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The Evolution of Artillery for Increased Effectiveness

June 10-11, 2008

Evolution of Artillery for Increased Effectiveness

Presented at:

Armaments Technology Firepower Forum

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Presented by:

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Chief NLOS Cannon Artillery Division

ARDEC, Picatinny Arsenal

Mission

- To destroy, neutralize or suppress the enemy by cannon, rocket or missile fire ensuring the integration of all supporting fires in a combined arms operation
- Most lethal form of land based armament often referred to as:
  - *"King of Battle"*
  - *"God of War"*
  - *"Ultima Ratio Regum"*
    - *"The Final Argument of Kings"*
  - *"God Fights on The Side With the Best Artillery"*
  - *"I do not need to tell you who won the war, you know, Artillery did."*

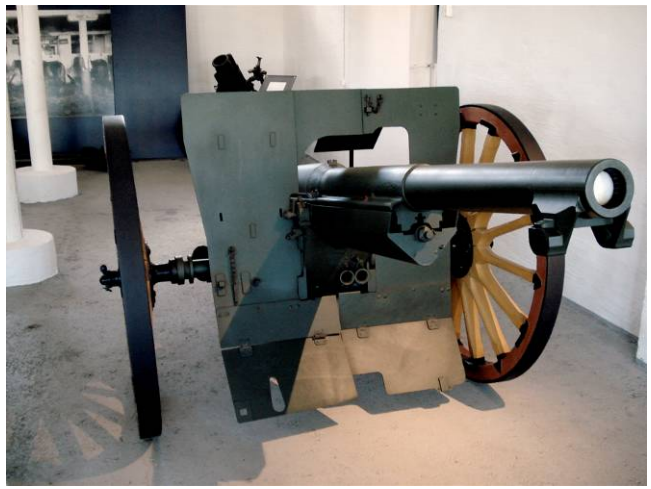
Goal

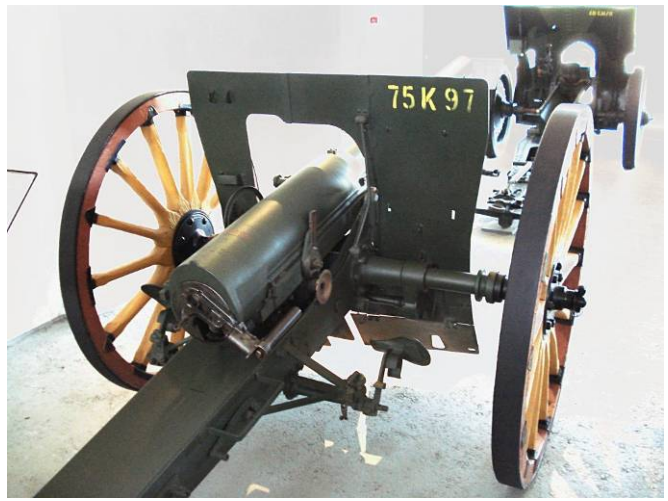
To provide an overview of historical highlights in the Development / Evolution of artillery and provide a snap shot of future trends

M777A1

1897 French 75 Fielded

- Hydraulic Recoil System
- Effective Breech loading (Nordenfeld Breech)
- Modern Sight
- Self contained firing mechanism
- Fixed Shell + Cartridge Ammunition

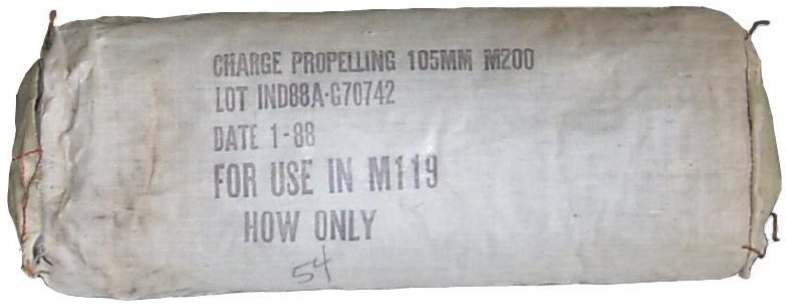




Evolution of Propelling Charges

- Black Powder
  - Low Power
  - Smoked
- Gun Cotton (Nitrocellulose)
  - More Powerful than Black Powder
  - Smokeless
  - Unstable
  - Burns Hot
- Double Based Powders
  - Nitrocellulose + Nitroglycerin
  - More Powerful than Gun Cotton
  - Smokeless
  - More stable than Gun Cotton
- Triple Based Powders
  - Nitrocellulose
  - Nitroglycerin
  - Nitroguanodine

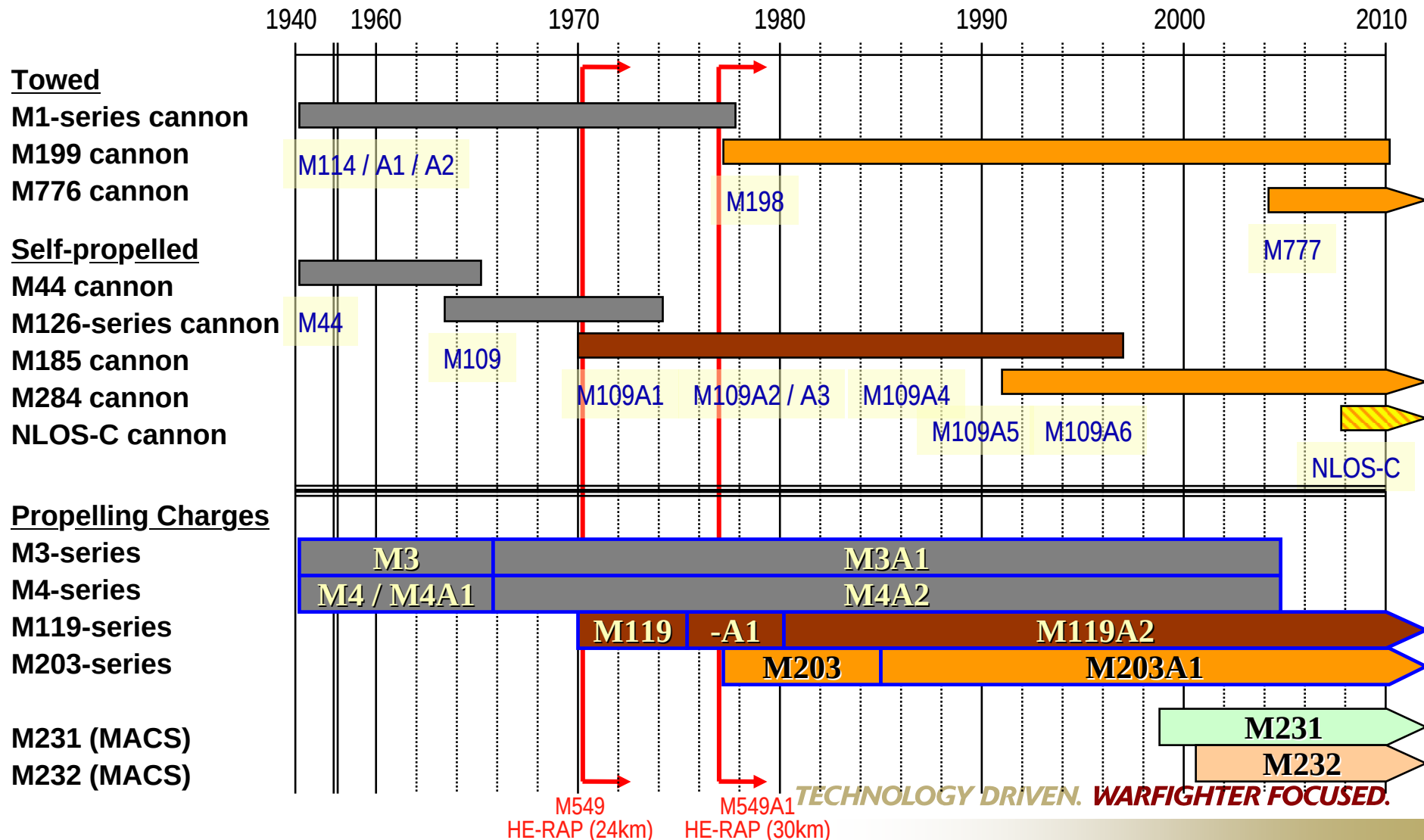
M67 Propelling Charge



M200 Propelling Charge

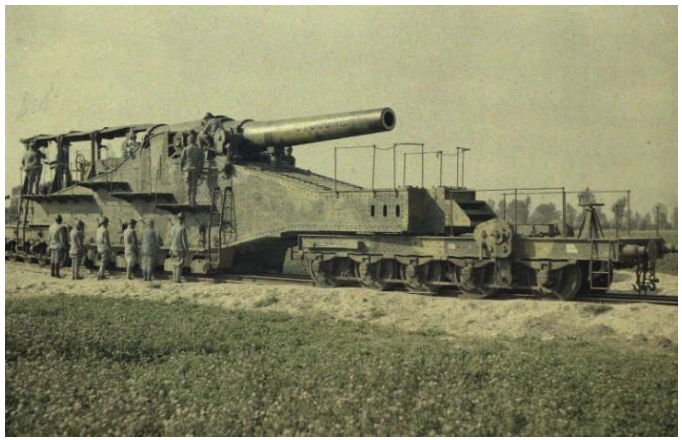
Propellant Summary Chart

- 155mm Artillery Upgrades - Infrequent

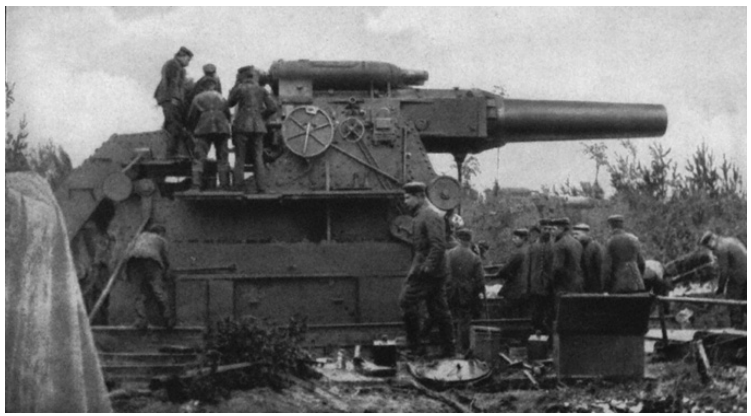


Late 19th Century

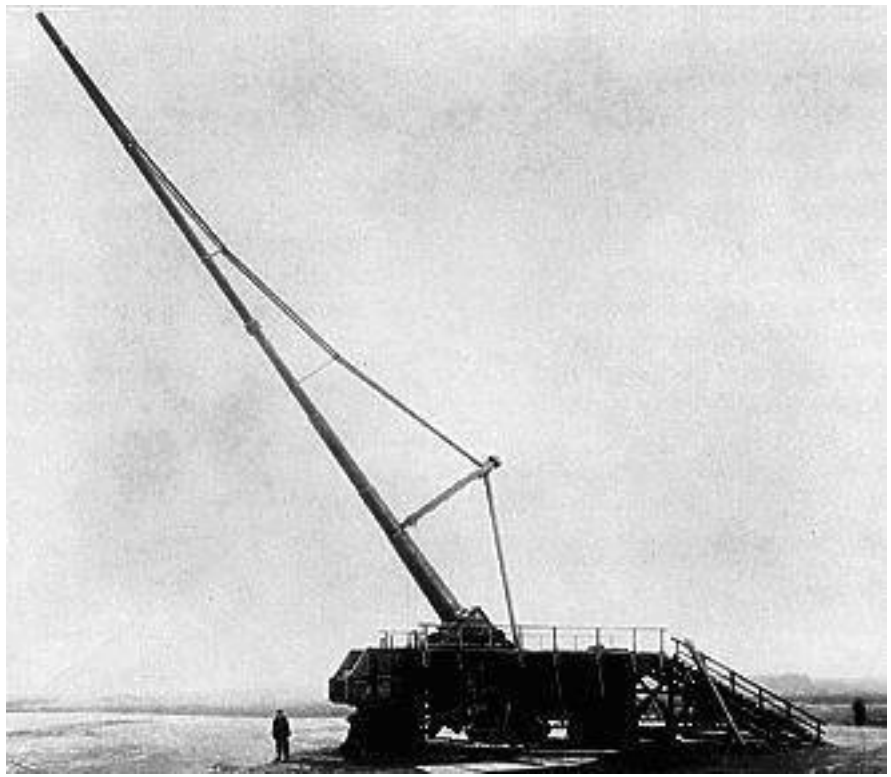
A Shift from smaller lighter mobile pieces that stayed with infantry to Larger Guns for Indirect Fire



French Cyclone



German Artillery



Paris Gun

World War I

- Predicted Fire Methods Developed
- Over 60% of Combat Casualties attributed to Artillery
- Expenditure of 1 billion rounds fired by all sides
  - Battle of Verdun 1916
    - 1,000 guns
    - 16 million rounds fired over 6 months
  - 200 million rounds produced for French 75
- French 75
  - Range : 6.9 km
  - 12 lb or 16 lb shrapnel round w/290 lead balls
- Smoke round first deployed
- Long Range Harassment Guns developed
  - Paris Gun
    - 75 mile range

Battle of Verdun

Self Propelled Guns come into widespread use

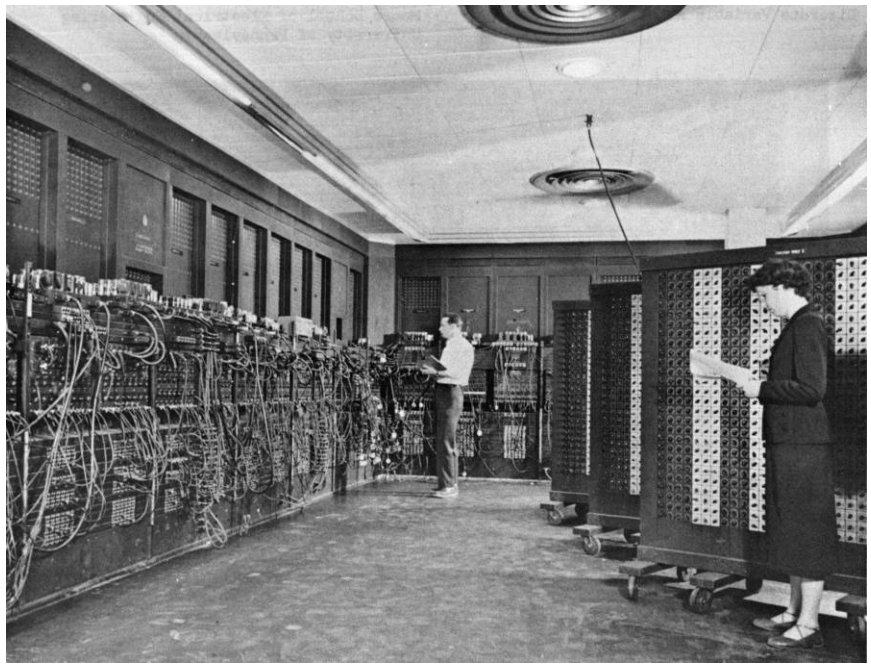
- Mark 1 Gun Carrier
- 105mm M7 “Priest”
- British Sexton
- 105mm German Wespe
- Soviet Katyusha
  - Self propelled Multiple launch rocket system
- US MLRS and 155mm Paladin

Dec 1944 US Artillery XMAS Present

- First Radar Proximity Fuze
  - Increased Effectiveness against personnel targets

ENIAC

- **E**lectronic **N**umerical **I**ntegrator **A**nd **C**omputer
- Computer developed for Artillery Firing Tables
- Trajectory tables to predict Projectile Flight
- 3D second order differential equations of motion performed manually

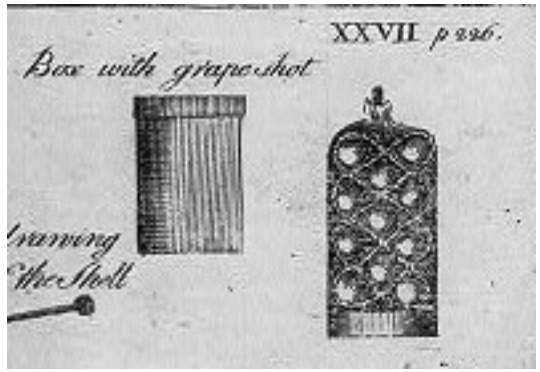


Artillery Developments

- Increased Mobility
- Longer Ranges
- Increased Firing Rates
- Increased Precision
- Increased Lethality
- Modern Battery : 6 Guns
  - 43 kg (~95 lbs) projectile @ 4 rounds per minute for 4 minutes yields…….
  - Over 1 metric ton of ordnance delivered per minute
- Desert Storm Massed Artillery Fires
  - 11 Artillery Battalions
  - Devastating Effects
  - Broke Enemy's "will to fight"

Artillery Ammunition

- Cannon Ball
  - Kinetic energy
    - Breach fortifications
    - Slice through Men & Horses
- Grape Shot
  - Smaller balls separating at Muzzle
- Chain Shot
  - Cannon balls joined by chain
- 1803 British General Henry Shrapnel
  - Balls blown from shell by burster charge
- Mid 1800's
  - Cylindrical-Conical projectile replaces cannon ball
  - Copper driving bands engage rifling in guns for spin stabilization and thus longer range



Grape Shot

Artillery Ammunition cont.

- 1950's
  - BRL (Now ARL)
  - Scientific & Systematic approach to analysis of wound ballistics
  - Fragment Mass striking velocity
  - Random Fragmentation munitions
    - 155mm M107
    - Large fragments reduced velocity, limited area of coverage
  - Controlled fragmentation material improvements
    - High-Fragmenting Steel
      - Smaller high velocity fragments, increased total number of fragments, larger lethal area
- Typical HE
  - Overkill on immediate area of detonation lacking large area coverage
  - Sub-missiling Principle
    - Increased lethality through spreading of munitions

ICM

- ICM (Improved Conventional Munitions)
- First Generation ICM's combined sub-missiling with controlled fragmentation and ground burst
  - 105mm M413 18 Ground burst
  - 105mm M444 18 Airburst
  - 155mm M449 60 Airburst
  - 8 inch M404 104 Airburst

Artillery Effectiveness

155mm	Cargo	% Casualty
M107	TNT	4.9
M107	Comp B	7.9
M449	60 sub-munitions	31.9

- Advanced ICM Artillery or DPICM
  - 155mm M483A1 — 88 dual purpose sub-missiles
  - 8 inch M509 — 195 dual purpose sub-missiles
  - 155mm M864 base bleed — 72 dual purpose sub-missiles

DPICM

M483

M509

M864

Combat Comparative Effectiveness (Vietnam)

Conventional	105mm	155mm	8 inch
Rds Expended	7,079	3,465	149
Rds / kill	31.6	13.6	16.6

ICM	105mm	155mm	8 inch
Rds Expended	1,121	772	153
Rds / kill	2	1.7	0.8

Live Fire Demonstration Effectiveness Comparison

		HITS					
	Total Rounds	Three Tanks	Six APC's	Eight Trucks	Six AA's	One Jeep	Total Hits
ICM 155mm, M483	*145*	*47*	*69*	*45*	*5*	*7*	*173*
M107: 155mm	*432*	*2*	*4*	*2*	*0*	*0*	*8*

Delivery Accuracy As a Function of Range

Projectile	Range (km)	CEP (m)
M795	20	119
M864	20	96
M864 (BB)	28	186
M549 (RAP)	30	267

- Delivery Error increases with Range
- Solutions to overcome delivery error
    - Smart or Precision Projectiles

Copperhead

First Cannon launched Precision round developed by U.S. Army

Projectile, HE, Guided, Cannon Launched, 155mm: M712 Copperhead

- 16 km Range
- Ground Laser locator designator

SADARM

- Initially developed for 8 inch Gun
  - Shifted to 155mm in 1980's
  - **S**ense **A**nd **D**estroy **ARM**or submunition

- Combat Proven 2003 Invasion of Iraq
  - 108 Rounds Fired
  - 48 vehicle kills
- Employs:
  - Infrared telescope
  - Millimeter wave Radar

Excalibur

- A Joint United States / Kingdom of Sweden Program
- Fin stabilized, gliding airframe uses GPS & Inertial Navigation System Guidance

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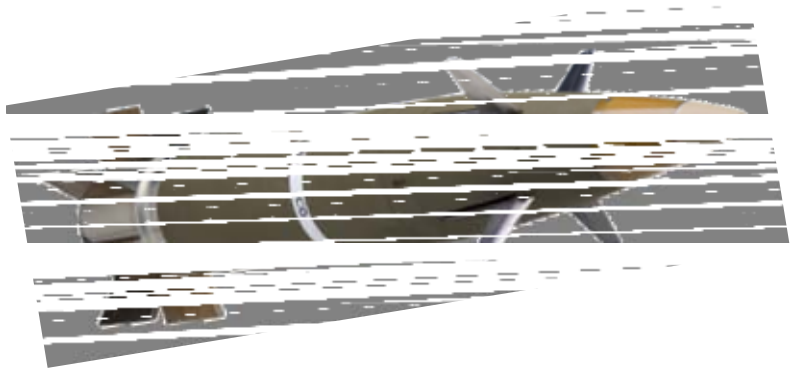
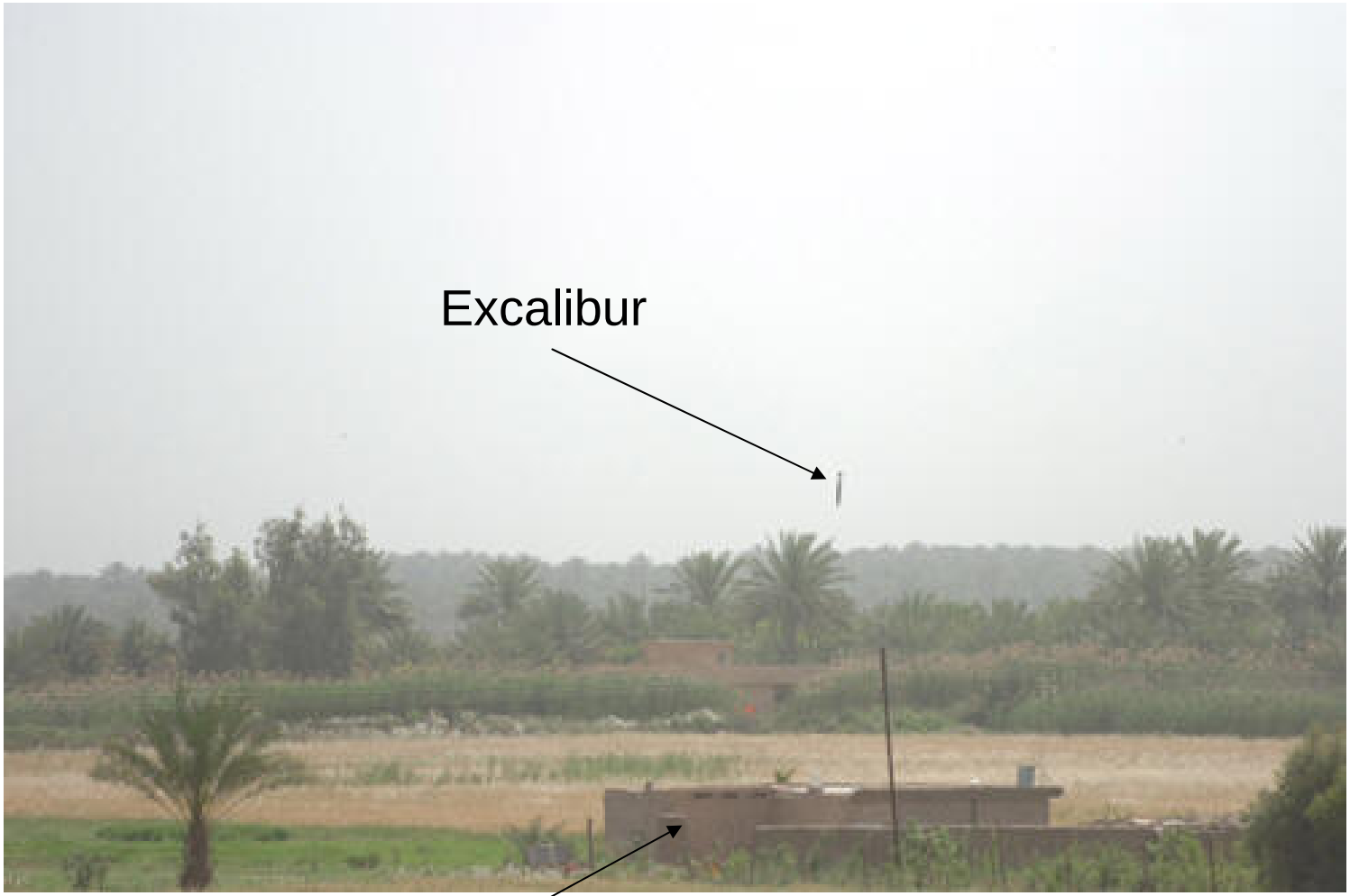
- **Accuracy of Less Than 10M CEP**
- **Minimizes Collateral Damage**
- **Employment Flexibility – Danger Close Fire Missions**
- **High Impact Angle**
  - **Ideal For Urban Terrain**
  - **Optimal Effects**
- **Increased Effects With Fewer Rounds**
- **Status**
  - **Initial Capability Fielded in 2007**



Makes Cannon Artillery Relevant in today's Urban Conflicts!

Excalibur



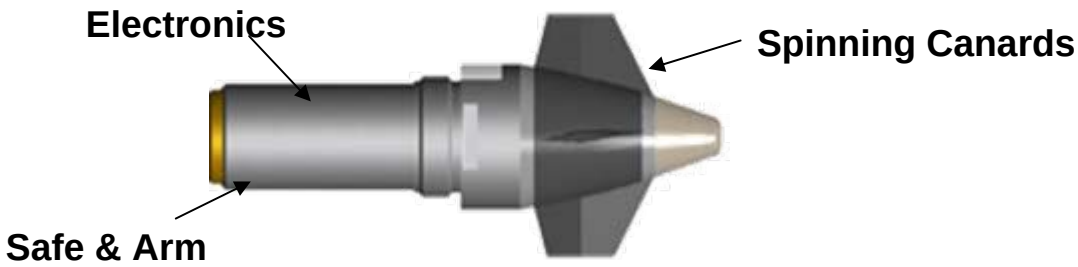
The Next Generation of Artillery

- Precision Guidance Kit (PGK)
- Infrared Illumination Round (XM1064/6)
- Very Affordable Precision Projectile (VAPP)
- Common Smart Submunition (CSS)
- Proximity Initiated Submunition (PRAXIS)
- Extended Range Artillery (ERA XM1113)
- Hybrid Propellant (XM350)
- Selectable Technology for Adaptive Response (STAR)
- Electromagnetic Gun System

PGK (XM1156)

- **Fits in standard 155mm High Explosive artillery projectile fuze wells (deep intrusion)**
- **GPS guidance (incorporates SAASM)**
- **20 Year Storage Life (no battery)**
- **Proximity & Point Detonating Fuzing**

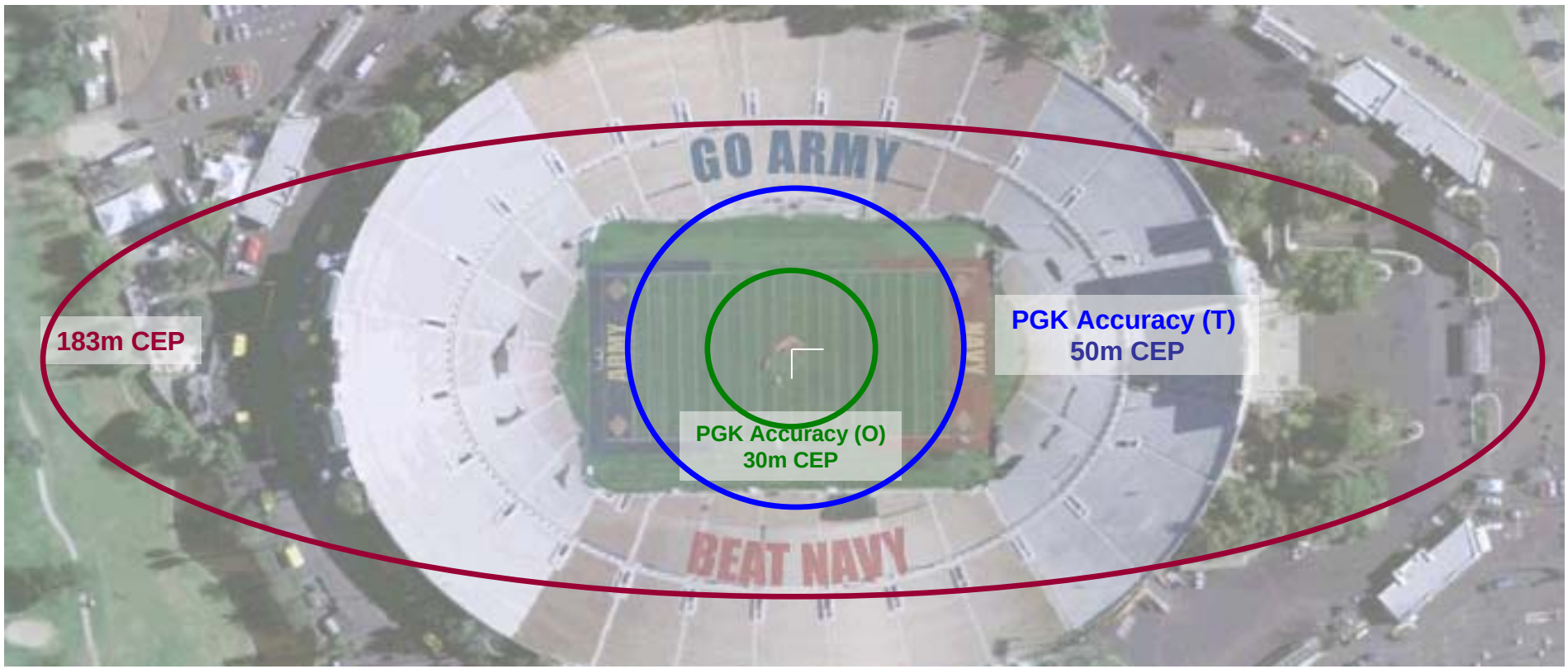
2007 Tech Demo Firing



PGK Delivery Accuracy

CEP Comparison - Guided vs. Unguided

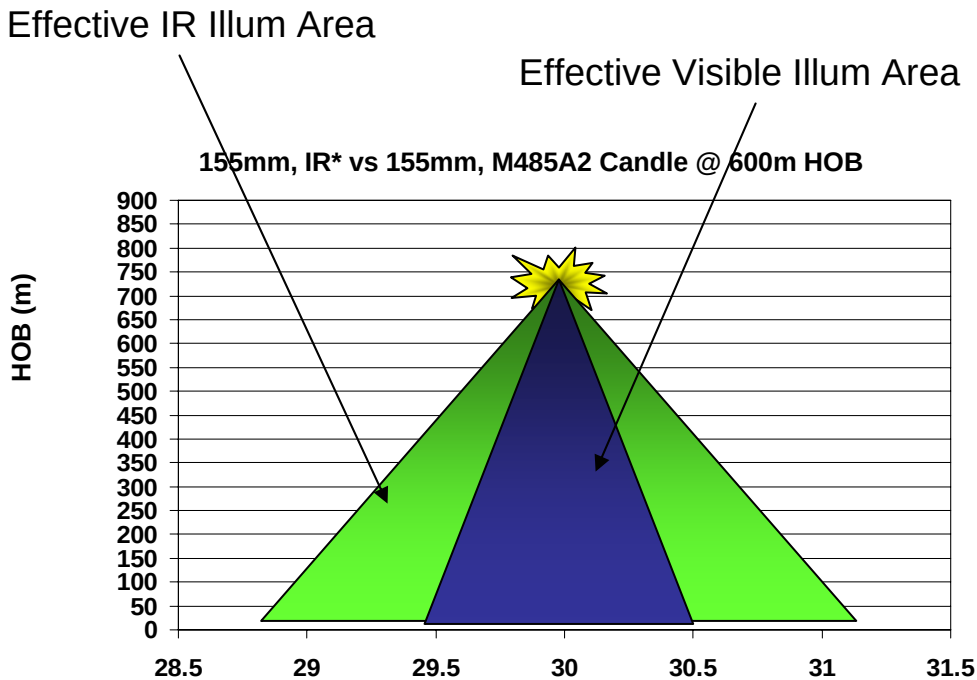
M109A6 – Paladin – 27km
155mm (HE) M549A1 with 1 mil Aiming Error at Low Angle



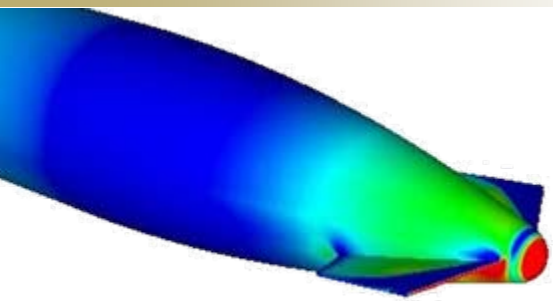
IR Illumination

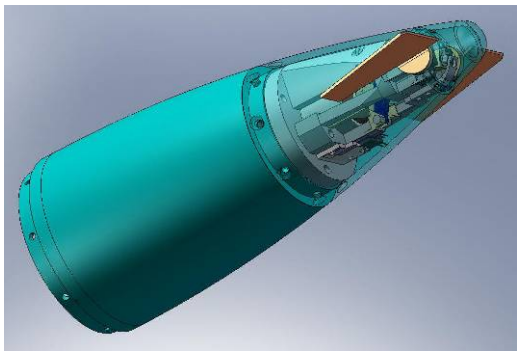
- IR Illumination provides the user with battlefield illumination in the infrared wavelength
- Allows user to witness movements of enemy in a dark battlefield

XM1066



Very Affordable Precision Projectile (VAPP)





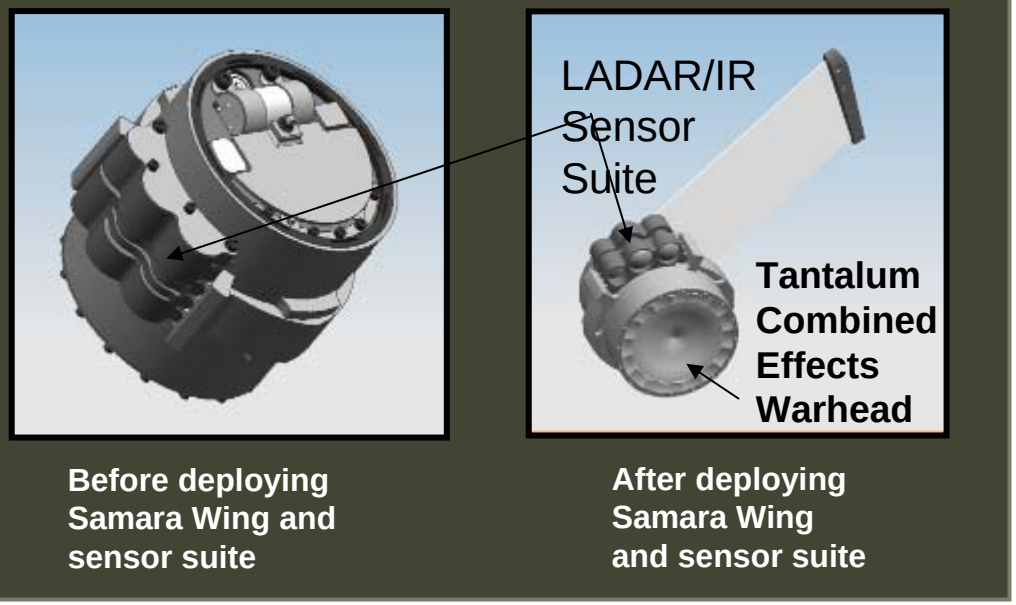
Description

- Design and demonstration of 105mm precision artillery to focus on affordability and performance

Performance Highlights

- GPS guidance augmented by Magnetometer
- $10,000 AUPP objective
- Range objective 24 km
- ≤10m CEP
- Greater lethality than legacy 105mm

Common Smart Submunition (CSS)



Before deploying Samara Wing and sensor suite

After deploying Samara Wing and sensor suite

Payoff

- Enables single round-multiple kill capability.
- Multi-platform applicability across projectiles/missiles/ mortars/UAVs.
- On board target discrimination capability.
- Reduced logistics footprint.
- Clean Battlefield

Mission Objectives

- Develop and demonstrate the next generation target discriminating submunition (school bus vs. tank)

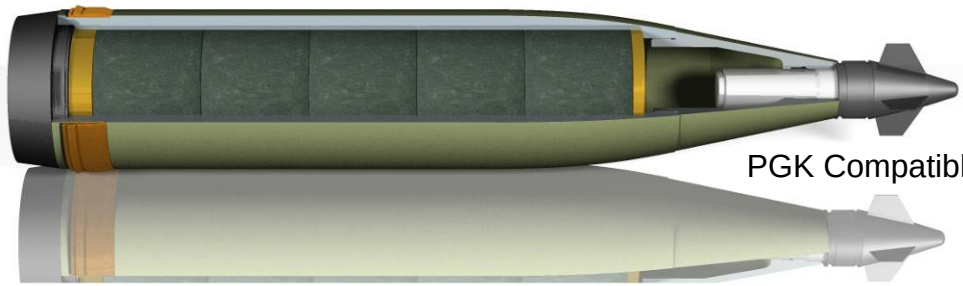
Improvements to meet ICM current requirements

- Near Surface bursting
- Warhead optimization for Anti-personnel capability
- Weapon integration – carrier for CSS

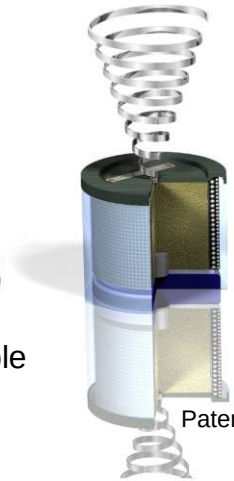
PRo**X**imity **I**nitiated **S**ubmunition

- Extreme Reliability Tri-Mode Proximity Fuze (0.99999)
  - Proximity 0.97
  - Impact 0.98
  - Time 0.98
- Goal-99 Proximity/Impact/Time reliabilities at 0.99 provides **1 in a million UXO**
- Pre-Formed Fragmentation (PFF) Dual Sized Tungsten Ball Matrix for anti-personnel and light materiel effects
- Fragmenting Steel Casing for Anti-Materiel Effects
- IM Explosive

Reutilize M483A1 Metal Parts



PGK Compatible

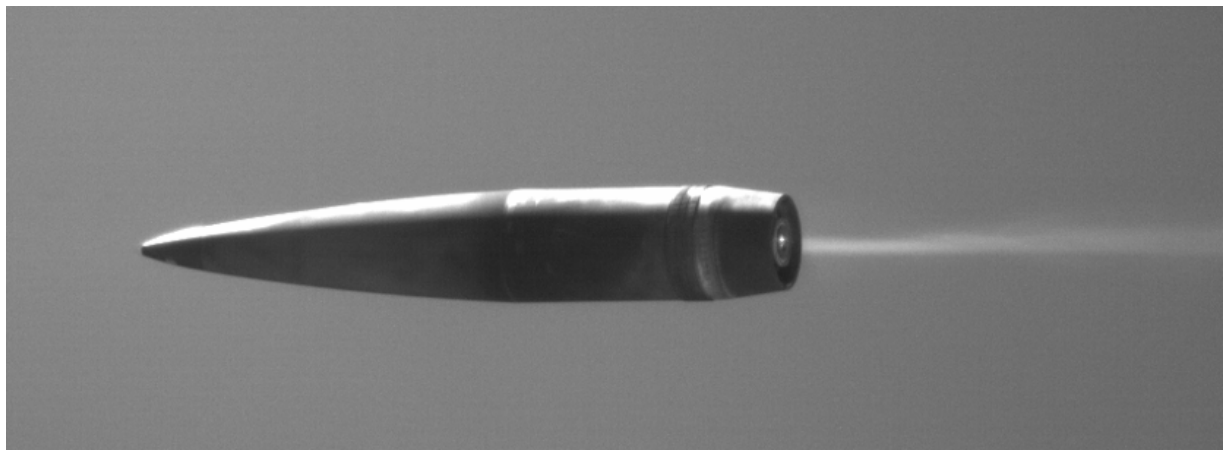


Patent Pending

5 Full Bore Submunitions

XM1113 Extended Range Artillery

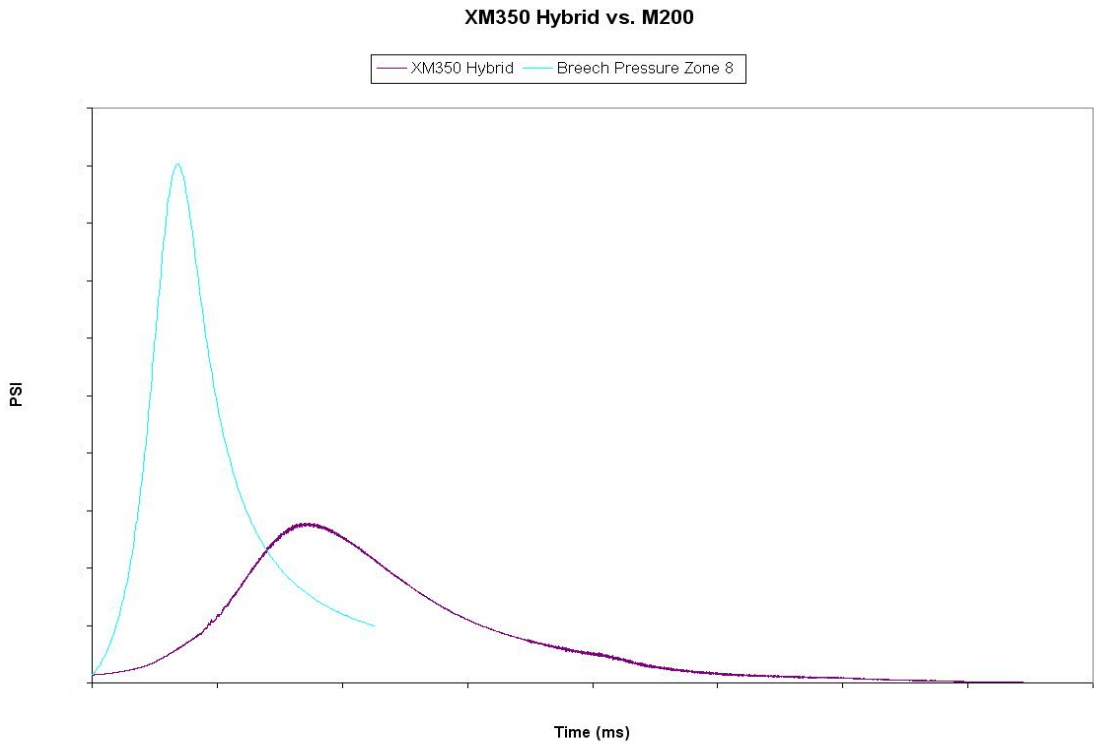
- Reach NLOS-C ORD requirement of 30 km (Threshold)
- Exceeds 40 km range in current 39 Cal systems
- Low cost solution based on proven technologies



XM1113 Range Demo 2007

XM350 Hybrid Propellant

- Goal: To replace M67 and M200 with a single propelling charge
- Consists of 6 Semi-fixed bag increments marked 1-6
- Combined the 6 bags create 1 zoned charge

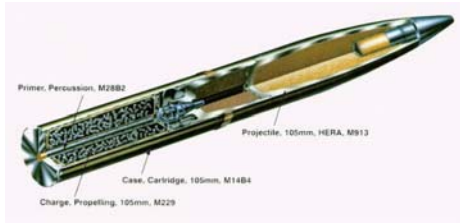


Scalable Technology for Adaptive Response (STAR)

Replace current DPICM cargo

M483

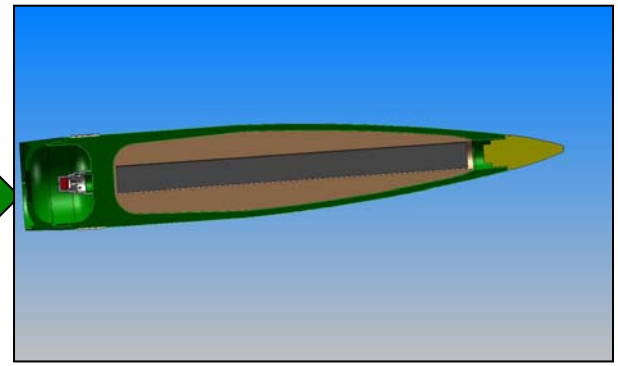
M795



M913

- Description: Develop enhanced capabilities for Artillery
  - Scaleable Output/Controlled Lethal Effects
  - Hardened for structures
  - Lower fire mission costs
  - Broader target set using adaptive response
  - Reduced collateral damage
- Warheads for:
  - 155mm: M483A1 & M795
  - 105mm: M913
- When Available: 3rd QTR FY11
- Metrics: Adaptive lethality (increase X% vs. materiel targets) and reduce collateral damage by 25% (min)

Technical Approach for STAR



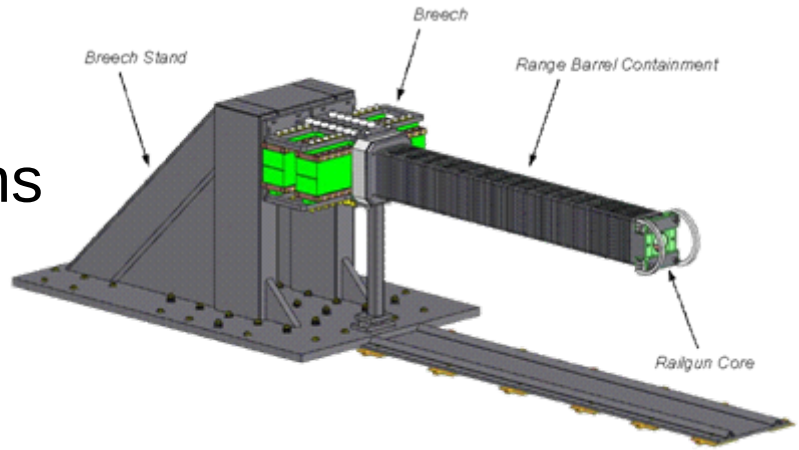
Develop and integrate new technologies

- Novel Energetics (Explosives & Propulsion)
- Combined Effects & Scaleable Effects Explosives
- Enhanced Fragmentation
- Advanced Fuzing
- Precision Guidance Kits

The EM Mortar Program Goals

Objective:

- To evaluate and demonstrate ElectroMagnetic (EM) launch technology as related to the missions of an advanced mortar weapon for the Future Combat Systems (FCS).



Goals:

- Design and demonstrate EM guns (coilgun and railgun) capable of firing modified 120 mm mortar rounds at velocities up to 420 m/s.

Tribute to Artillery

Acronyms

- NLOS – Non Line of Site
- MLRS – Multiple Launch Rocket System
- HE – High Explosive
- ICM – Improved Conventional Munition
- TNT – Tri-Nitro Toluene
- DPICM – Dual Purpose Improved Conventional Munition
- CEP – Circular Error Probability
- BB – Base Bleed
- RAP – Rocket Assist Projectile
- HOB – Height of Burst
- SAASM – Selective Availability Anti-Spoofing Module
- CFD – Computational Fluid Dynamics
- UXO – Unexploded Ordnance

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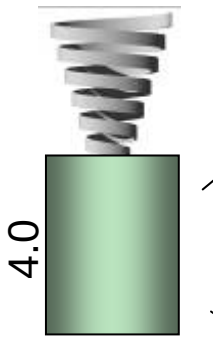
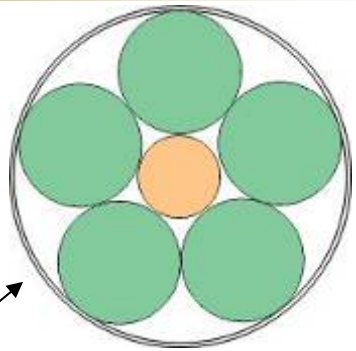
Backup

Artillery and Missile Applications

PRAXIS





G-MLRS
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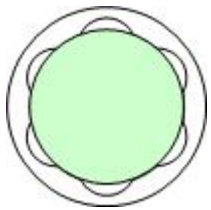
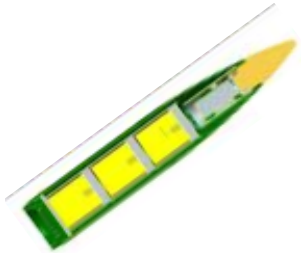
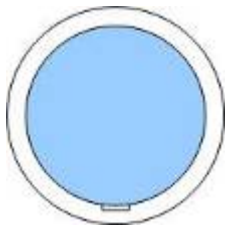


M915
(3)

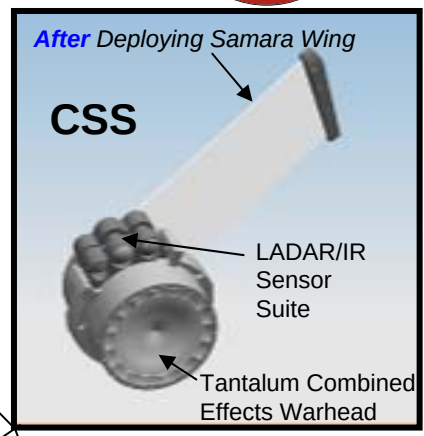


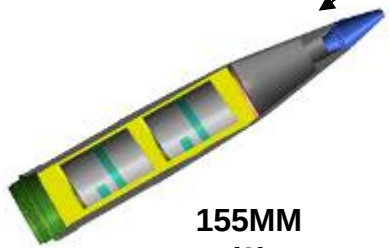


155mm
(5)

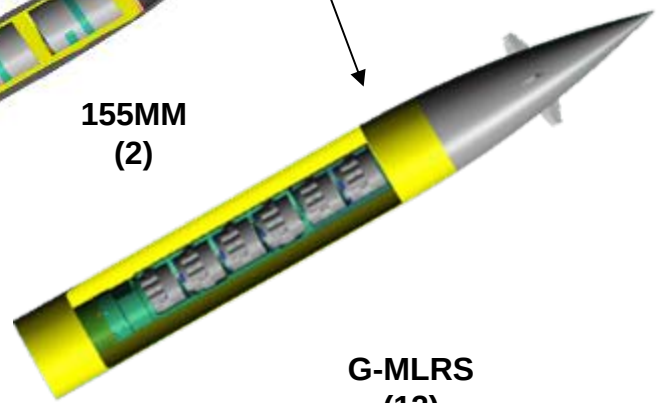
CSS

105MM
(2 Resized)





155MM
(2)



G-MLRS
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