C
-Storage Temps	-51C to +71C

- Non-lethal capability for OOTW researched internationally
- In RSA RDM is developing local 40mm non-lethal rounds
  - 80m/s muzzle velocity
  - Paint marker
- Other ballistic NL Research :
  - Stun-grenades
  - Water-cannon
  - Shock rounds
  - Agent dispenser

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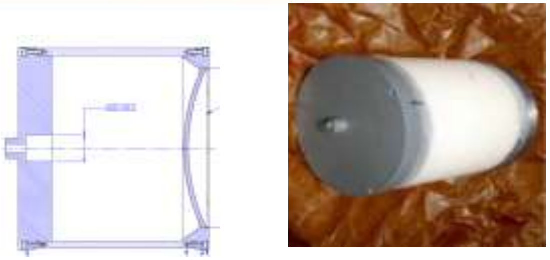
Implications – Energetic Materials

Credit : Somchem (RDM)

- Capacity for R&D in RSA very small
- Emphasis on IM formulations:
  - Lower vulnerability of weapon systems
  - Increased survivability
- Firepower implications
  - Future systems lighter for same yield or higher yield for same mass
  - Lower collateral damage systems
  - Increased range for equivalent terminal effect
- SANDF imperative:
  - Invest in knowledge base to evaluate firepower impact of new developments
  - Small scale testing

Implications – Warheads and Propulsion

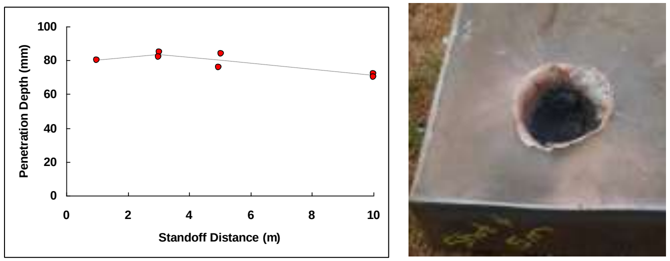


CSIR Compact EFP IED Surrogate

Single Slug

Binary-slug

Heavy Multi-slug EFP Surrogate



Single Slug penetration performance

- Requirement balance between conventional and asymmetric scenarios
- Multi-mode trend
  - Versatile
  - Effective but low-collateral
- Increased hit probabilities
- Future for propulsion is long range
- Specific requirements for OOTW
- SANDF Imperative :
  - Sustain and support local capacity
  - Adapt solutions for African conditions
  - IED scan

Conclusions

- New (short term) developments in firepower dictated by asymmetric warfare requirements
- Emerging material technology and scientific understanding dominant in new firepower developments
- Long term research indicate much improved range and terminal effect
- Challenge is to satisfy diverse requirements of different scenarios

Thank You

FJ Mostert
fmostert@csir.co.za

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