



***LOW RECOIL, HEAT TRANSFER MITIGATING
RAREFACTION WAVE GUN ENGINEERING, MODELING
AND LARGE CALIBER SYSTEM DEMONSTRATOR
DEVELOPMENT***

**BRIEFING FOR THE NDIA GUNS AND MISSILE SYSTEMS
CONFERENCE - APRIL 23 – 26, 2007**



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**WEAPON SYSTEMS &
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LOW RECOIL, HEAT TRANSFER MITIGATING RAREFACTION WAVE GUN ENGINEERING, MODELING AND LARGE CALIBER SYSTEM DEMONSTRATOR DEVELOPMENT



- **SONIC RAREFACTION WAVE GUN TECHNOLOGY**
- **ENGINEERING DEVELOPMENT**
 - **MODELING & SIMULATION**
 - **DESIGN & ENGINEERING**
 - **PERFORMANCE TESTING**
- **TRANSITION**
- **SUMMARY**



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► Sonic **RAREFACTION WAVE GUN** (RAVEN) is a Projectile Launch Method that achieves:

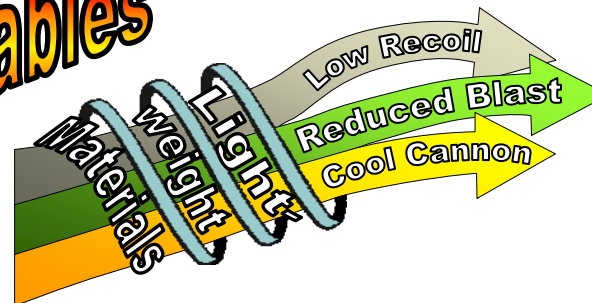
- ✓ Unprecedented Reductions in Recoil Impulse
- ✓ Significant Reductions in Gun Barrel Heating
- ✓ Muzzle Blast Reduction

RAVEN was [Invented at Benet Laboratories](#), US Army, Oct 2002 by Dr. Eric Kathe (Patent: 6,460,446)

While Maintaining the Efficiency & High Projectile Velocity of Conventional Guns (No Loss in Projectile Velocity)



RAVEN Enables



Lightweight Systems

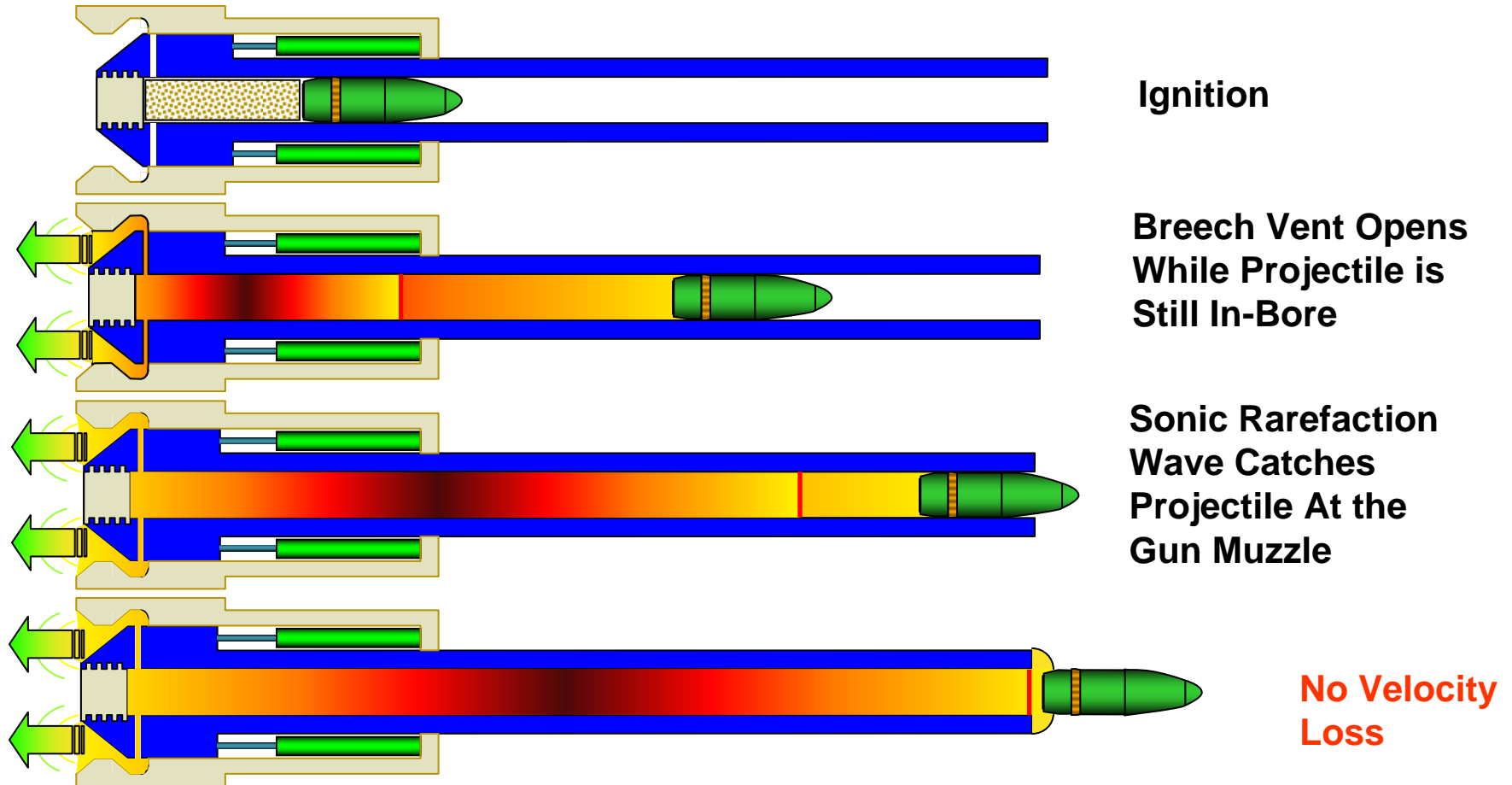


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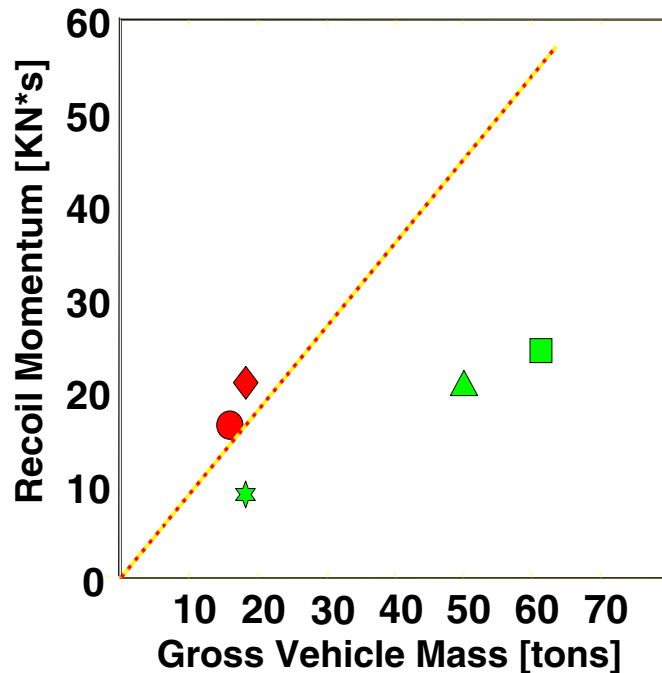


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50% - 100% Recoil Reduction for No Velocity Loss

- High Velocity Guns Can Be Nearly Recoilless
- High Efficiency Recoilless Operation Obtainable
- Can Maintain High Lethality on a Lighter Platform



●	M551	116%	OSL
■	M1A1	49%	OSL
◆	M8 AGS	128%	OSL
▲	M60A1	43%	OSL
★	105mm RAVEN	54%	OSL
---	Ogorkiewicz Stability Limit (OSL)		

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- **Approximately 50% Reduction in Barrel Heating**
 - Enables Lightweight Gun Barrel Technology
 - Allows Increased Firing Rate
 - Mitigates Need for Erosion Protective Coatings
 - May Use More Energetic Propellants

- **Approximately 2/3 Reduction in Muzzle Blast**
 - Lower Vision Obscuration
 - Lower Overpressure on Front of Vehicle/Platform

- **Control of Muzzle Velocity via Rarefaction Wave (ex.: artillery zoning)**



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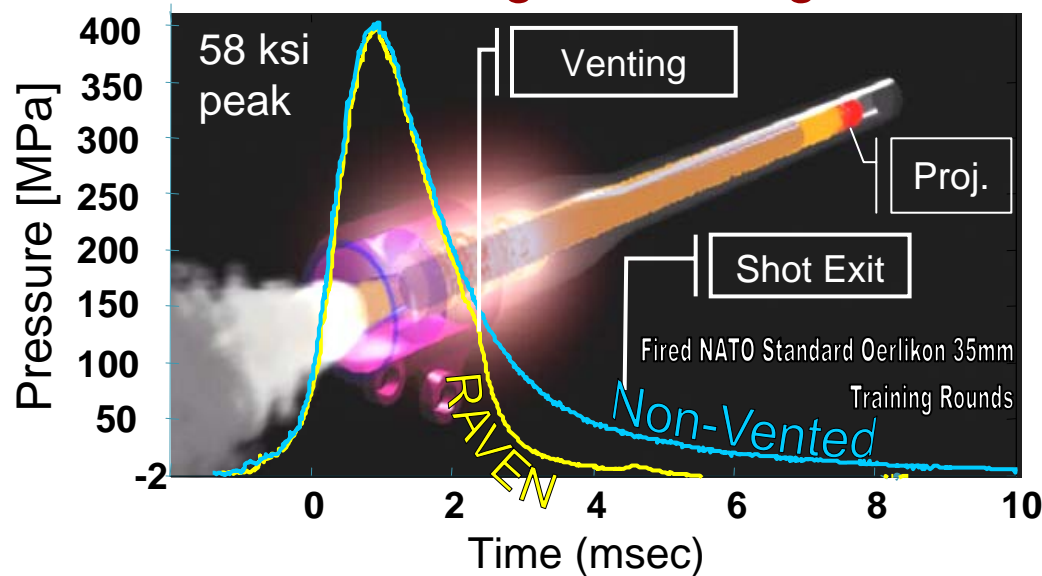
• 35mm Rarefaction Wave Gun Demonstration

- Inertial Breech Vent
- External Breech Guide
- Thrust Generating Exhaust Nozzle



35mm Proof-of-Principle RAVEN Cannon

Proven Through 35mm Firing Tests



- ✓ 61% Recoil Reduction
- ✓ 41% Heat Transfer Reduction
- ✓ No Loss of Muzzle Velocity

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ENGINEERING DEVELOPMENT & DEMONSTRATION

• ARDEC Technology Base Program Objectives

- ✓ Advance Sonic Rarefaction Wave gun (RAVEN) technology (from TRL 4) Enabling
 - Lightweight Cannons & Firing Platforms
 - Reduced Heat Transfer / Higher Rates of Fire
- ✓ Demonstrate TRL 5 for large caliber RAVEN Cannon (Direct & Indirect Fire)
- ✓ Integrate State-of-the-Art materials and processing technology for minimum system weight and maximum performance
- ✓ Transition technology into a solution for Army and other Defense/Commercial needs

	 Advanced Interior Ballistics Models	 MSI MENTIS SCIENCES, INC. 150 Dow Street, Tower Two • Manchester, NH 03101 603.624.9197 • Fax 603.624.9254	 SFSA ARES, Inc.	Design & Testing, Fabrication
Gun & Ammo Design, Systems Engineering	Advanced Materials Development & Application			

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- **Direct Fire RAVEN Demonstrator** (FY06 Design, FY07 Build & Test)
 - Based on 105mm FCS MRAAS Direct & Indirect Fire Cannon
 - Swing Chamber Allows Rear Venting & Rapid Fire
 - Rear Venting Cased Telescoped Ammunition (Slug Projectile)
 - Inertial Breech Vent to Expansion Nozzle (Thrust Generated)
 - Split Nozzle (Inertial Breech Cast Steel Outer Nozzle Slides Over Composite/Steel Fixed Inner Gun Nozzle)
- **Next Generation RAVEN Demonstrator** (FY07 Design, FY08 Build & Test)
 - Design for Minimum Weight – Advanced Materials
 - Alternative & More Efficient Vent Methods



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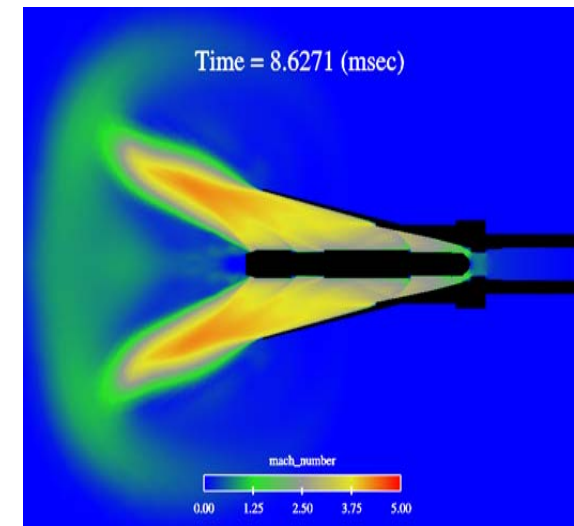
• Modeling & Simulation

New 1-D Finite Volume Interior Ballistics & Dynamics RAVEN Gun Design Tool

- Validated with 35mm RAVEN Closed Breech & Vented Firing Data
- Includes Recoil Brake, Muzzle Brake, Thrust, Heat Transfer Models

Computational Fluid Dynamics_Fluent, GTBL, NGEN

- 2-D Axis-Symmetric Fixed and MDM Modeling of Vent Gas flow
- Thrust, Heat Transfer & Shock Structure Analysis
- NGEN/CFD_Fluent Coupling (ARL/ARDEC FY07– 08)
- Erosion Modeling (ARDEC FY07 – FY08)
- Blast Field Modeling (SEA, Inc. FY08)



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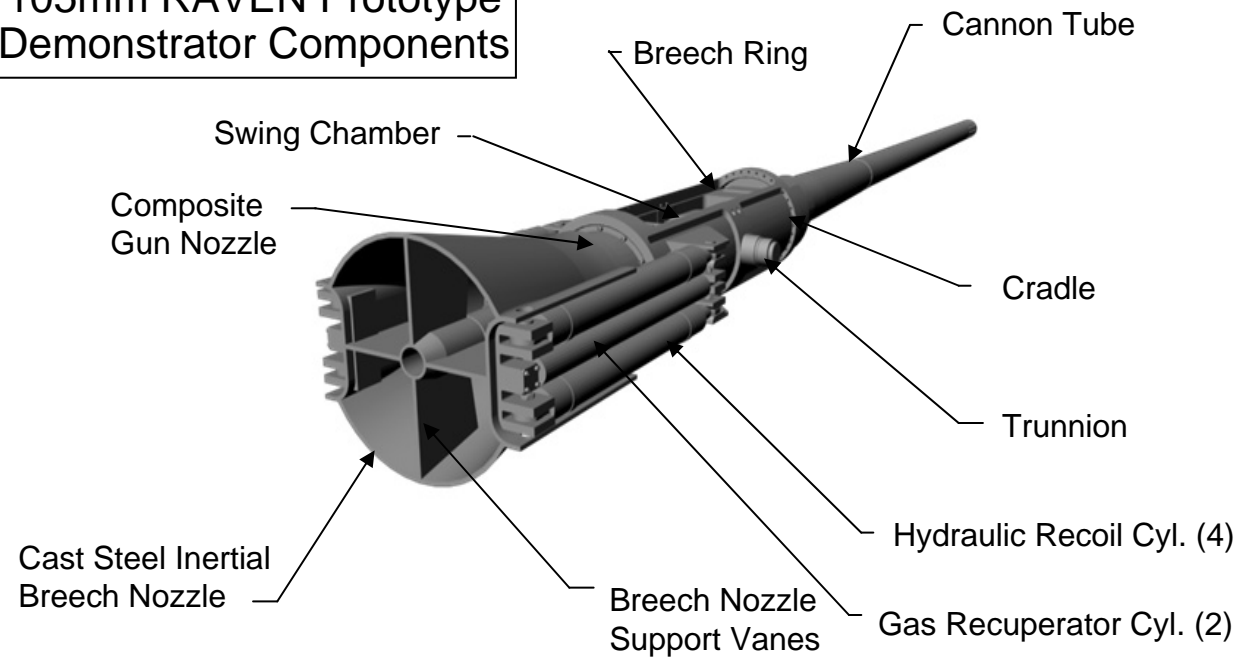
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105mm RAVEN Prototype Demonstrator Components



<u>System</u>	<u>Trunnion Impulse</u>	<u>Muzzle Energy*</u>	<u>Energy/Impulse</u>
105mm M68/M900	19,100 NS	7.86 MJ	412
105mm MRAAS/Slug	23,580 NS	8.97 MJ	380
120mm M256/M829A3	29,400 NS	11.7 MJ	398
105mm RAVEN	9,852 NS	8.76 MJ	889

* Ambient

**58% Recoil Reduction
Over RAVEN Closed Breech
& FCS MRAAS Baseline**

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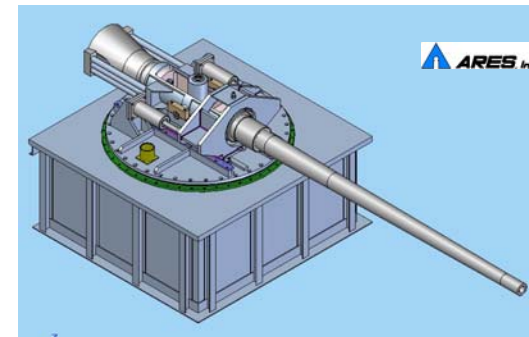
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• Performance Testing

- **Hardstand Testing _ M&S Validation**
 - Interior Ballistics Engineering Data
 - Recoil Dynamics Engineering Data
 - Thermal Measurements
 - Blast Field Characterization

- **Light Weight Vehicle Platform Testing**
 - Stability Analysis
 - Blast Field Characterization



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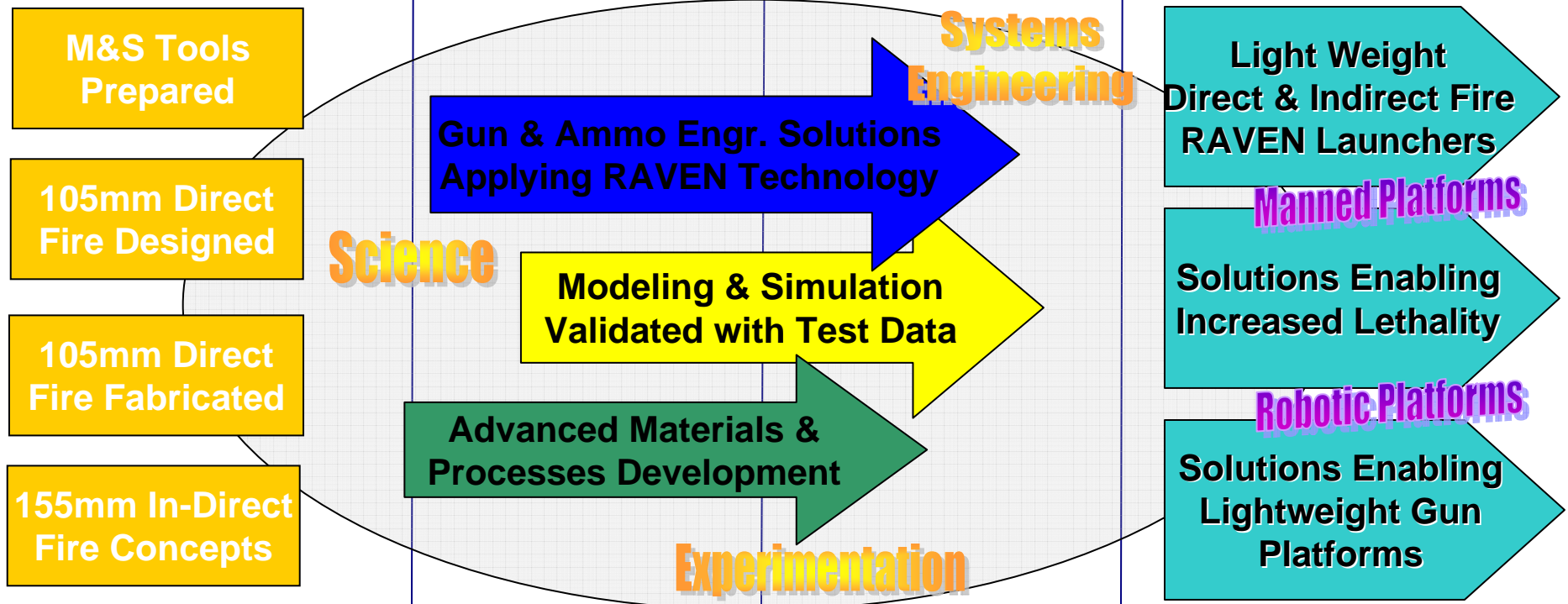


CURRENT STATE

TECHNOLOGY DEVELOPMENT & DEMONSTRATION

ENDSTATE

FY07	FY08	FY09	FY10+
Spiral Development – Medium & Large Caliber Technology Demonstrators			



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SUMMARY

- **State-of-the-Art Design, Analysis, M&S and Fabrication**
 - **Designed Utilizing State-of-the-Art Modeling & Simulation and Design Tools**
 - **Maximum Use of Advanced Materials & Manufacturing Processes**
- **RAVEN is a Breakthrough Generic Gun Technology that will Lighten the Force & Pave the Way for Next Generation High Mobility Projectile Launcher Systems**
 - **Light Weight Direct & Indirect Fire Systems Gun Systems**
 - **Mounted & Robotic Ground Platforms or Individual Weapons**
 - **Ground, Aerial, Naval or Amphibious Platforms**

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