Variable Volume Chamber Cannon (V^2C^2)

United Defense

Presented to:

NDIA

International Armaments

Technology Symposium

& Exhibition

June 14 - 16, 2004

United Defense V²C² Program

United Defense

- **Internal Research & Development Program began March 2003**
- **V²C² Program Objectives …Identify & Develop an Innovative Technology that Will Reduce Development Costs and Risk Associated with Fielding New 105mm Artillery:**
  - **Must Use Adaptations of Proven Gun Technology (keep it low risk)**
  - **Must Use a Current Fielded Propellant (to achieve significant cost and logistics benefits)**
  - **Must Optimize Integrated Armament-Ammunition Performance**

  Thus enabling:
  - **Reduced Logistics Tail, Support, & Cost**
  - **Reductions in Overall System Weight**

The V²C² Development Team

United Defense

- **Development Team:**
  - **United Defense: System Design; Variable Volume Design, Seal Design, Integration, Test Projectile Fabrication, Project Lead**
  - **U.S. Army ARDEC: Test Projectile Design, Laser Igniter, Internal Ballistics Analysis, Structural Component Design (Benet Labs)**
  - **U.S. Army ARL: NGEN Internal Ballistic 2-D Code dP Analysis**
  - **U.S. Army Watervliet Arsenal: Gun Tube and Breech Fabrication**
- **Contractual Arrangement**
  - **All Work Conducted Under a Government/Contractor Cooperative Research and Development Agreement (CRADA)**
  - **Integrated Team Approach with Work Split Between Organizations Based Upon Areas of Expertise to Leverage Strengths**

V^2C^2 Armament System Overview

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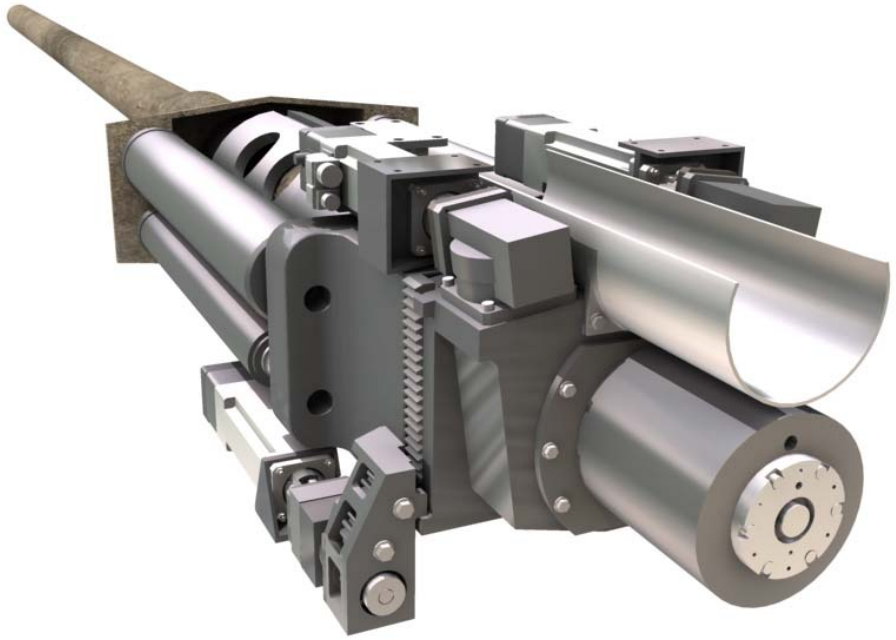
- Variable Volume Chamber Cannon (V^2C^2) Patent Pending
- Fully-Automated 105mm, 62-caliber Cannon
- Utilizes Propellant (M231 & M232) MACS Common to 155mm Artillery
- Fires Existing Projectiles/Fuzes
- Extended 105mm Range (>30km assisted/24km unassisted)
- Estimated weight of Fully Automated Cannon ~ 2100 lb



V²C² Breech Configuration

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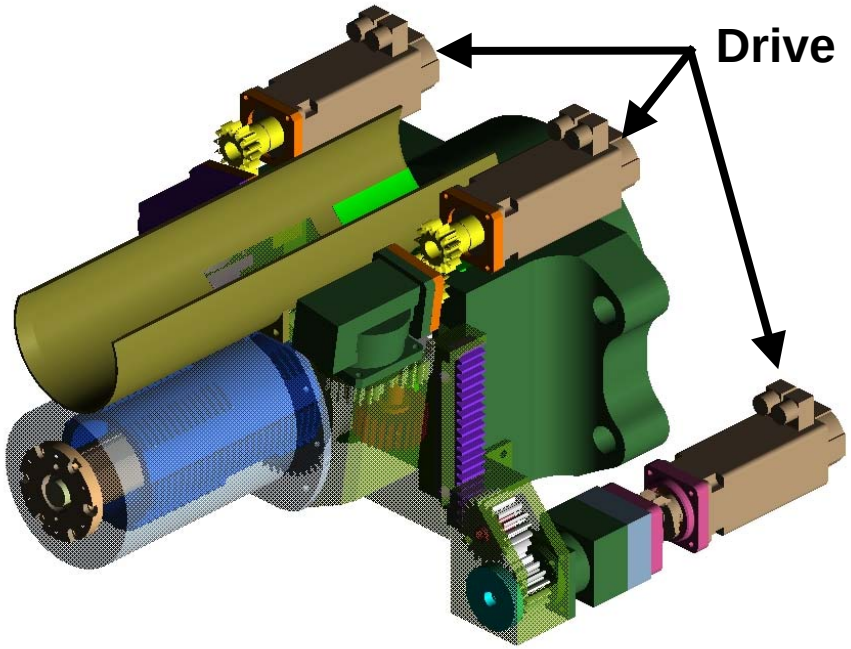
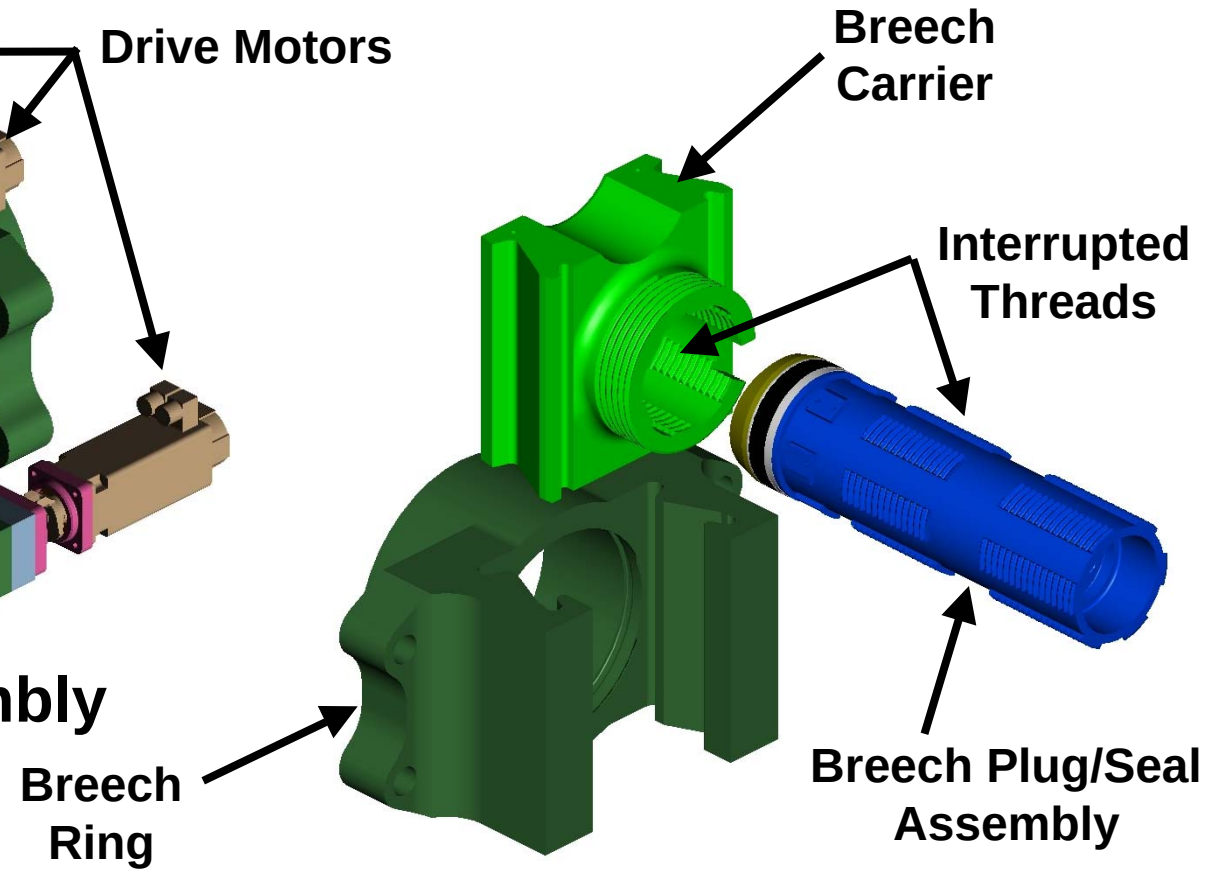


Breech Assembly



Exploded View
(structural components)

V^2C^2 Breech Operation

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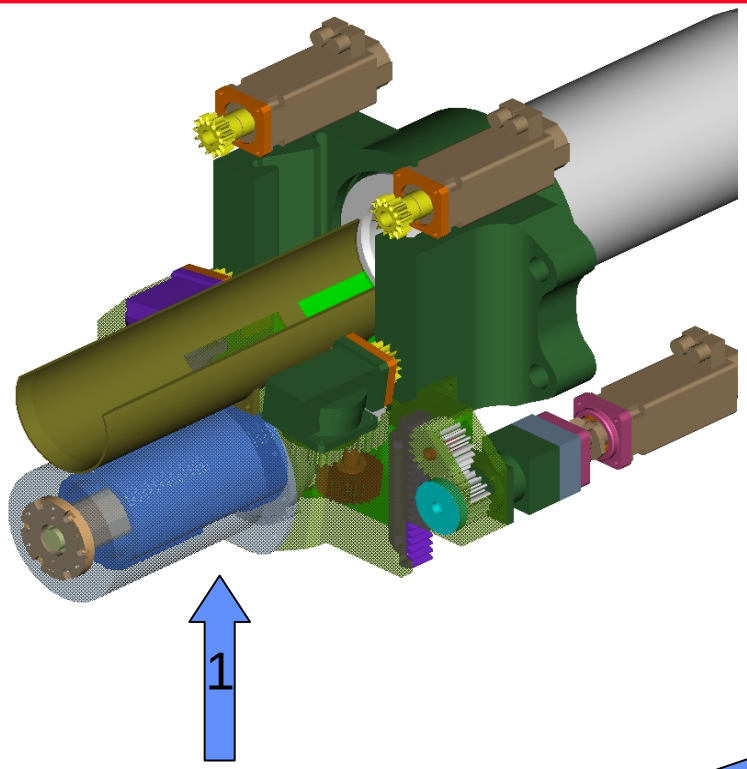
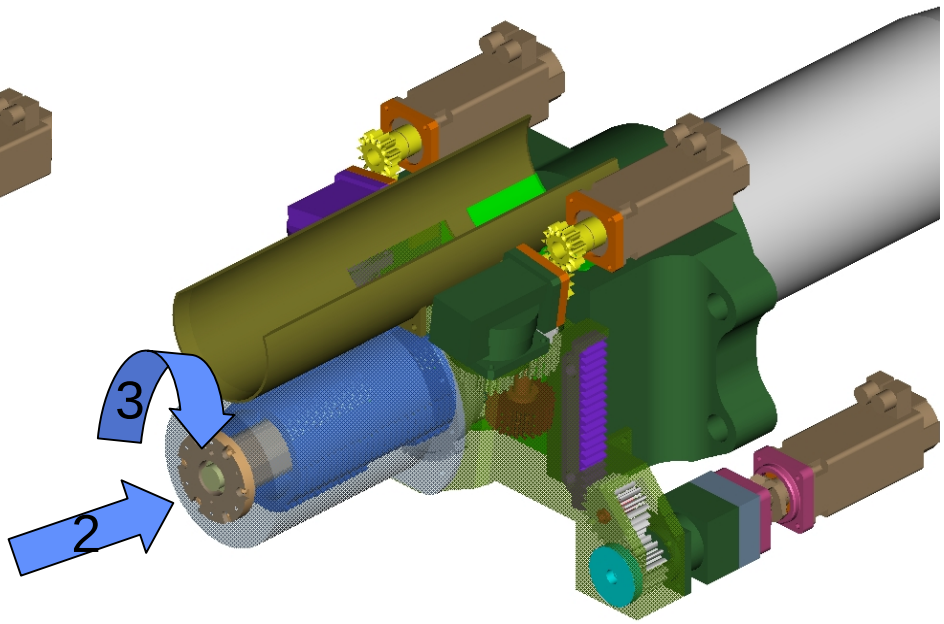


1. Raise Breech Carrier



2. Translate Breech Plug Assembly into Chamber to Set Chamber Volume

3. Rotate Breech Plug to Lock

V²C² Zoning Solution & Ballistics

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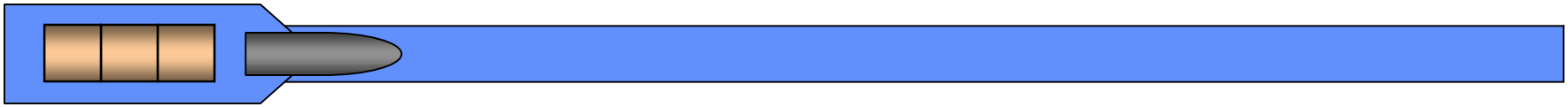
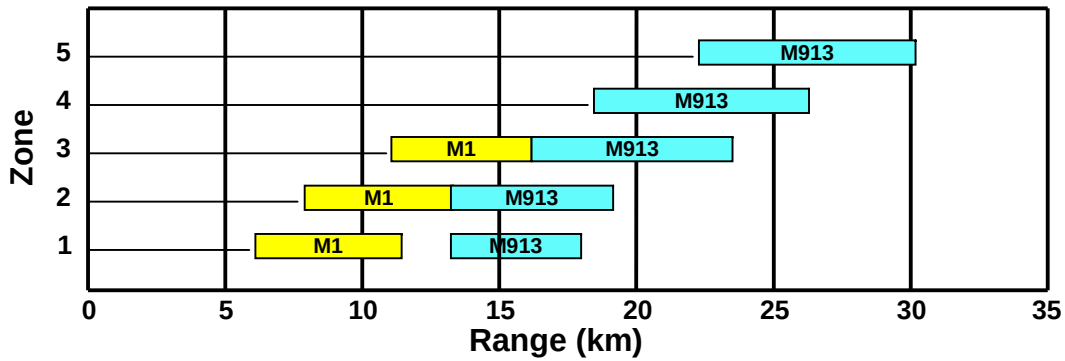


Zone	Charge Solution		Chamber Volume (in^3)	Peak Breech Pressure (psi)	Muzzle Velocity (M/sec)	M913 Max Range (km)
5	3 – M232		800	45,000	975	30.1
4	2 – M232		500	38,000	830	26.3
3	2 – M232		800	22,700	775	23.3
2	1 – M231		500	27,000	560	18.8
1	1 – M231		800	16,400	505	17.6



V^2C^2 Proof Of Principle (P.O.P.) System

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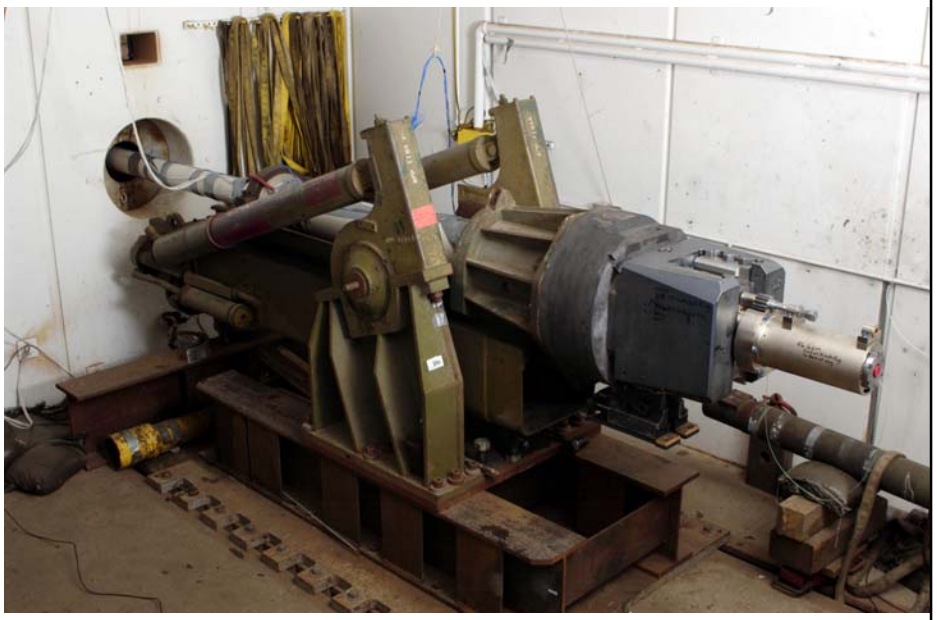
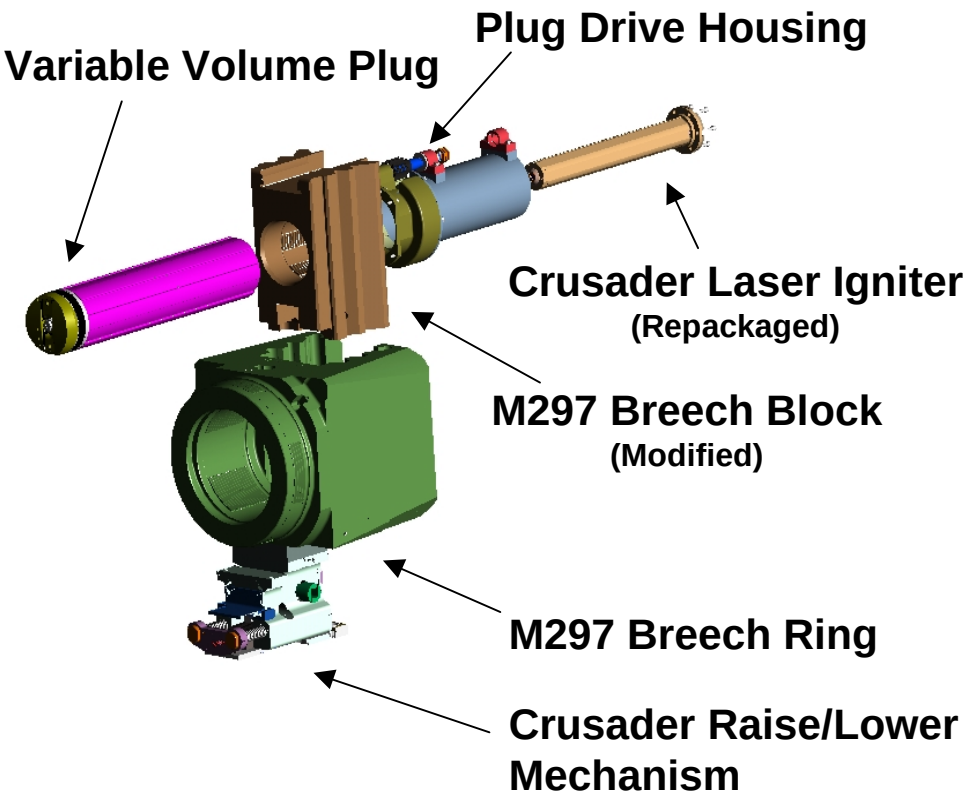
P.O.P. Cannon Test Stand



V^2C^2 Cannon Installed in Firing Position

P.O.P. Cannon Design



V²C² Test & Evaluation

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- **P.O.P. Cannon Firing, total of 164 shots**
  - **Demonstrated acceptable internal ballistics under all conditions of propellant conditioning, zones, and charge placement.**
  - **Demonstrated muzzle velocity repeatability under all conditions**
  - **Breech seal performance has been exceptional**
- **Breech Drive Brass Board Checkout**
  - **Completed several operational tests to prove out breech automation**
  - **Currently conducting 20,000 cycle durability test**
- **Dual Axis Make-Break Motor Drive Brass Board**
  - **Two competing designs fabricated for testing**
  - **Risk mitigation testing of both designs complete**

Internal Ballistic Performance

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- **Muzzle Velocity has been Demonstrated that will Result in 30 km Range with M913 RAP or Denel Igala Family**
  - **Recent Zone 6 firings with 700 c.i. Chamber provided additional MV to propel Denel projectiles to excess of 30km with same propellant charge as Zone 5 and very low negative dPs**
- **All Pressures Waves are Within Acceptable Limits**
  - **Current MACS charge qualification allows up to 6,000 psi negative pressure differential as passing, pressure between -6,000 and -10,000 requires review**
  - **The V2C2 Cannon has been tested with conditioned propellant at -54 C, ambient, and 63C, and all combinations of charge placement**
  - **Mean differential pressure measured is -1,450 psi, worst case is -5,800 psi**
- **Muzzle Velocity Repeatability**
  - **MV repeatability tests almost complete, data to be fully analyzed after completion of remaining 21 shots in late June**
  - **Thus far the 1 Sigma deviations range from 2 to 9 m/s**
  - **For Comparison the 155mm Crusader 1 Sigma MV variations ranged from 3 to 20 m/s**

V2C2 Advantages

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- **Lightest Weight Long Range 105mm Cannon in the World**
  - **Flattened pressure/travel curve yields muzzle velocity at optimized chamber pressure**
  - **Higher muzzle velocity with similar chamber pressures as current M119**
  - **Objective design incorporates UDLP improved high strength gun steel currently being used in large caliber Navy guns**
  - **Fully automated version expected to weigh approximately 2100 lb (952 kg)**
- **Logistics benefits in using same propellant as all current U.S. fielded 155 Artillery**
  - **Eliminates the need to fund development of a propellant for a newly fielded 105mm cannon**
  - **Only one propellant to procure, stockpile, deploy, and move around the battle field to supply both 105mm and 155mm artillery**
  - **On average requires less ammunition weight to fire missions currently being fired by current M119 towed artillery**

V2C2 Advantages

United Defense

- **Performance**
  - **Designed to fire at 10 rounds per minute**
  - **Designed to sustain 10 rounds per minute for 92 rounds with chamber spray cooling system similar to that in FCS NLOS-C SPH**
  - **Has extended range (30 km) and thus extended mission capability over current U.S. semi-fixed 105mm ammunition**
  - **Fires current inventory of 105mm projectiles to velocities and ranges consistent with their current use**
    - **Unassisted projectiles require the addition of an obturator (simple field modification)**
    - **Rocket assisted projectiles (M913) may require new rotating bands but low inventory makes it easy to produce new inventory with improved bands as stock is replaced**
    - **Projectile modifications required are the same as that required by any long range cannon**
  - **Fires Denel Igala family of projectiles to full design capability**

V²C² 2004 Program Plan

United Defense

- **Complete Test Firings… ~ 45 Additional Shots**
  - **Objective …Refine various design parameters to mature design**
  - **Focus areas include MV repeatability, seal optimization, firing of legacy projectiles, evaluation of residue affects to support design of automated system**
  - **Estimated Completion …July 2004**
- **Brass Board Test Stand Evaluation of Breech Drive**
  - **Complete durability testing**
- **Make/Break Breech Drive Brass Board Testing**
  - **Validate performance of dual axis make/break connectors**
- **Design of Next Generation Automated Cannon**
  - **Develop TDP for TRL 6 and 7 prototype assessment**
- **Design of Feed System for Rate-of-Fire Evaluation**
  - **To support TRL 6 and 7 prototype assessment**
- **Fabrication and Firing of Fully Automated Cannon**

Summary

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- **V^2C^2 Technical Feasibility Demonstrated …TRL 5**
- **Successfully proven the use of 155 MACS Propellant and current inventory 105mm Projectiles**
- **Expected to offer significant reductions in logistics and manpower burdens**
- **Designed to integrate into an 18 to 20 ton weight class vehicle**
- **Risks identified and on path to mitigation**
- **TRL 6 Configuration can be ready for firings in early 2005**
- **Excellent example of ARDEC-Industry cooperative design effort**