



The University of Texas at Austin



# Eraser



# ***Transitioning EM Railgun Technology to the Warfighter***

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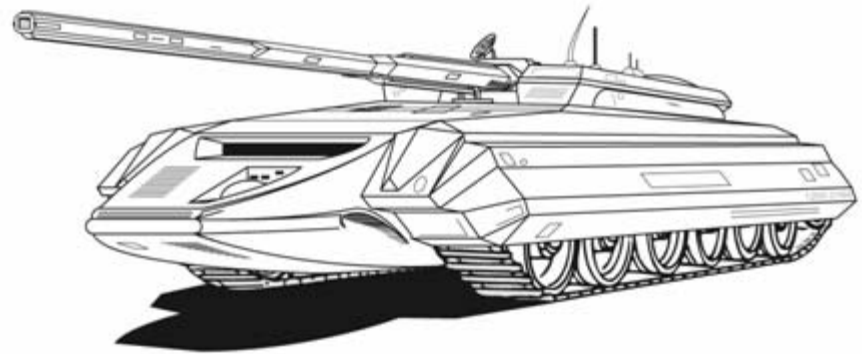


# The Governator is correct!

- At the IAT, we are harnessing large quantities of electric energy to enable radically new capabilities for the warfighter.
- These new electric weapons are capable of accelerating high energy hypervelocity projectiles from electric railguns on land, sea, and air platforms,



**Electric guns are real.**



and are capable of protecting these platforms by electromagnetic protection systems.



# Hypervelocity Electromagnetic Railguns

What are they?

How do they work?

Why change to electromagnetic energy?

How can we use them?

When can we have them?

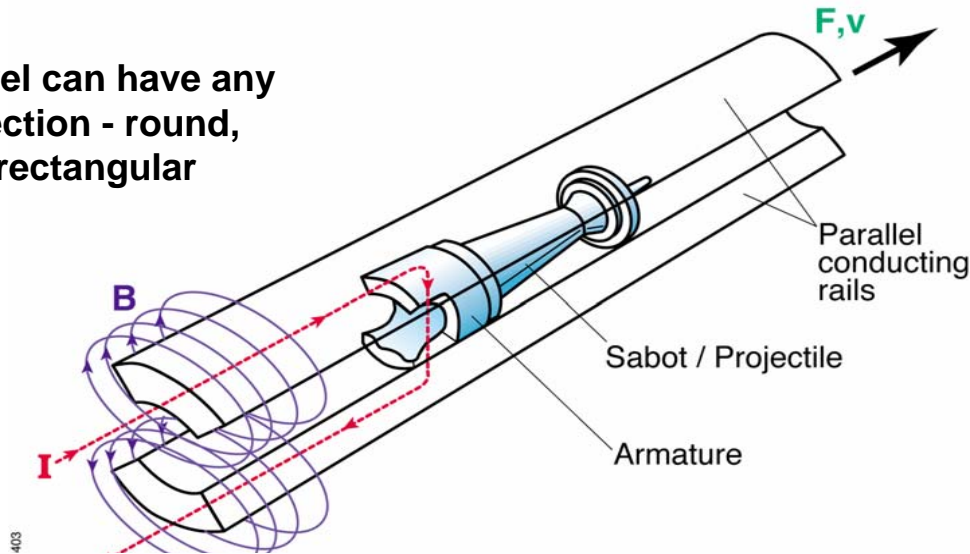
What are the implications for the Army and the Navy?



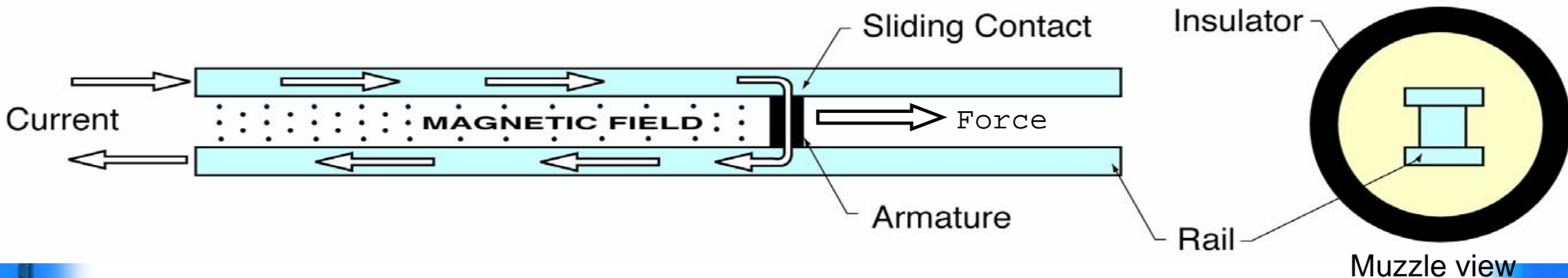
# What is an Electromagnetic Railgun?

Converts Electricity to Kinetic Energy

The barrel can have any cross section - round, square, rectangular



The accelerating Force is provided by Electromagnetic Forces and can accelerate projectiles to very high velocities



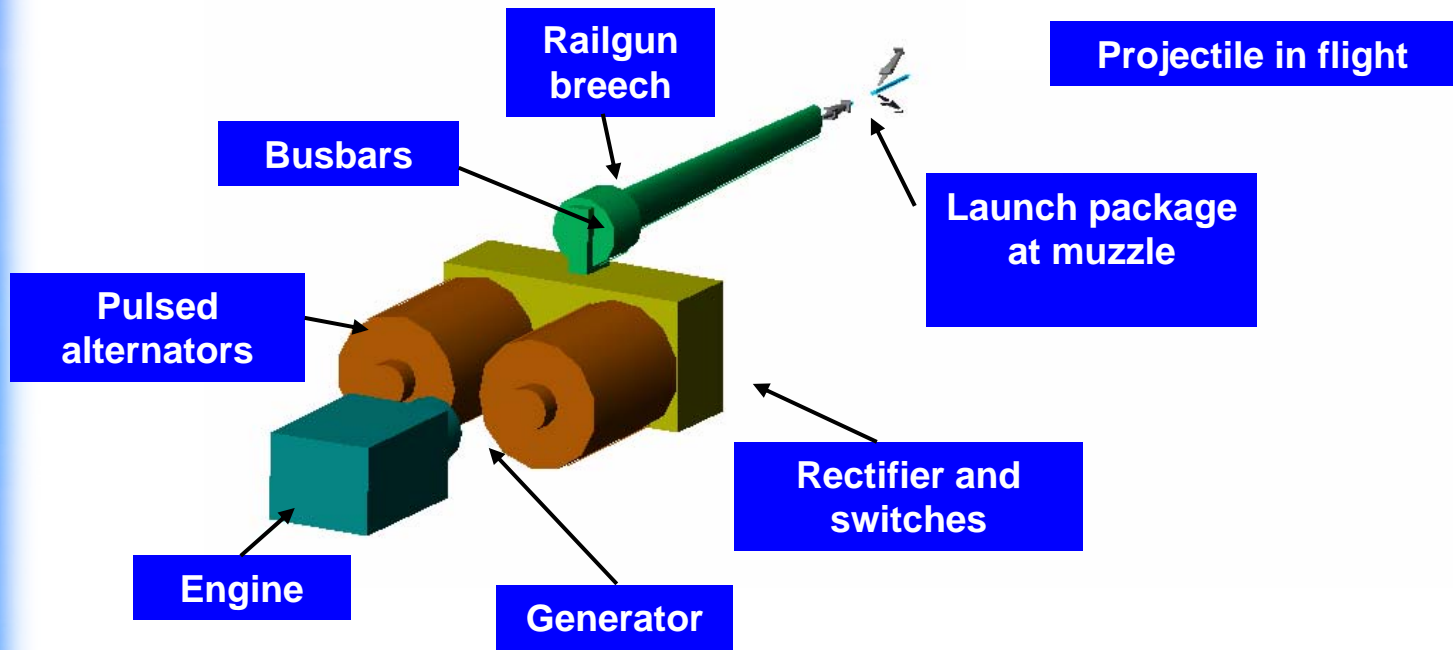
**We routinely launch projectiles to hypervelocities (from 2-6 km/sec) in our laboratory.**



# What is an Electromagnetic Railgun System?



Target defeat



The IAT addresses the critical issues for all of these components for direct and indirect fire



# Why Transform to Electromagnetic Energy?

- **Controlled/Precise/Variable Lethality** – Non lethal to overwhelming lethality (1 to 1000 km)
- **Increased Battle Space** – Capable of extremely long ranges
- **Survivability** - No hazardous propellants and possibly no explosives on board
- **Logistics** - Smaller ammunition (8% of mass – 10% of volume for direct fire) - Eliminate propelling charges for NLOS/long range fires
- **Operational Flexibility**
  - Convert fuel to kinetic energy
  - shorter time of flight
  - Multi role, multi mission
  - Minimum / controlled collateral damage
- **Entirely New Missions** – ultra long range precision strike(up to 1000km )

Positions DoD industrial base to more accurately reflect changes in U. S. economy.

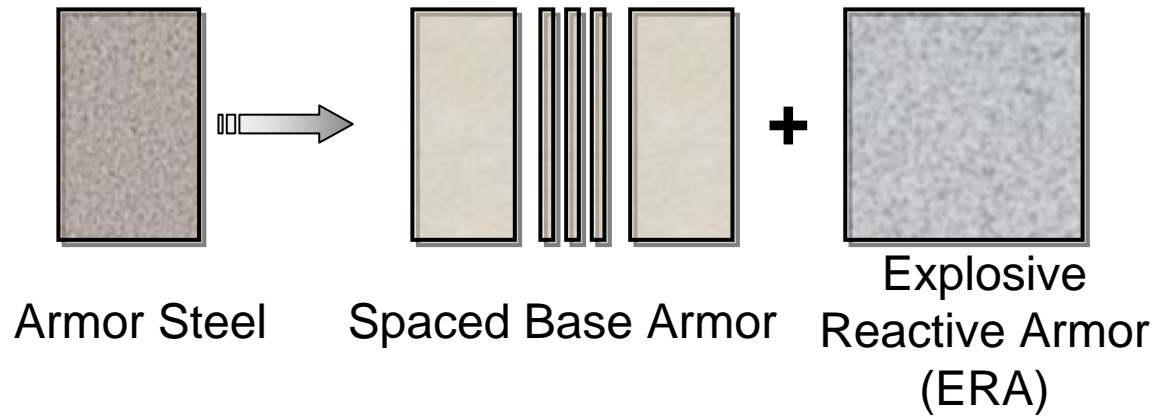


# What are the Critical Science & Technology Challenges?

- **Hypervelocity Lethality**
  - Defeat of Modern Armor
  - Hypervelocity Guidance and Control
- **Electromagnetic Railgun Lifetime**
- **Electric Power**
- **Power Conditioning/Switching**



# Greatest Lethality Challenge

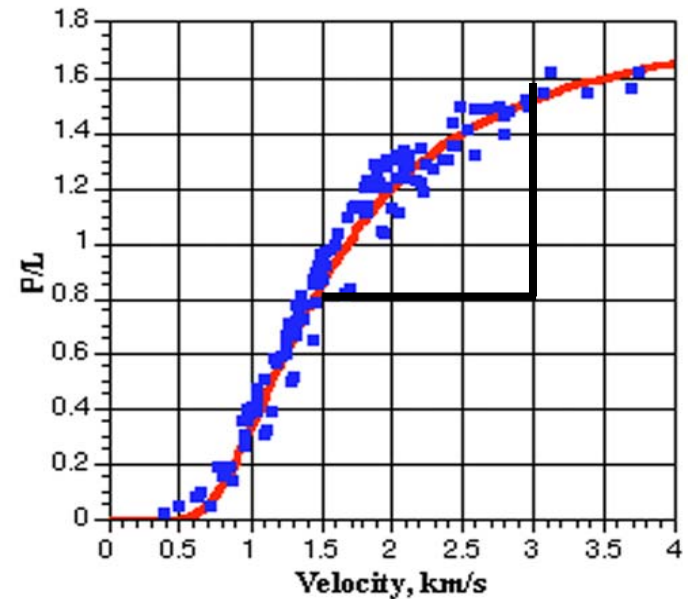


**Explosive Reactive  
Armor defeats shaped  
charge warheads and  
kinetic energy rods  
and can be retrofitted  
to combat vehicles**



# Lethality: Direct-Fire Hypervelocity Novel Tungsten Penetrators Defeat Current and Future Armors

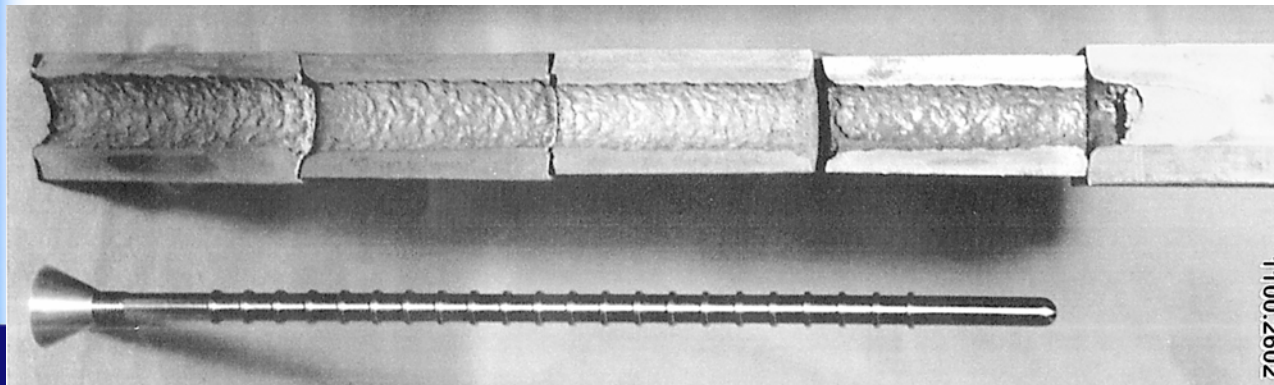
$$\frac{P}{L} \approx \sqrt{\frac{\rho_P}{\rho_T}} f(V)$$



*Hypervelocity rods penetrate more because target strength is overwhelmed.*



**M-1 Abrams  
Muzzle Velocity**

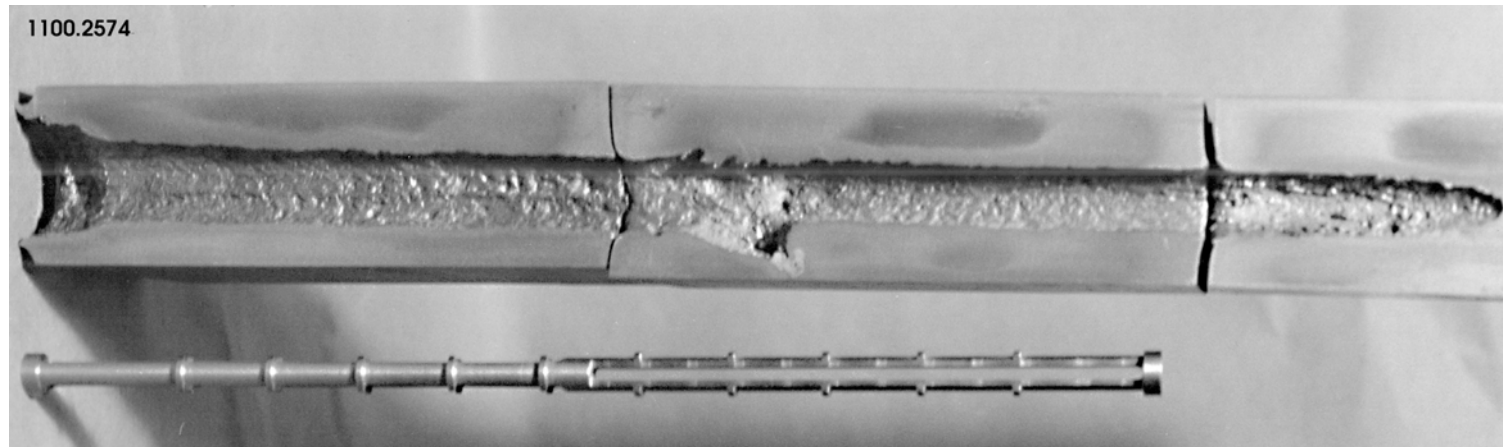
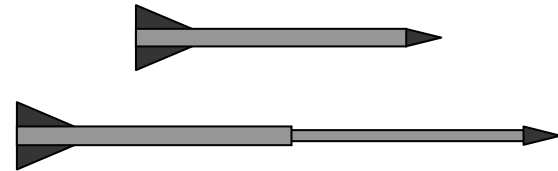


# Hypervelocity Provides Important New Capabilities

$$P=L \sqrt{\frac{\rho_P}{\rho_T}} f(V)$$

## IAT Extending penetrators:

- Launch and fly long rod to target
  - Extend before impact
- Impact in extended configuration



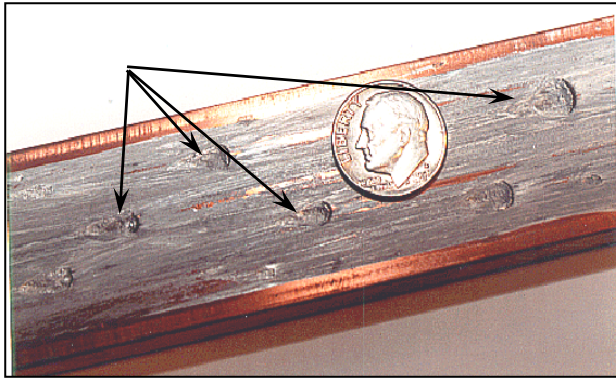
# Hypervelocity Lethality



- Understanding the physics at impact has enabled us to develop hypervelocity novel penetrators which can provide the
    - Lethality overmatch
- And more importantly
- The necessary lethality with significantly **reduced launch energy**



# Railgun Lifetime Challenges



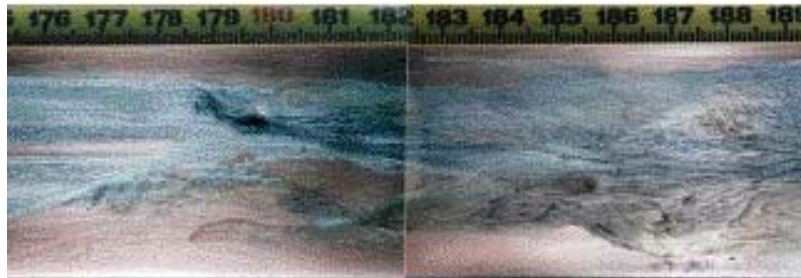
## Gouging

- Surfaces rub past each other at high speed



## Muzzle Blast

- High temperature muzzle arc (20,000 K)
- Severe damage to ends of rails and insulators
- Large optical/thermal signature



## Arc Transition

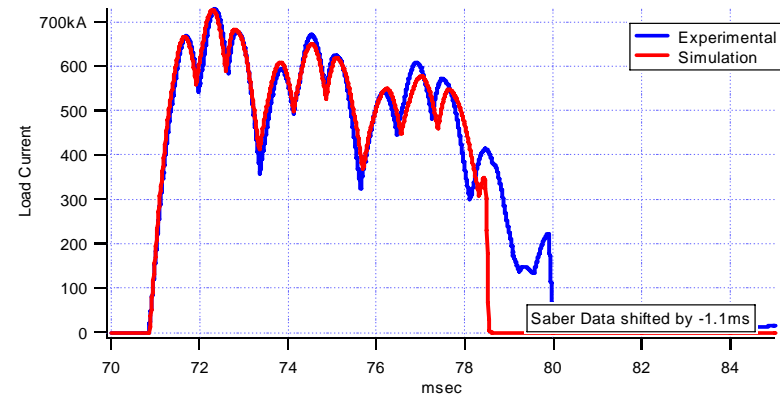
- 20,000 K arc at rail/armature interface

**All of these critical challenges are resolved**

# Power Source - The Major Technical Challenge for Army Applications



- IAT developed a simulation for a new type of pulsed alternator – providing an independent validation tool for Government and industry
- Pulsed alternator technology transitioned from UT Center for Electromechanics to Industry (Curtiss-Wright)

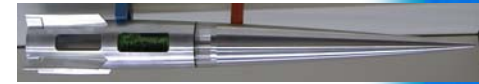
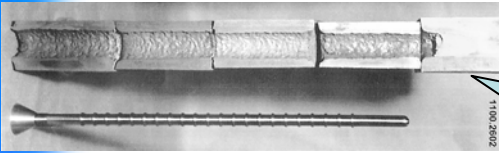


Combines flywheel and pulsed alternator technologies

# In the past several years, all of the critical “showstoppers” have been resolved

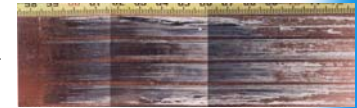
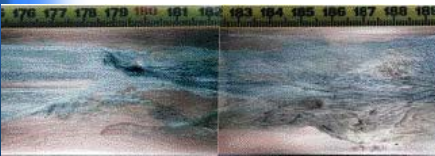
## • Hypervelocity projectiles:

- Tungsten nose tips **survived** hypervelocity flight up to 3 km/sec.
- Hypervelocity rods **penetrate** more because **target strength is overwhelmed**.
- Novel hypervelocity projectiles have been fabricated with **low parasitic mass**
- Electronic components for guidance, navigation and control have been tested above **100kgees**



## • Railgun Bore Life:

- Hypervelocity **gouging eliminated** by proper choice of materials
- **Transition** to arcing contact at hypervelocity **eliminated** by novel E M Gun designs which also eliminate contact and damage to insulators
- **Multiple shots** on single set of rails (60 shots for Navy-similar test series underway for Army)



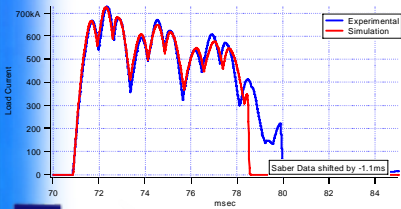
## • Signature

- Muzzle shunt **reduced muzzle blast** by 3 orders of magnitude



## • Pulsed Electromagnetic Power

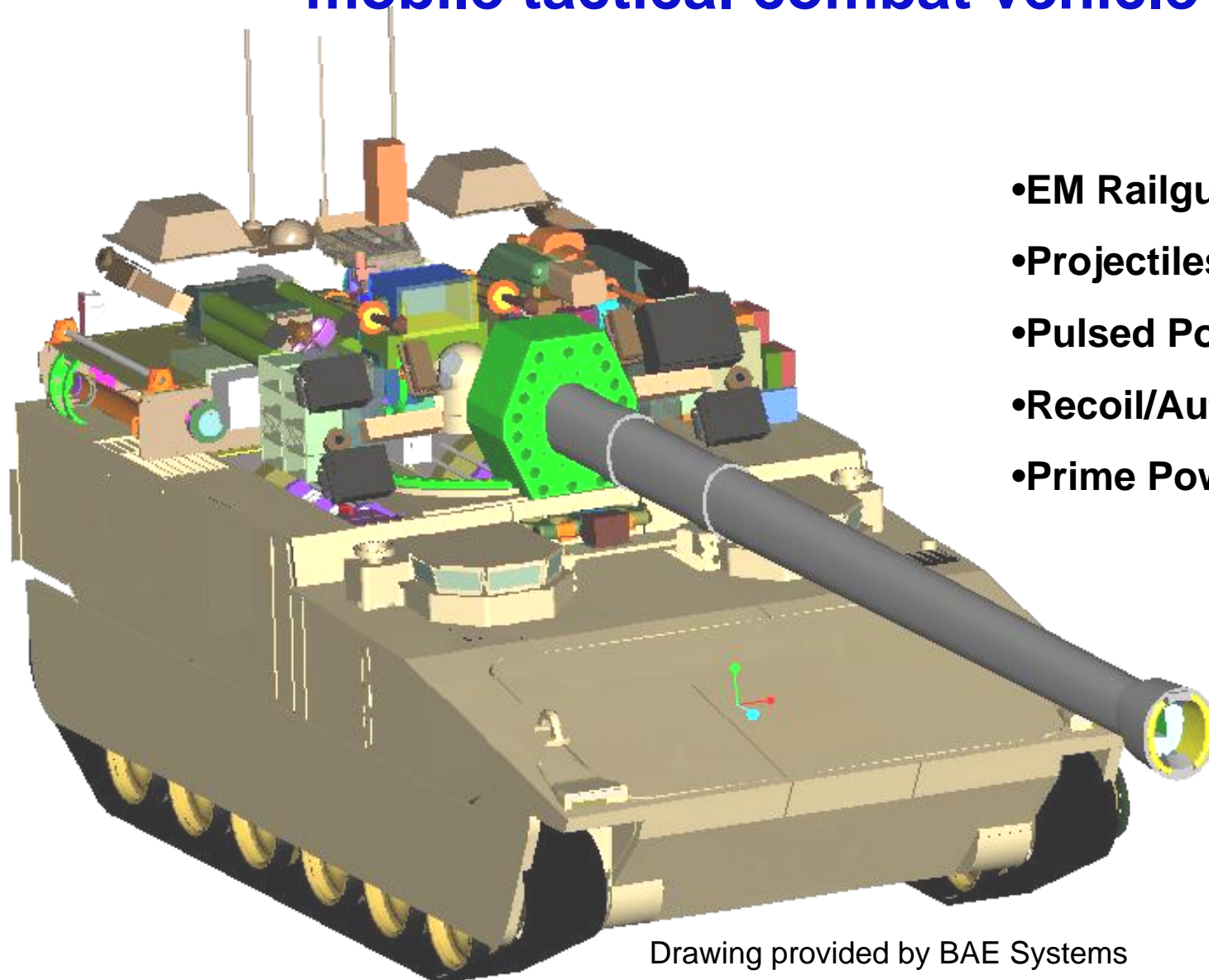
- A **simulation** for a new type of pulsed alternator provided an independent validation tool for Government and industry
- **Pulsed alternator** technology transitioned from UT Center for Electromechanics to **Industry**





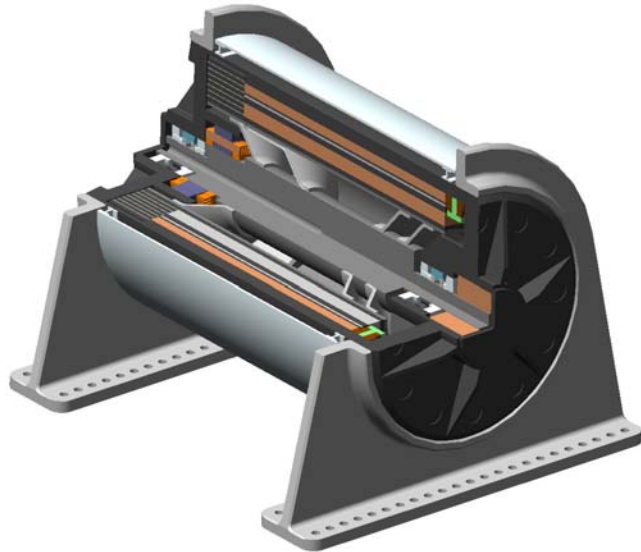
# Can EM technology be integrated into a mobile tactical combat vehicle?

- EM Railgun
- Projectiles
- Pulsed Power Supply
- Recoil/Auto Loader
- Prime Power



Drawing provided by BAE Systems

# New Types of Electric Pulsed Power Sources are Required



- A pulsed alternator stores kinetic energy in the rotor and converts kinetic to electric energy to power the railgun.

- The pulsed alternator incorporates an integral flywheel to store energy for a number of shots without recharge.

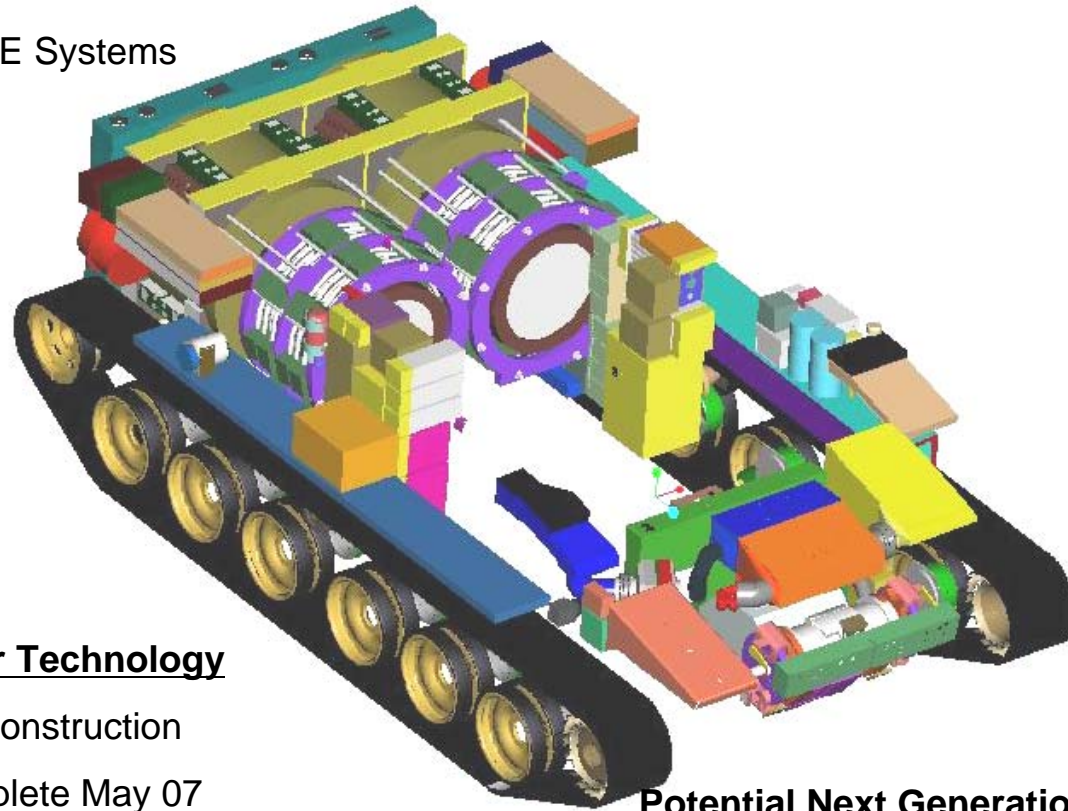
- Recharge occurs with an electric motor powered from the hybrid vehicle engine/generator/battery.



- ARDEC has contracted with Curtis-Wright to build a power source to provide 2-5MJ kinetic energy at railgun muzzle.

# Direct Fire – Pulsed Alternators and Low Energy Hypervelocity Projectiles are the Enabling Technologies

Drawing provided by BAE Systems



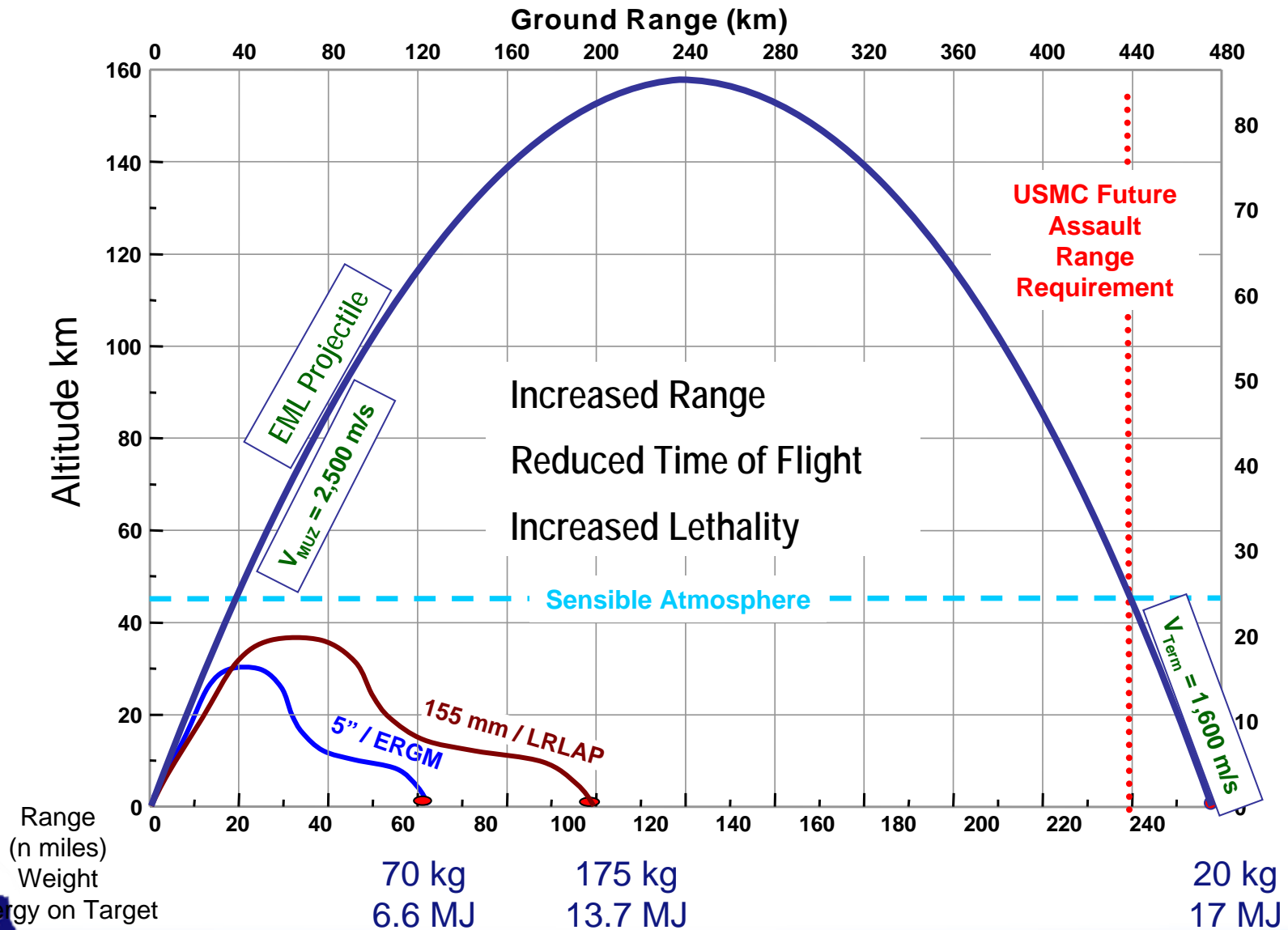
## Current Pulsed Alternator Technology

- Pulsed alternator under construction
  - First alternator complete May 07
  - Alternator system complete FY08
- 2-5MJ muzzle KE
- Volume 1.9 m<sup>3</sup>
- Mass 7000 kg

## Potential Next Generation Power Source

- Pulsed alternators completion FY(10-11?)
- 8-10MJ muzzle KE
- Volume 1.5m<sup>3</sup>
- Mass 4000kg

# DARPA challenged IAT to evaluate Electromagnetic Launch to provide Unprecedented Gun Ranges



# Innovative Naval Prototypes

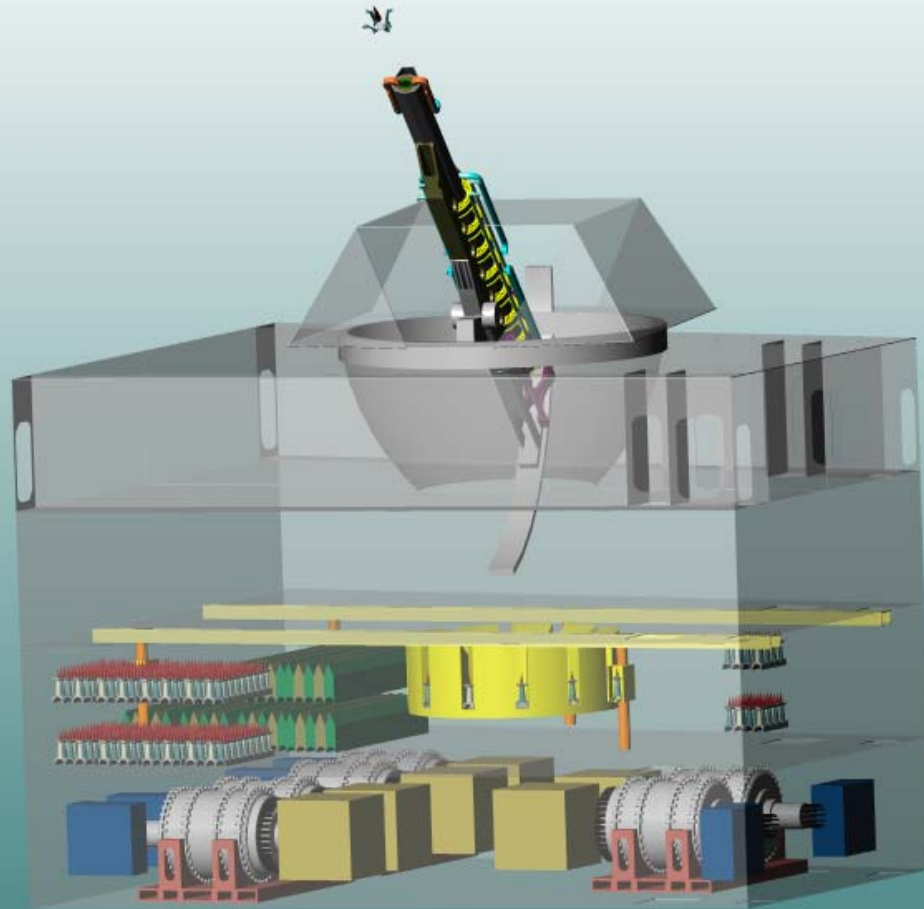
- **Disruptive technologies** that for reasons of high risk or radical departure from established requirements and concepts of operation are unlikely to survive without **top leadership endorsement**.



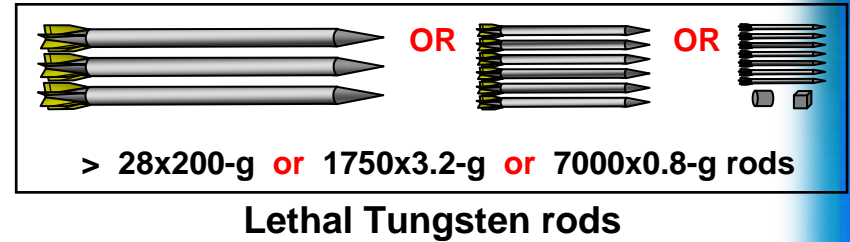
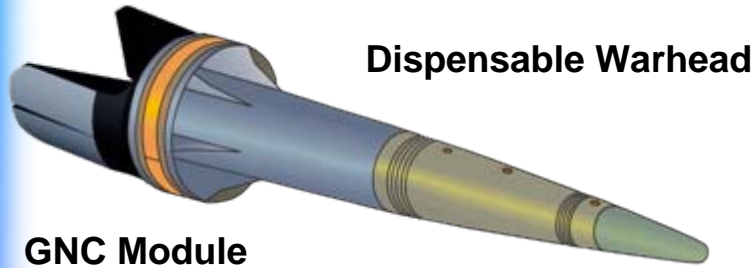
*Admiral Michael G. Mullen USN. - CNO*

**The Electromagnetic Railgun has been selected  
as the First Innovative Naval Prototype**

# Sea-based Long Range Precision Fires

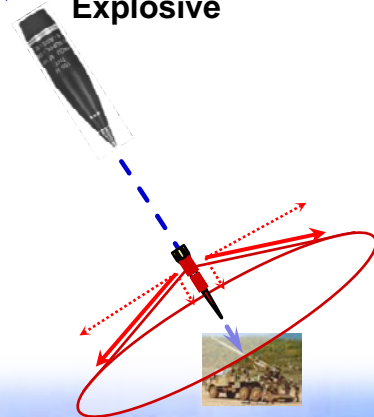


# Lethality: In-Direct Fire KE Provides Rain of High Velocity Rods

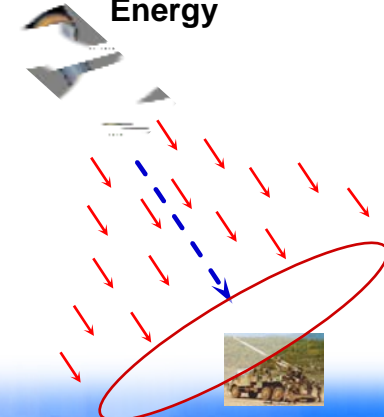


- Inert tungsten rods
- Uniform lethality over impact area
- Control impact area by height of dispersal
- Minimum collateral damage

**Conventional High Explosive**

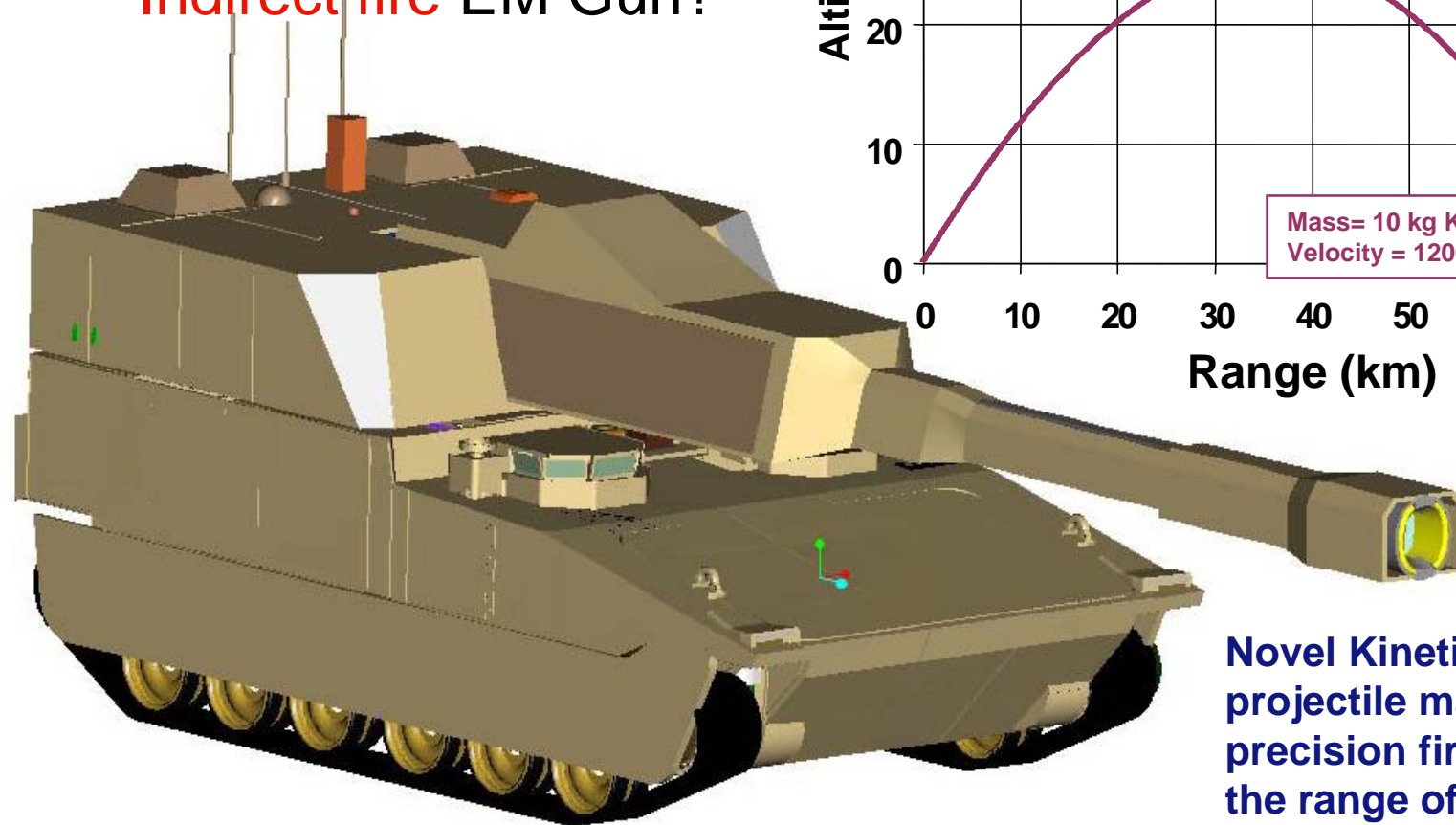
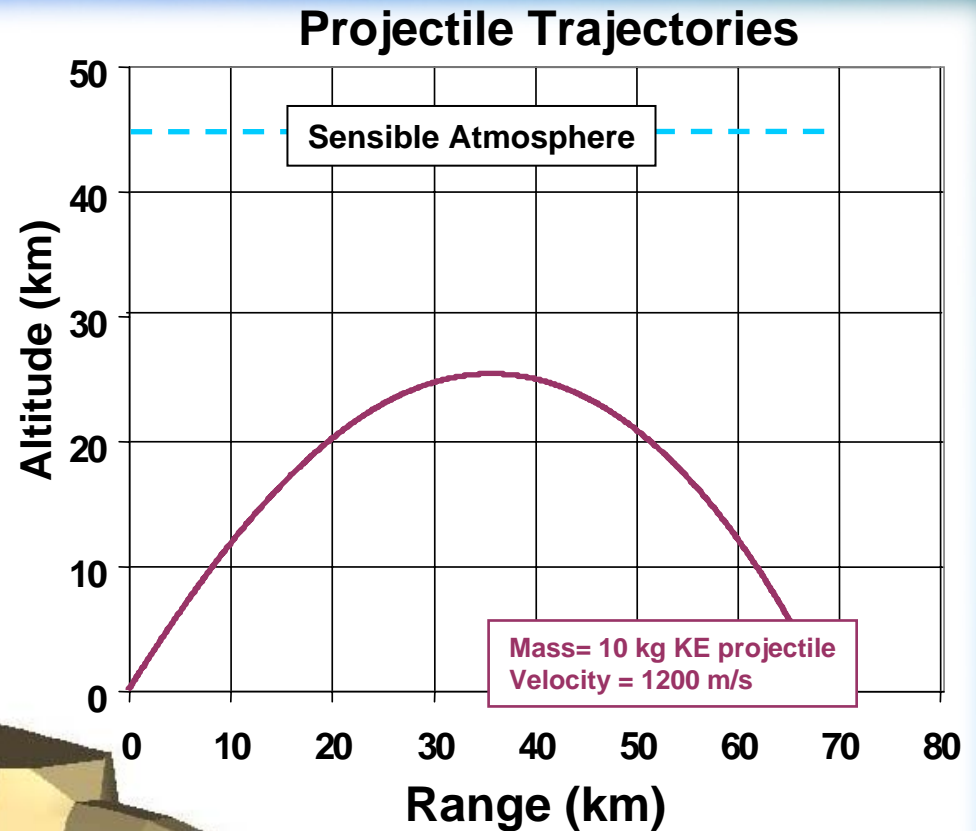


**EM Kinetic Energy**



# Long Range Precision Fires:

What is the expected performance of an **Indirect fire** EM Gun?



**Novel Kinetic energy projectile may provide precision fires at 2-3 times the range of conventional artillery munitions.**

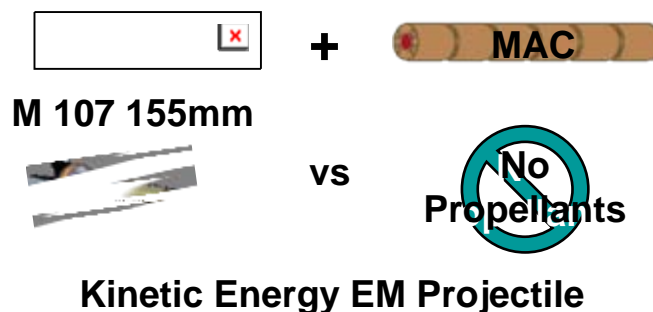


# Survivability and Logistics Implications

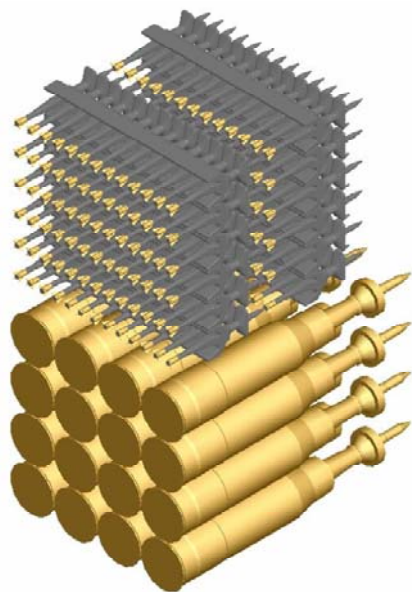
## Precision Direct Fire



## Precision In-Direct Fire



150 Inert EM KE  
Projectiles  
packaged in  
same space as  
16 M829s



8% the Volume  
10% the Weight

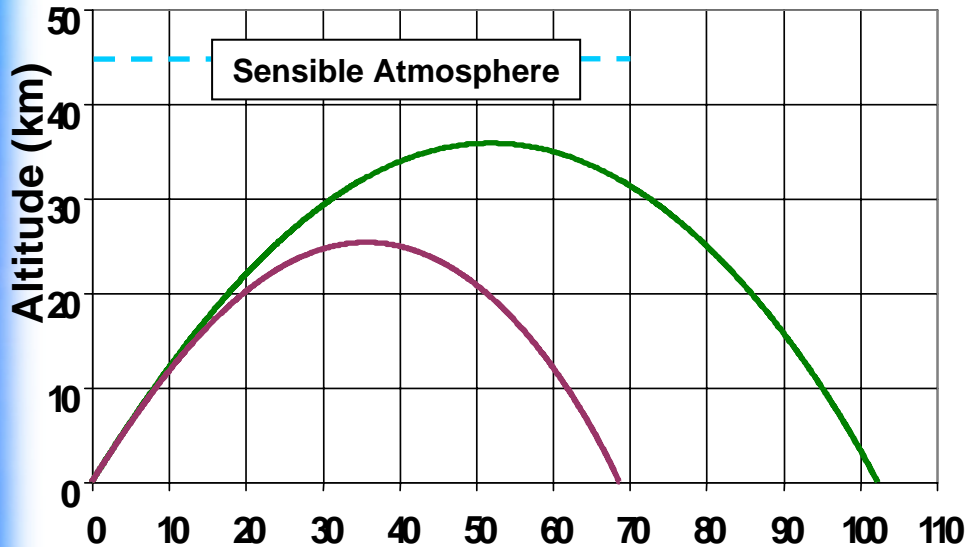
## Eliminate/Reduce:

- Propellants and propellant charges
- Army propellant manufacturing facilities
- Army loading facilities
- Army propellant lifetime assessment
- Shipping and storage of hazardous materials

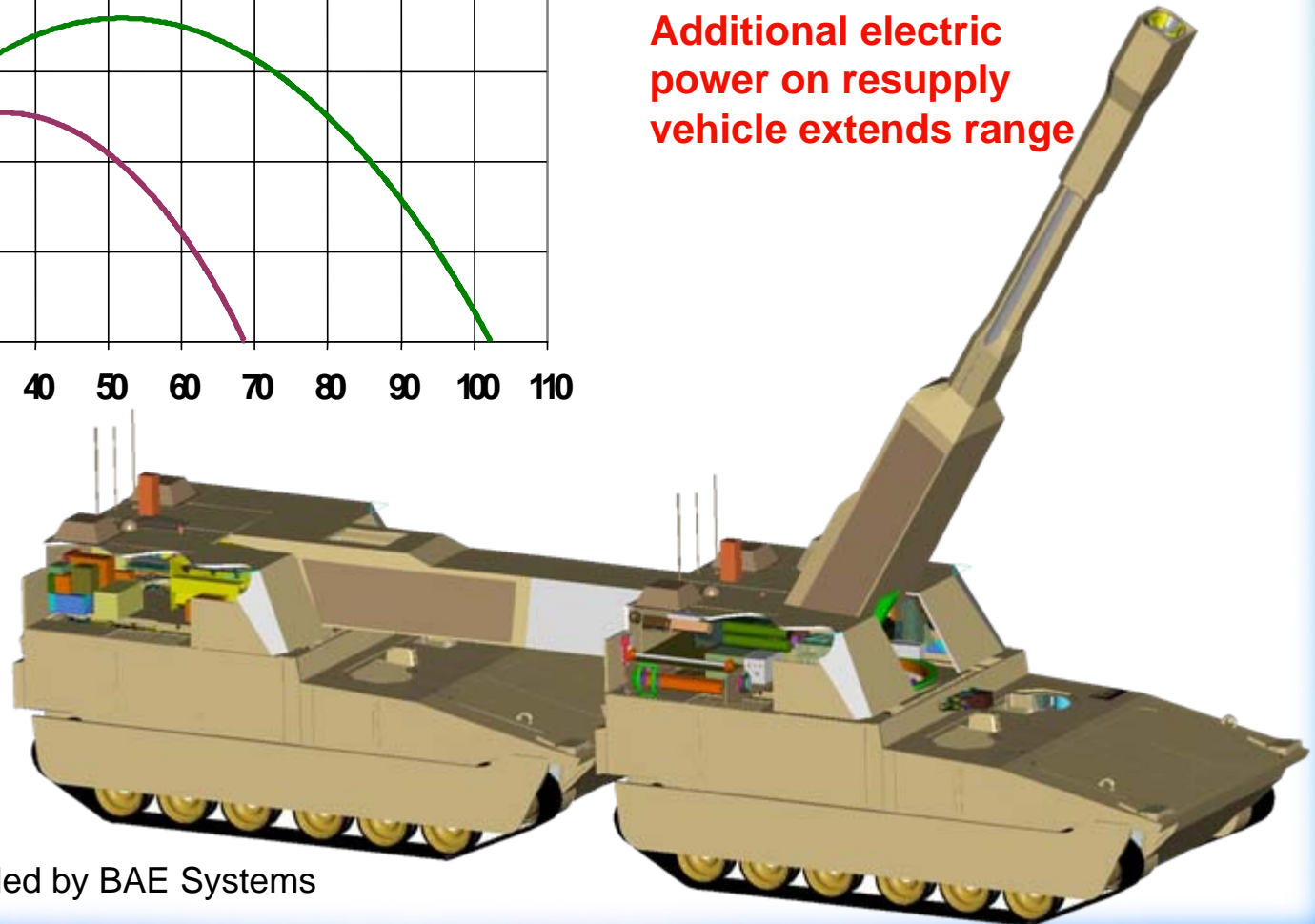
## Reduction of:

- Trucks
- Truck drivers } convert to warfighters
- O&M costs

The elimination of propelling charges (MACs) provides space for additional electric power in the resupply vehicle.



Additional electric power on resupply vehicle extends range



Drawing provided by BAE Systems

IAT Talk 1358

# Summary

- **We have been successful in achieving major advances** in the fundamental science and technology of EM Railguns
- The Army and Navy are actively pursuing ground and sea-based EM Railgun **applications**
- The implementation of EM Railgun technology will not only provide the opportunity to **replace** or significantly **enhance** existing weapon capabilities, but will provide the National leadership **revolutionary new tactical and strategic** options
- The **IAT commitment** is to ensure that when EM Railguns are employed, they will be in the hands of U.S. Forces.
- **We are seeking your help** to provide insight and manufacturing, engineering and integration competence so that unmatched revolutionary capabilities are available to our warfighters

