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2006 Insensitive Munitions & Energetic Materials Technology Symposium

New Multi-purpose Warhead Designs with Novel and Insensitive Explosives

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Acknowledgements

- Co-authors
  - Rich Fong
  - LaMar Thompson
- Industry Partners
  - Aerojet-Gencorp
  - Alliant Techsystems
  - Ensign Bickford

Outline

- Explosive Formulations
- Application: Test Results
  - Demolition
  - Anti-Armor
  - Multi-Purpose
- Summary

Explosively Formed Penetrator (EFP) Warheads

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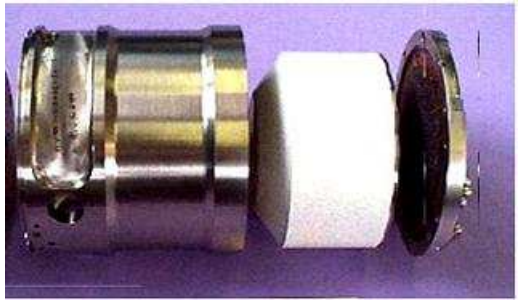
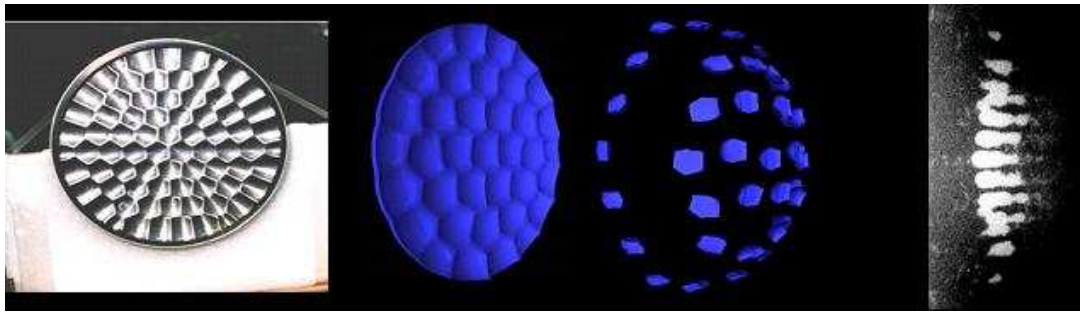
Single EFP

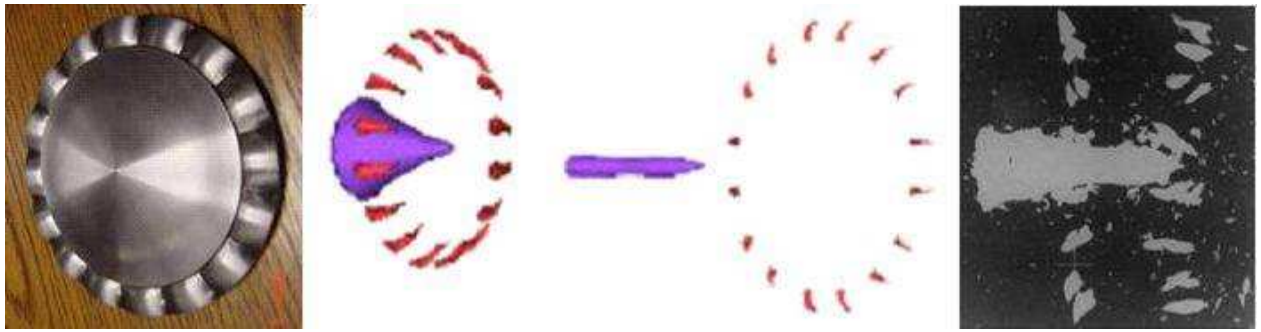
Warhead hardware



Multiple EFPs



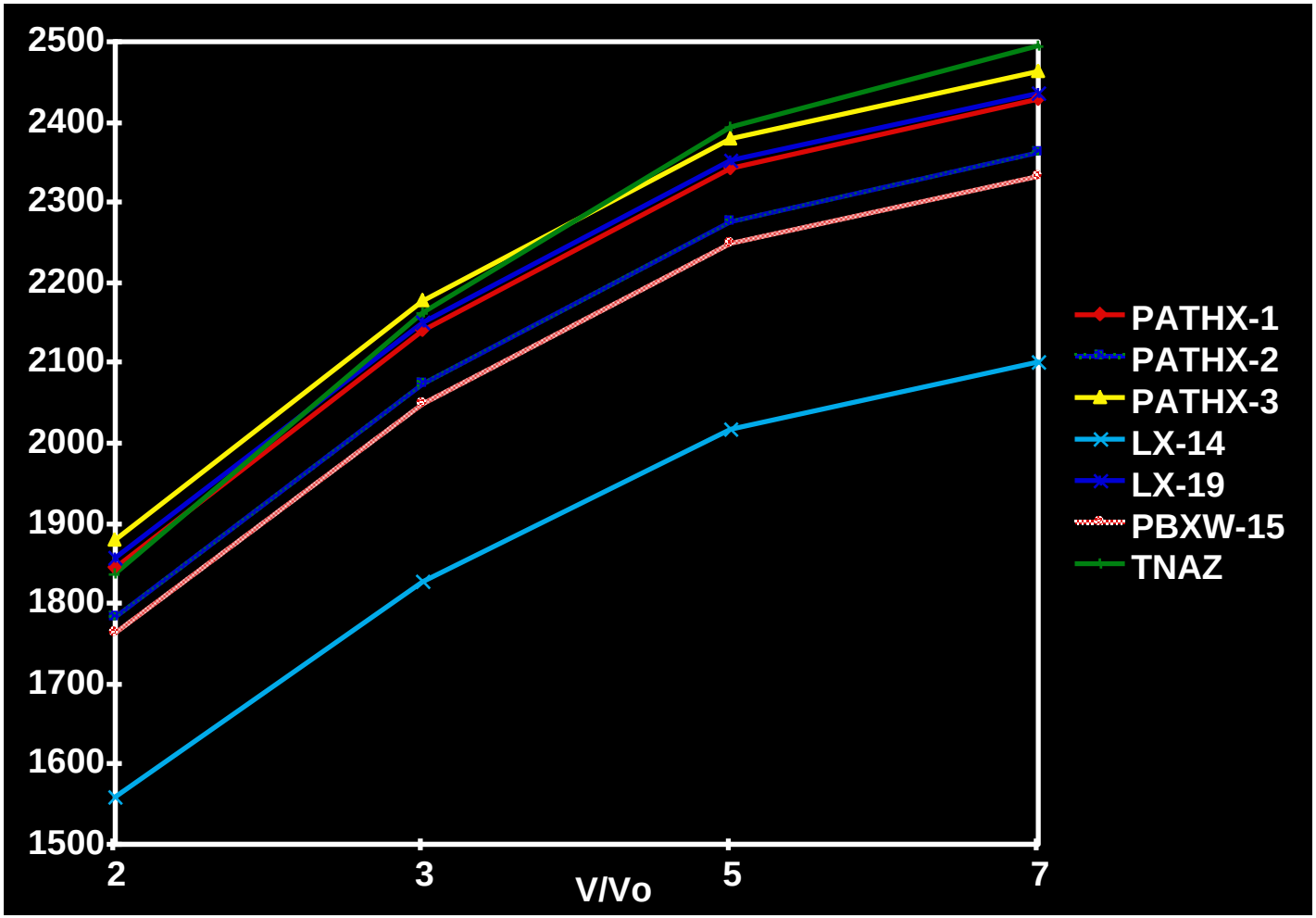
Combined Effects EFP



Explosive Formulations

Formulation	Explosive	Binder	Density (g/cc)	Pcj (Kbar)	Detonation Velocity (km/sec)
Comp C-4	95.5% RDX	4.50%	1.65	257	8.37
LX-14	95.5% HMX	4.50%	1.83	370	8.80
LX-19	95.5% CL-20	4.50%	1.98	418	9.44
Paste Explosive*	X% HMX	Y%	1.65	-	7.35
PATHX-1	92% CL-20	8%	1.96	415	9.39
PATHX-2	95% CL-20	5%	1.94	401	9.24
PATHX-3	92% CL-20	8%	1.98	421	9.50
PAX-11	94% CL-20	6%	1.96	393	9.37
PAX-12	90% CL-20	10%	1.92	366	9.09
PAX-29	77% CL-20	8% (15% Al)	1.96	384	9.23
PAX-2A	85% HMX	15.00%	1.77	340	8.46
PBX N-107	86% RDX	14.00%	1.64	-	8.06
PBX W-17	94% RDX	6.00%	1.67	312	8.17
TNAZ	100% TNAZ	0.00%	1.84	372	8.85
*Ensign Bickford Product					

Calculated Energy



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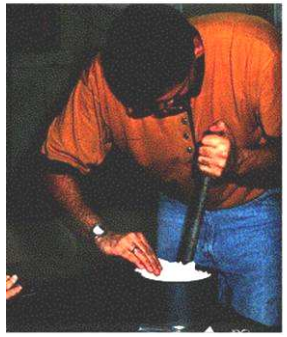
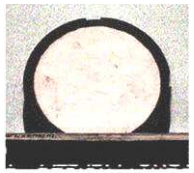
Improved Warhead Performance with Novel and Insensitive Munitions Explosives

- Increase EFP length
- Increase EFP velocity
- Multi-Purpose Warheads

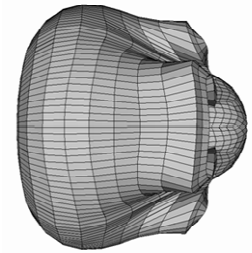
M303 SOF Demolition Kit
Demolition Warhead Applications

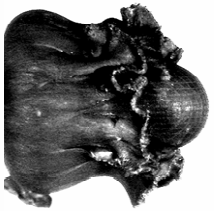
Baseline EFP Warhead packed with C-4





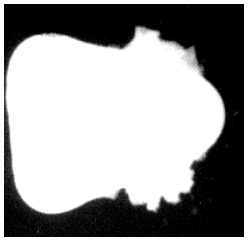
3D Computer Simulation

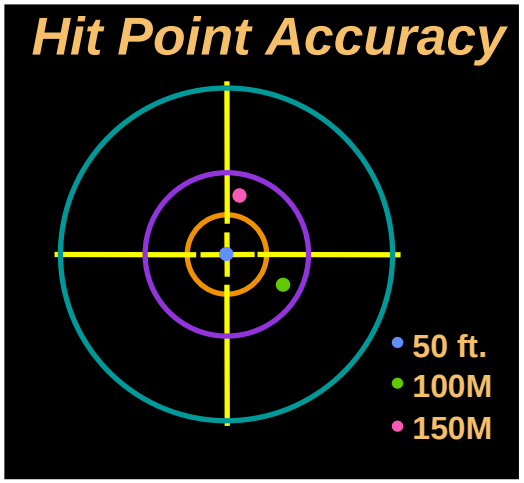




Cordin Photo of EFP in Flight

Flash X-Ray





Warhead

Armor Target (Exit)

Concrete Wall (Exit)

Column

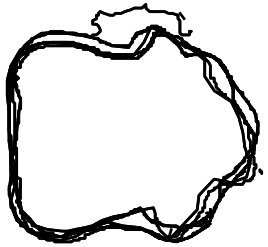
Brick Wall (Exit)

Explosive Formulations

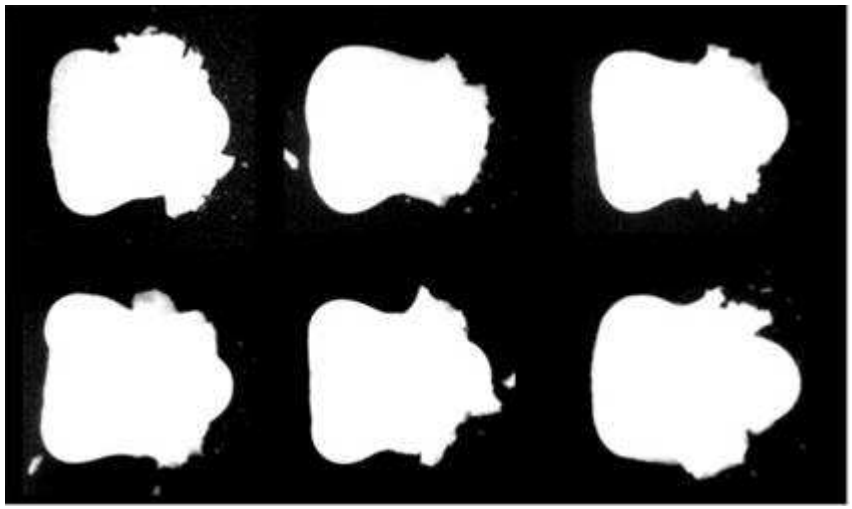
Formulation	Explosive	Binder	TMD (g/cc)	P_{cj} (Kbar)	V_{det} (mm/µsec)
Comp C-4	95.5% RDX	4.5%	1.65	257	8.37
LX-14	95.5% HMX	4.5%	1.83	370	8.80
PAX-2a	85% HMX	15.0%	1.77	340	8.46
PBX W-17	94% RDX	6.0%	1.67	312	8.17
PBX N-107	86% RDX	14.0%	1.64	-	8.06
Ensign Bickford Paste Explosive	X% HMX	Y%	1.65	-	7.35

C-4 Warhead Test Results

6 X-rays Overlay



Shot 1 Shot 2 Shot 3



Shot 4 Shot 5 Shot 6

Range (m)	10	20	50	60	100
No. of tests	17	3	52	3	5
Avg. radial miss distance (cm)	6.0	17.0	15.0	25.0	16.8
Defeated required armor target	Yes	Yes	Yes	No	No

Alternate Explosives Warhead Tests Results

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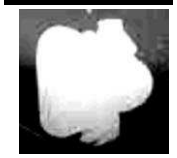
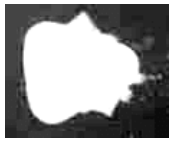
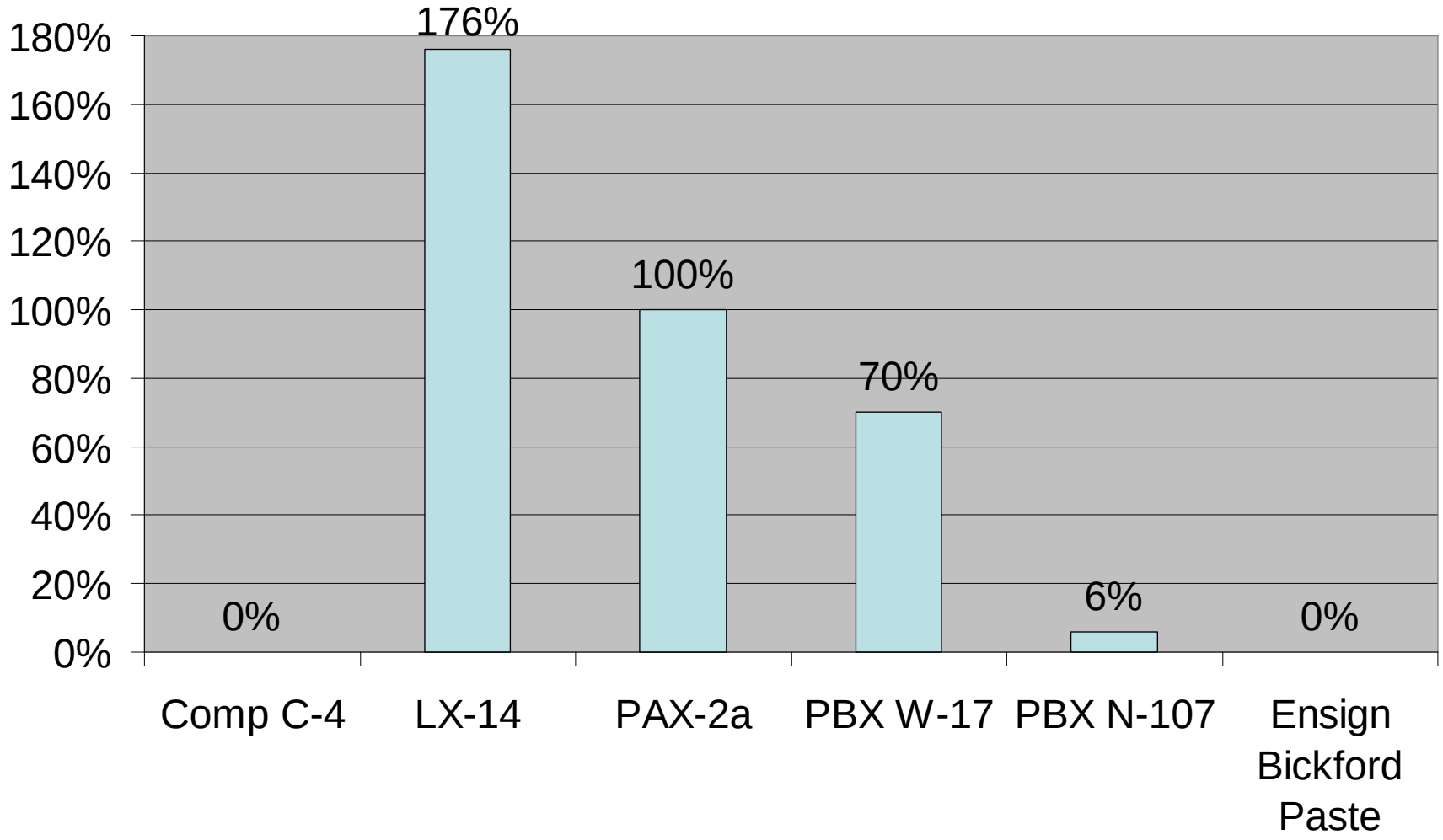
"Increased Velocity and Calculated Effective Range"

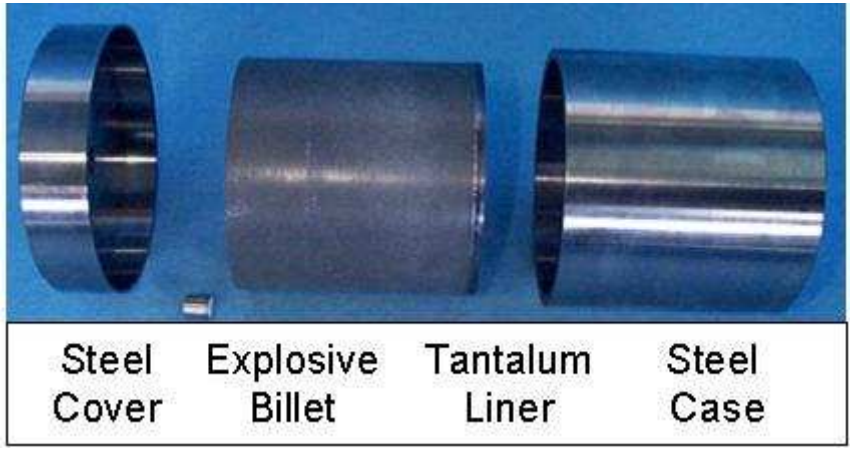
	Formulation	Velocity	% Velocity Increase over C-4 Baseline	Calculated effective Range (m)
	Comp C-4	2.35	-	50
	LX-14	2.88	22%	138
	PAX-2a	2.76	17%	100
	PBX W-17	2.56	9 %	85
	PBX N-107	2.37	1%	53
	Ensign Bickford Paste	2.35	0%	50

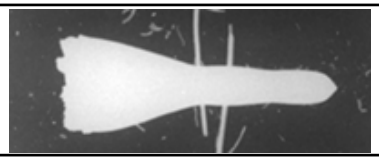
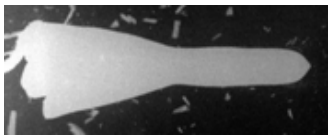
Alternate Explosives Warhead Tests Results

”Increased Effective Range”



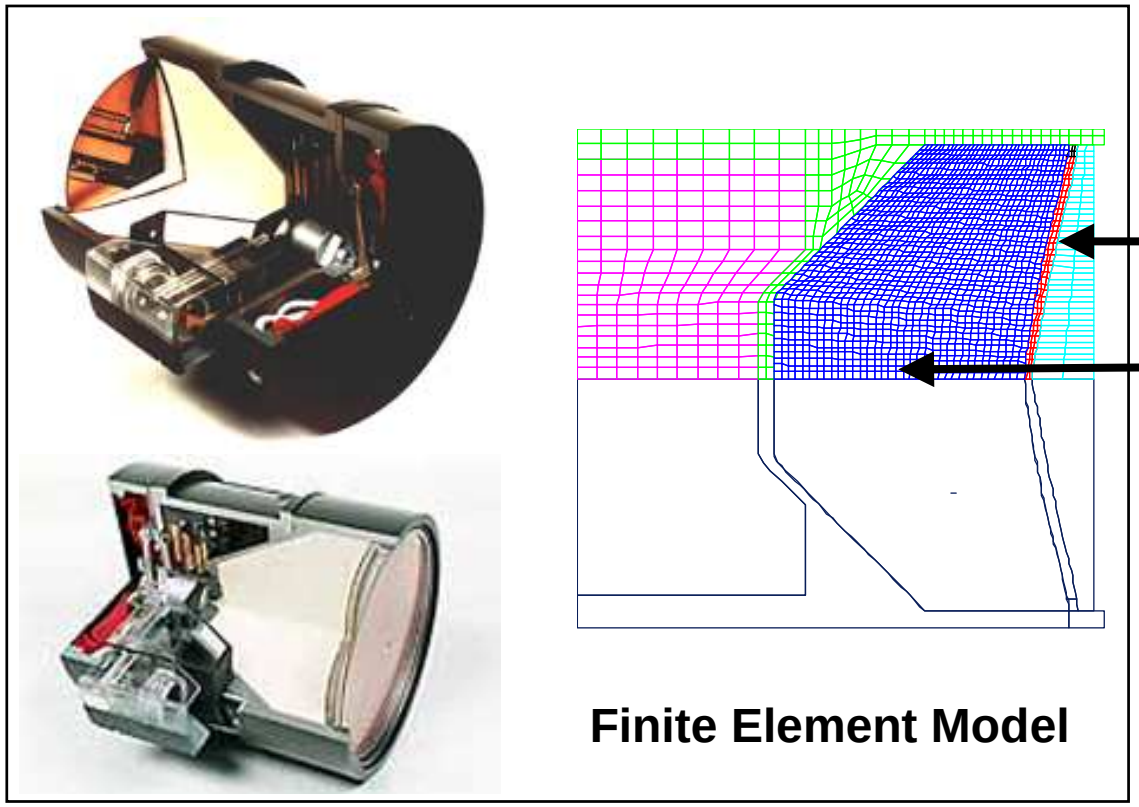
Prototype EFP Warhead



Explosive	X-Rays	Simulation	% Increase Velocity	% Increase in EFP length
Octol			Baseline	Baseline
PAX-11			11%	1.2%
PAX-29			13%*	*

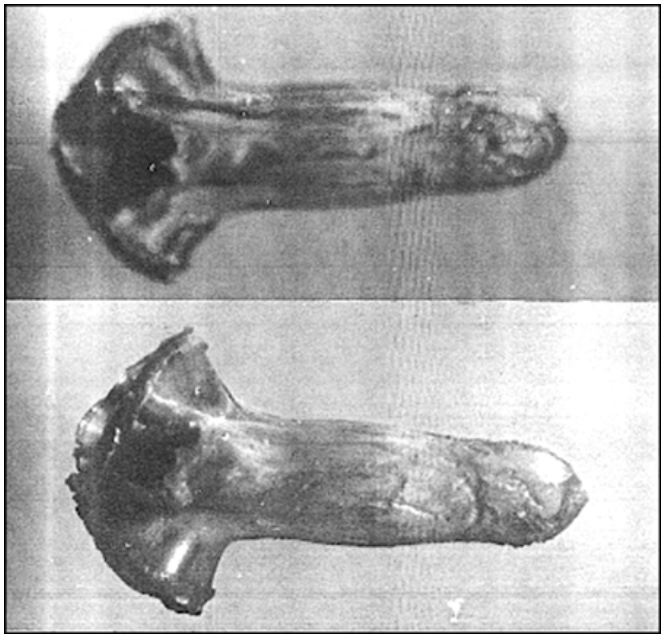
*Fractured into two pieces, estimated values

Baseline Warhead Test Configuration



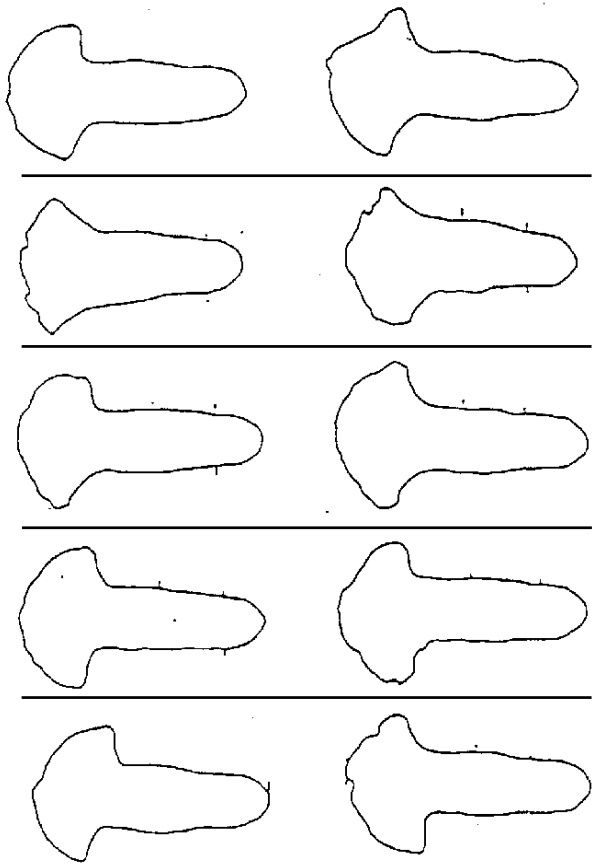
- Demonstrated design
- Tactical configuration
- Hardware available

Baseline “LX-14” Warhead Test Results



Cordin Photo of Baseline EFP

X-ray tracings from 5 tests



UP View **Down View**

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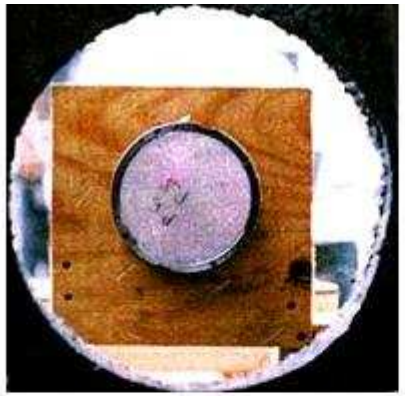
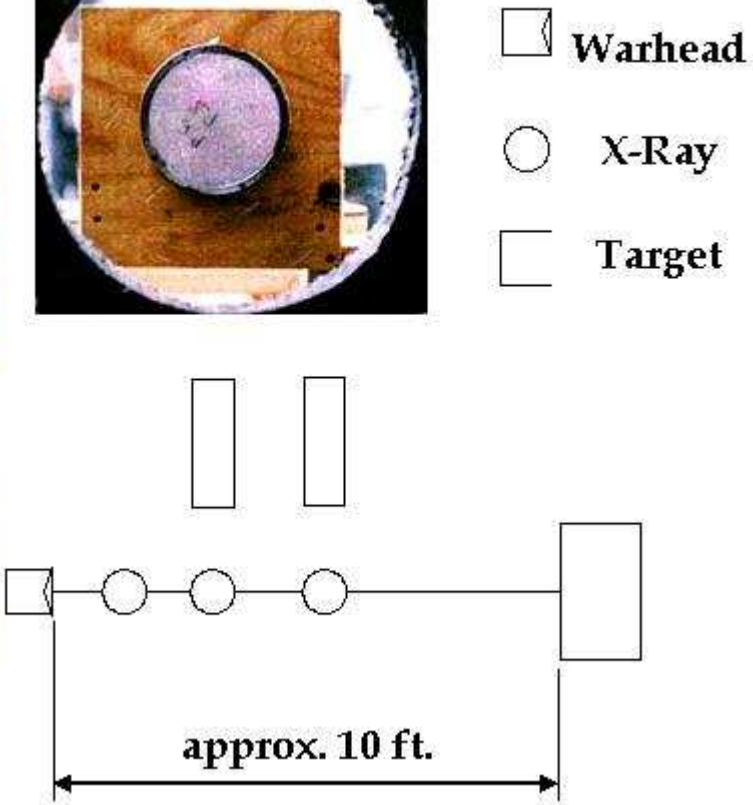
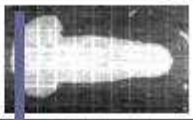
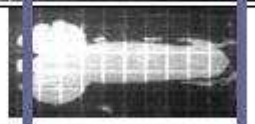
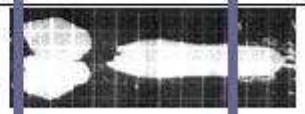
Warhead Test Setup





Novel Explosives Warhead Test Results w/Baseline Liner

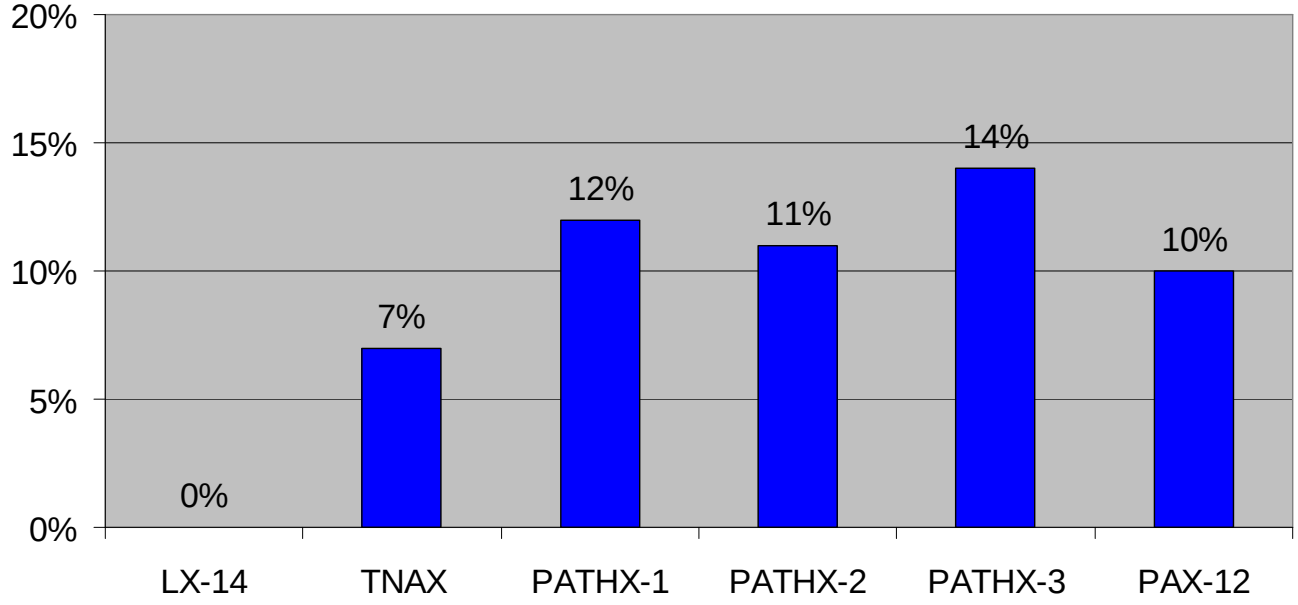
"Increased Velocity and Penetration"

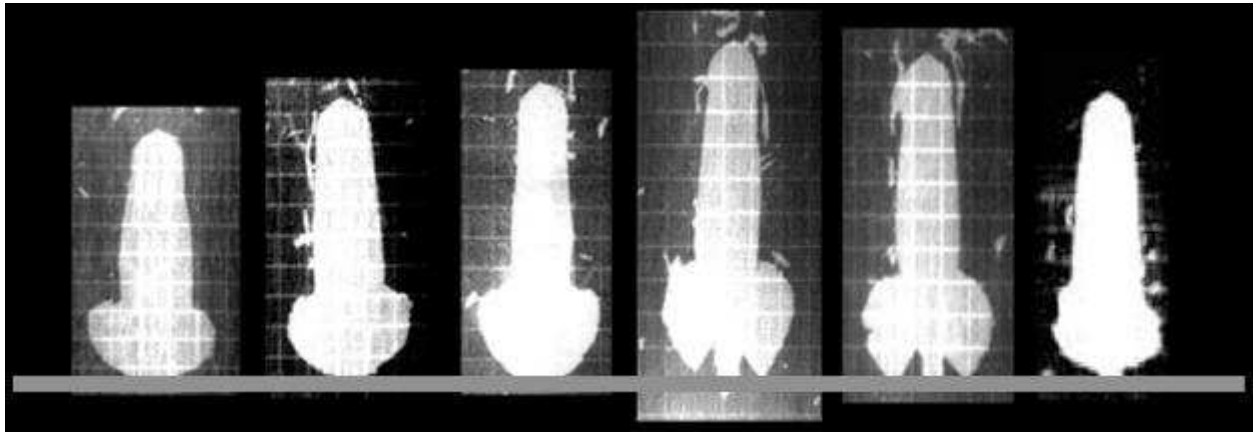
Explosive used in Test	X-ray	% Increase over LX-14		
		Length	Velocity	Penetration
LX-14		-	-	-
TNAZ		7	5	7
PATHX-1		10	7	12
PATHX-2		18	6	11
PATHX-3		12	9	14
LX-19		20*	11*	17*
PAX-12		4	5	10

***Note EFP broke**

Novel Explosives Warhead Test Results w/Baseline Liner

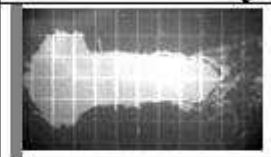
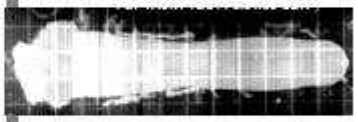
”Increased Penetration”





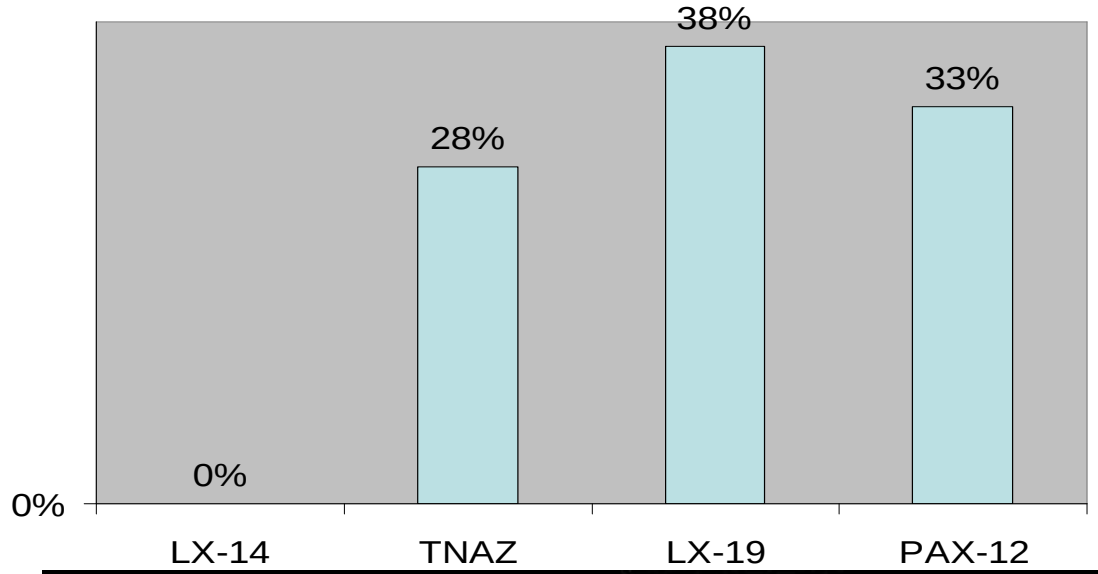
Novel Explosives Warhead Test Results w/Redesigned Liners

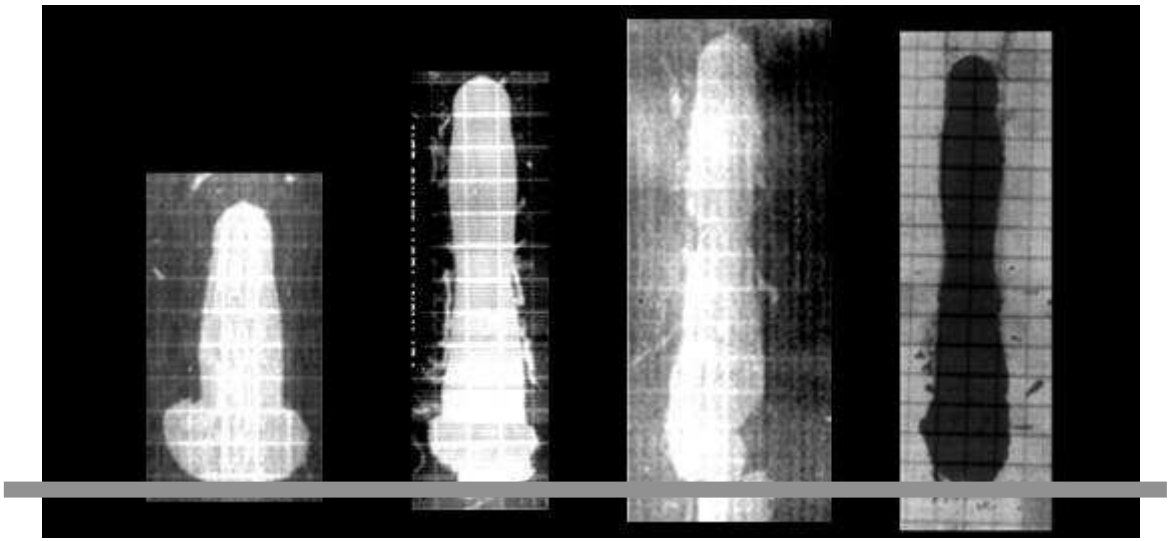
”Increased Penetration”

Explosives used in Test	X-ray	% Increase over LX-14	
		Length	Penetration
LX-14 (Baseline)		-	-
TNAZ		44	28
LX-19		56	38
PAX-12		51	33

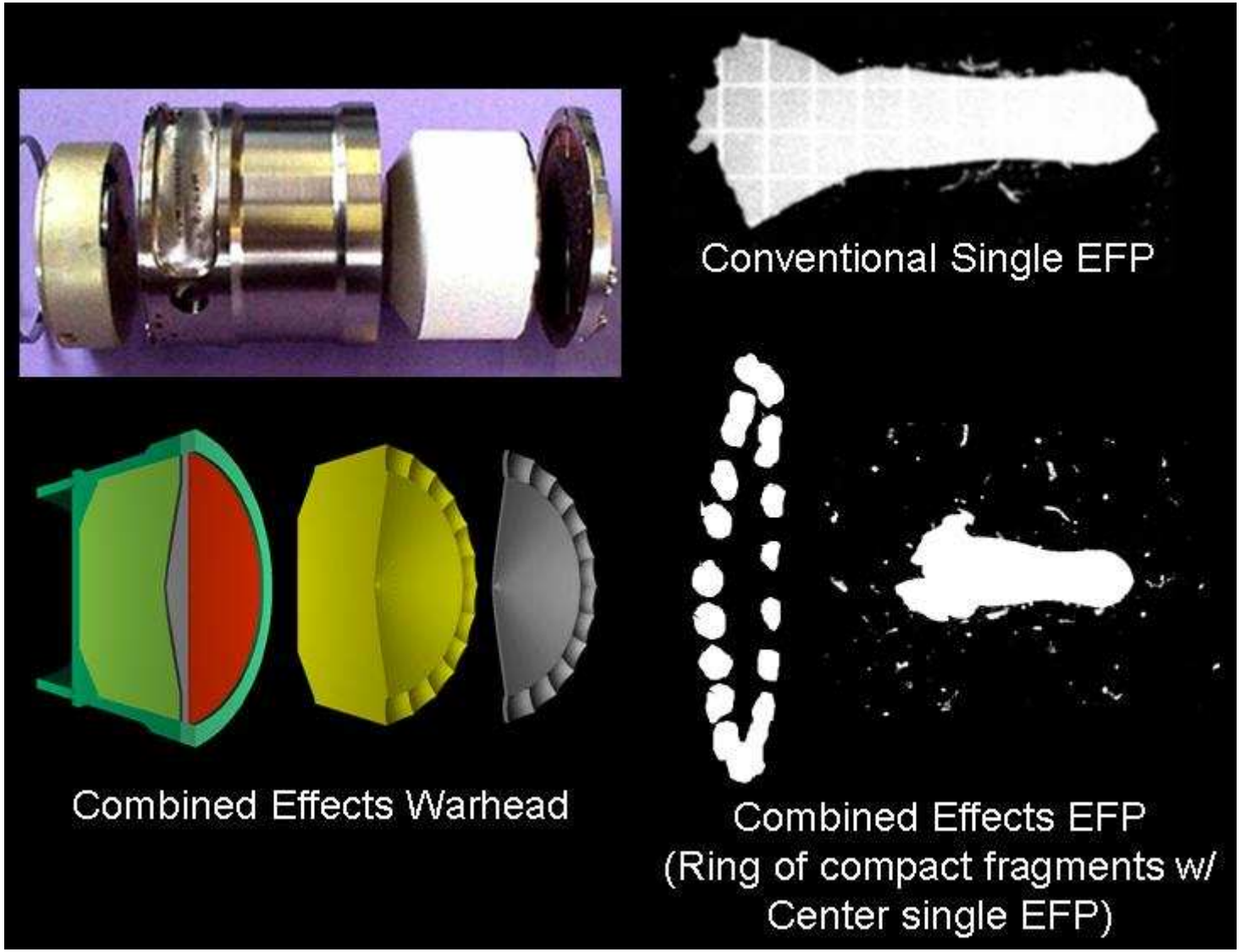
Novel Explosives Warhead Test Results w/Redesigned Liners

”Increased Penetration”

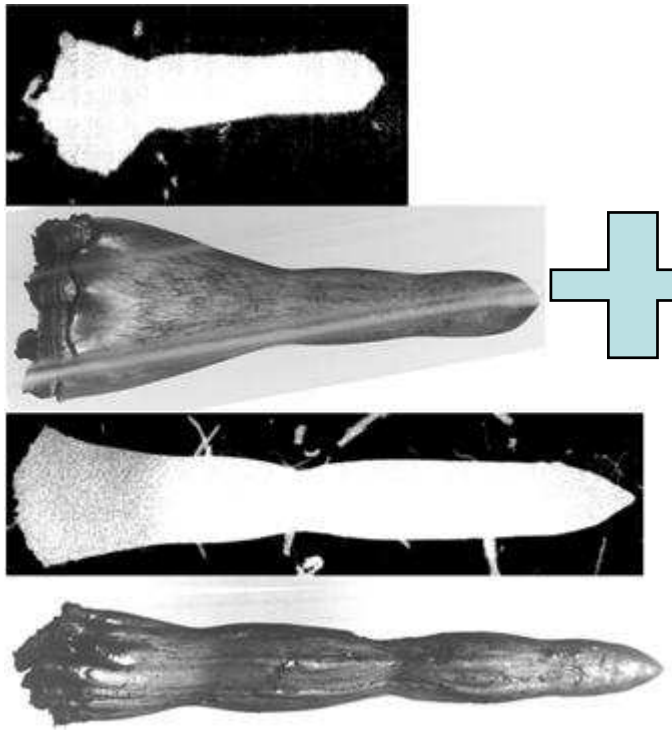




Multi-Purpose Combined Effects Warhead w/PAX-2a



Improved Warhead Performance with Novel Explosives for Future Smart Munitions



Novel Explosives

Novel Explosives is an Enabling Technology for

- Smaller & lighter warheads
- More lethal and multi-purpose warheads
- Future smart munitions