



Lightweight Small Arms Technologies



Lightweight Small Arms Technologies (LSAT)



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Lightweight Small Arms Technologies Top 5 Soldier Weight Contributors



Lightweight Small Arms Technologies (LSAT)

For Automatic Rifleman:

1. M249 Squad Automatic Weapon w/200 rds Ammo
2. 5.56mm Ammunition (400 rounds)
3. Body Armor & Helmet
4. Communication Equipment
5. Canteen/Water





Lightweight Small Arms Technologies Goals



Lightweight Small Arms Technologies (LSAT)

Goals:

- 35% weapon weight reduction
- 40% ammunition weight reduction
- Reduced training & maintenance
- Maintain cost of current systems



Approach:

- “Clean Slate” design
- Reduced weight as the priority
- In depth trade studies
- Extensive modeling & simulation

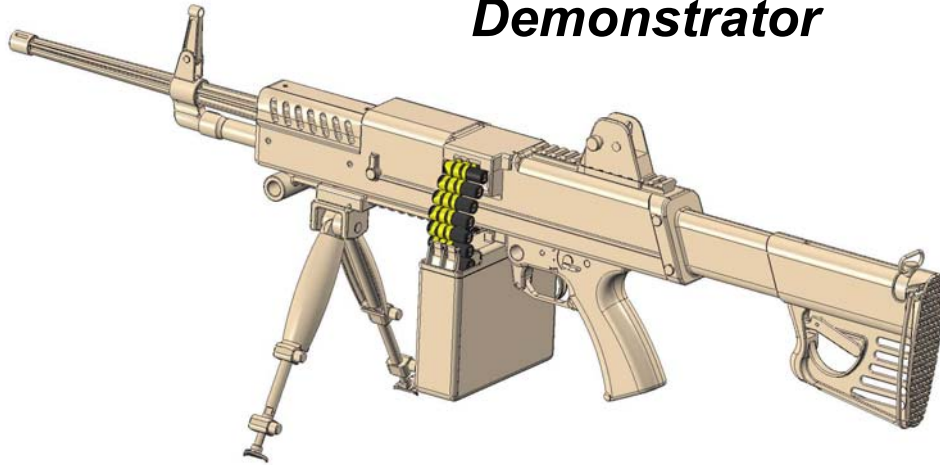


Lightweight Small Arms Technologies Program Approach



Lightweight Small Arms Technologies (LSAT)

Light Machine Gun Demonstrator



- Achieve 50% overall weight reduction
- Pursue parallel Cased Telescoped and Caseless Ammunition design approaches
- High commonality of design and function, some action component differences

5.56mm Telescoped Ammunition



- Focus is development of technologies- not specific weapon system
- Demo via Light Machine Gun with 5.56mm ammunition
- In parallel, Company Machine Gun study to determine feasibility of single weapon with a single round of ammunition for both LMG and MMG



Lightweight Small Arms Technologies Comparative Weights



Lightweight Small Arms Technologies (LSAT)

M249



Developmental Configuration Common to both CT and Caseless Ammunition



Program Goal

CTA

CLA

System 38.3

38%

44%

52%

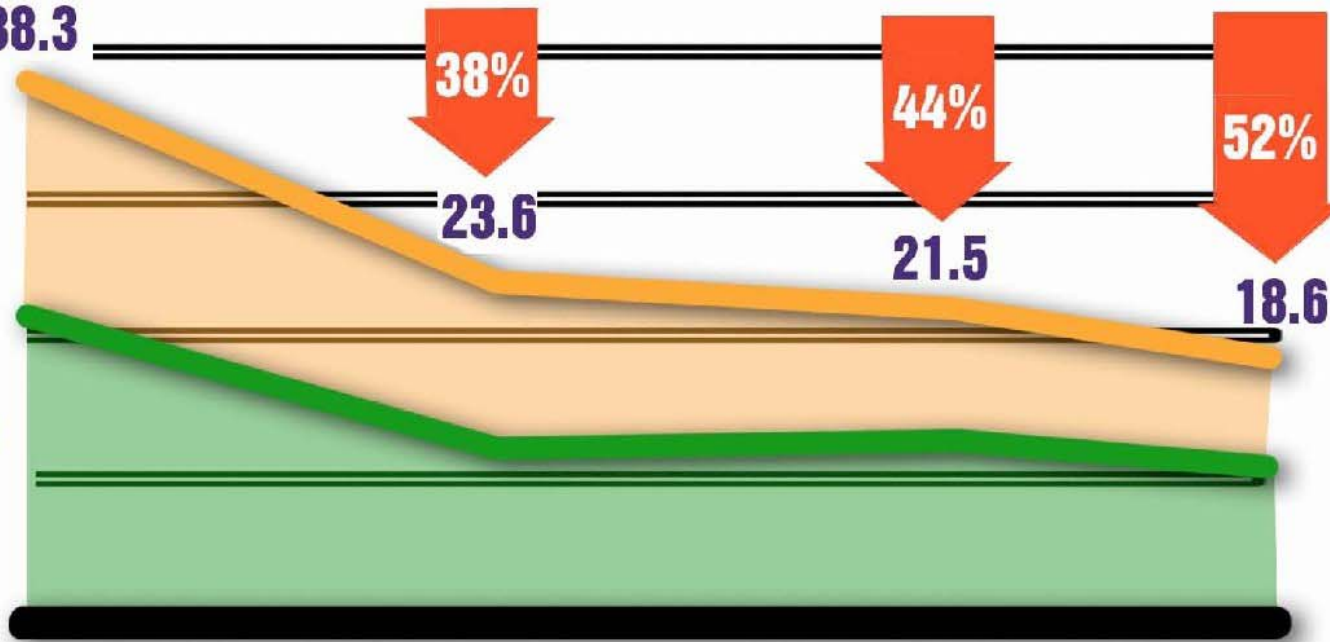
Weapon

23.6

21.5

18.6

**Ammo: 600
Rds + Pkg**

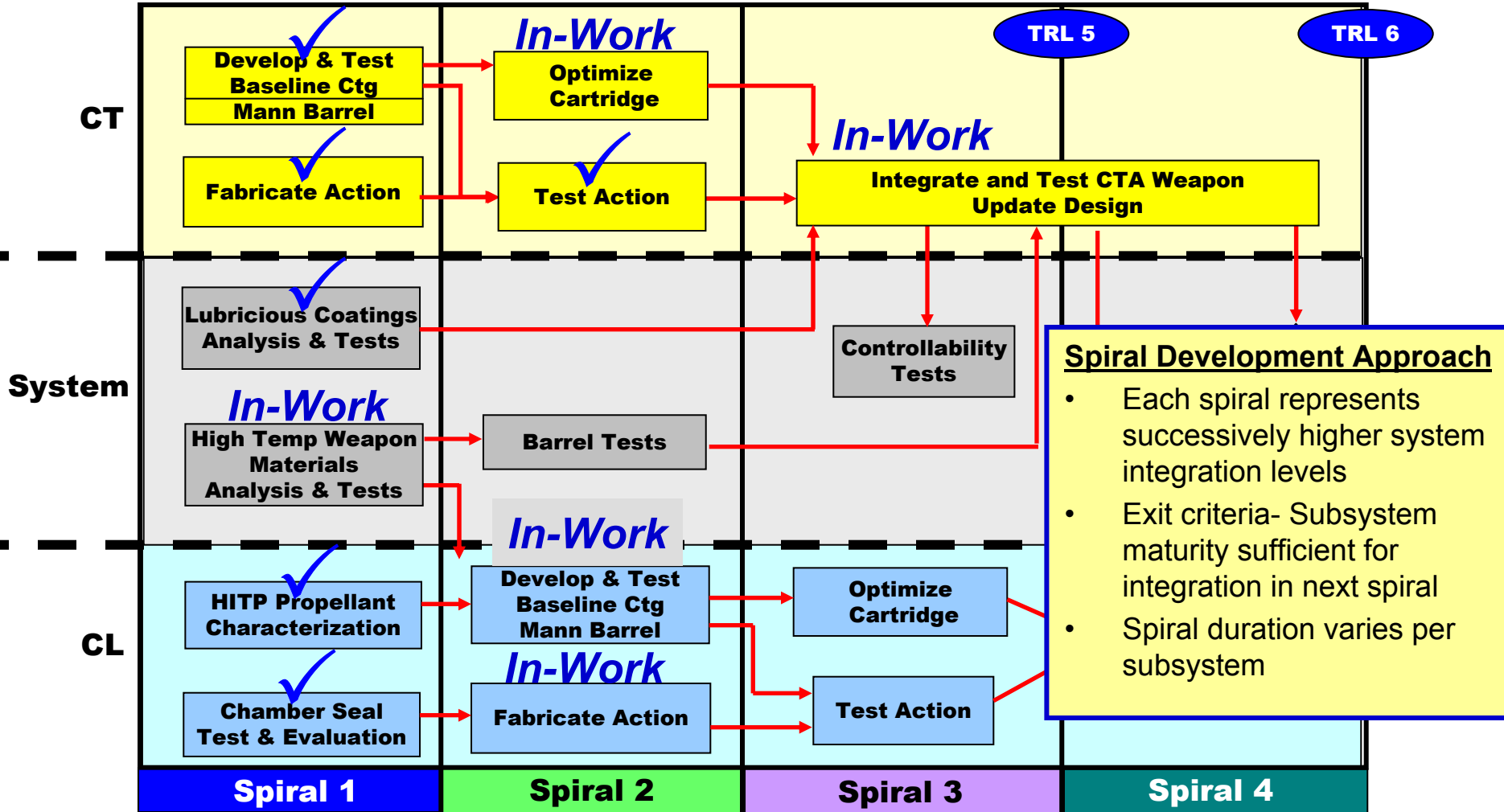




Lightweight Small Arms Technologies Concurrent & Leveraging Activities



Lightweight Small Arms Technologies (LSAT)

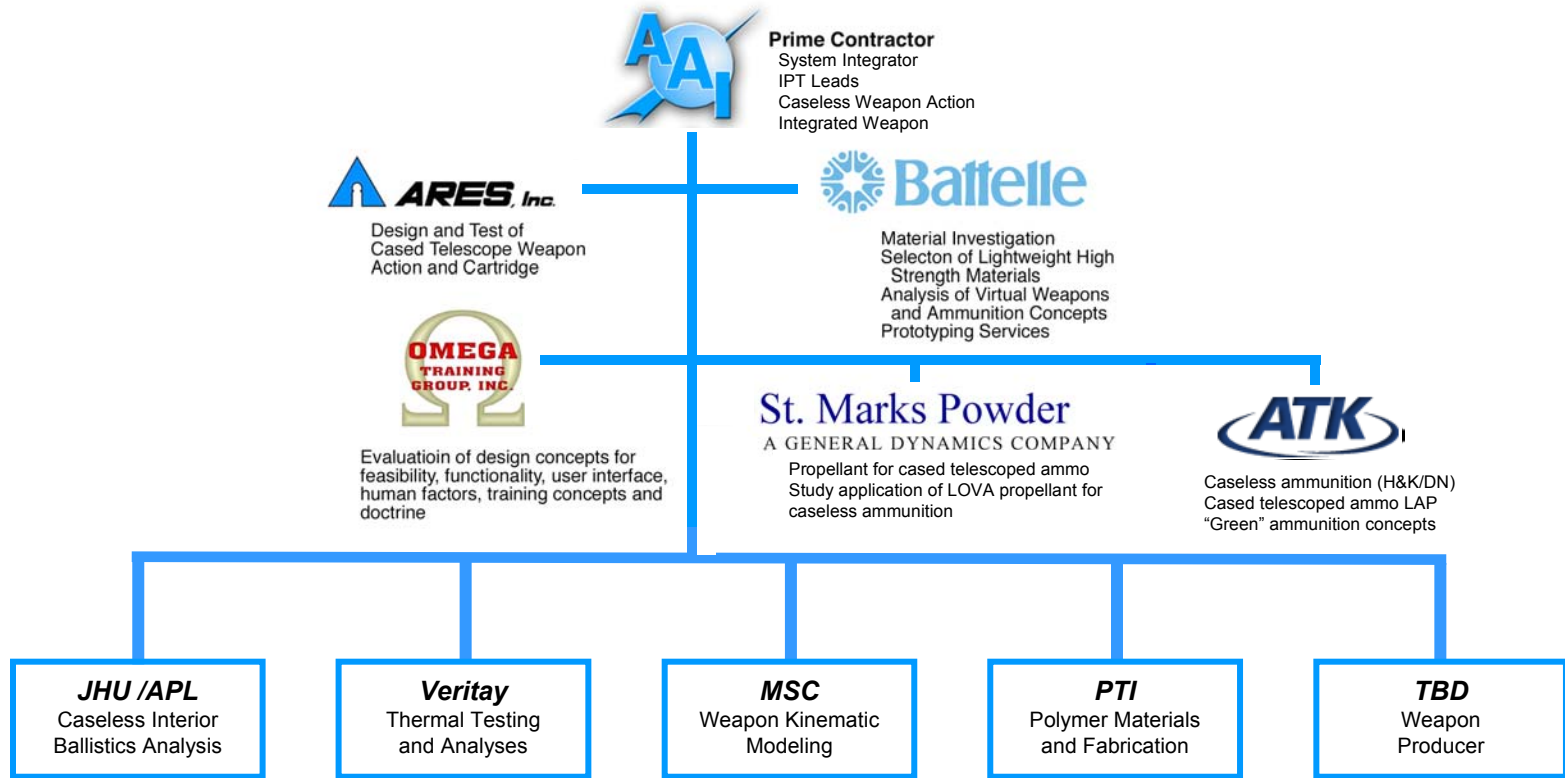




Lightweight Small Arms Technologies AAI Contractor Team Members



Lightweight Small Arms Technologies (LSAT)

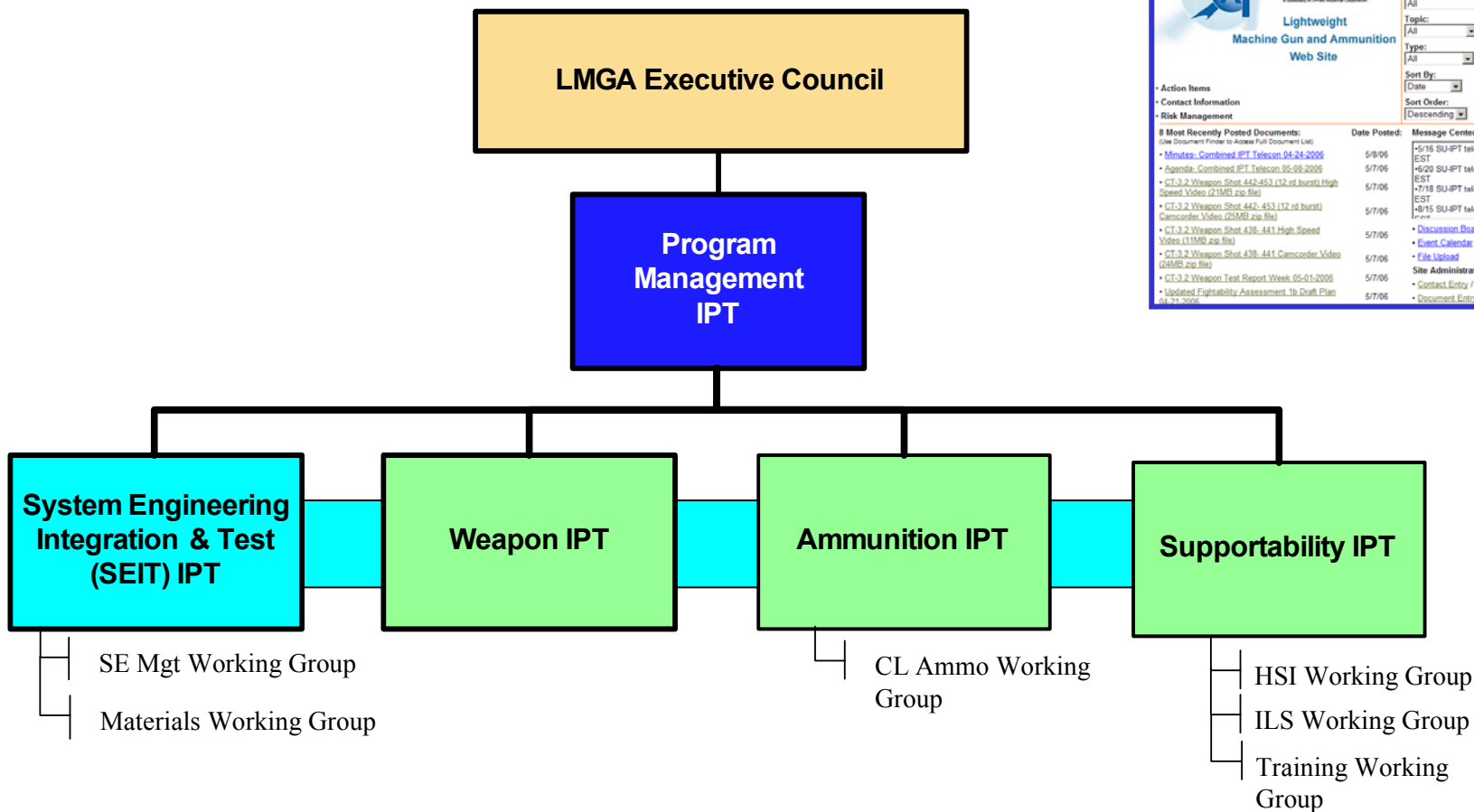




Lightweight Small Arms Technologies Integrated Product Team Organization



Lightweight Small Arms Technologies (LSAT)

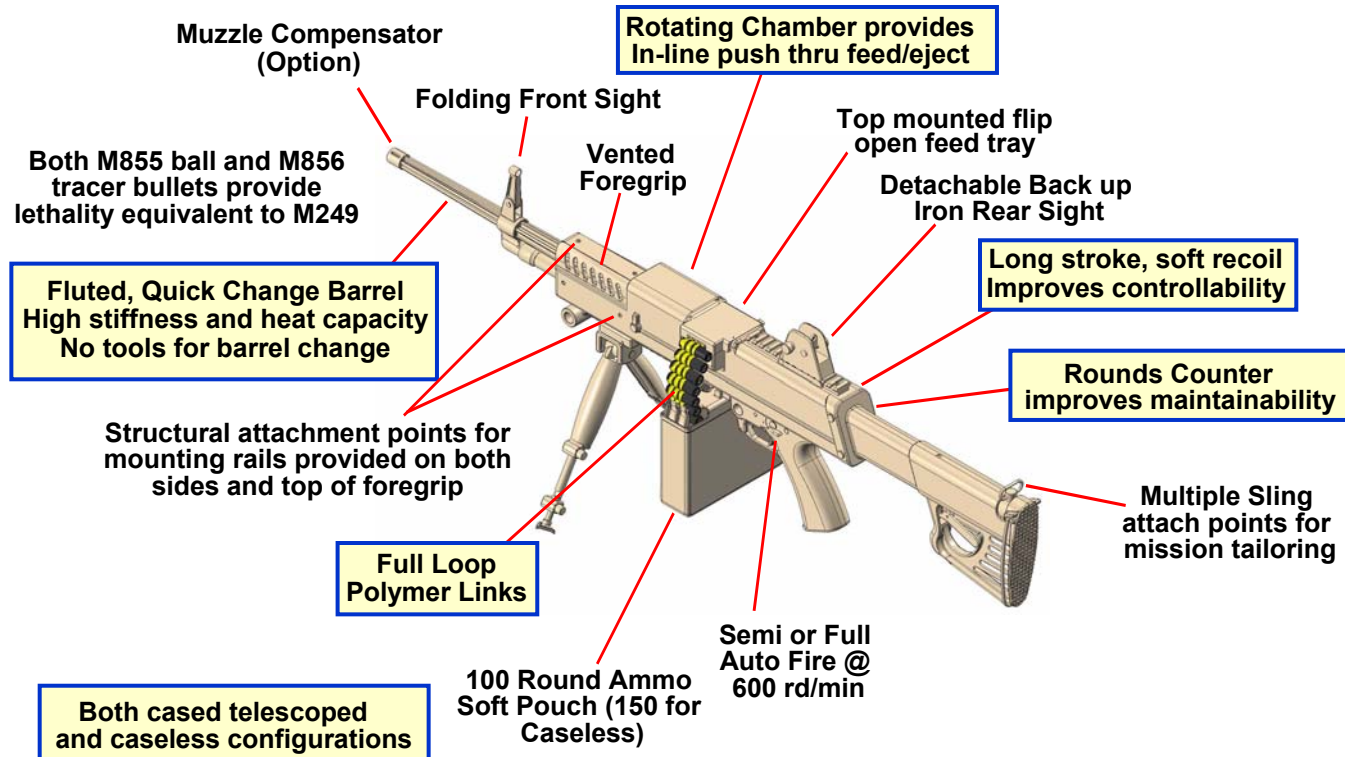


Lightweight Small Arms Technologies Weapon Design and Performance Features

Lightweight Small Arms Technologies (LSAT)

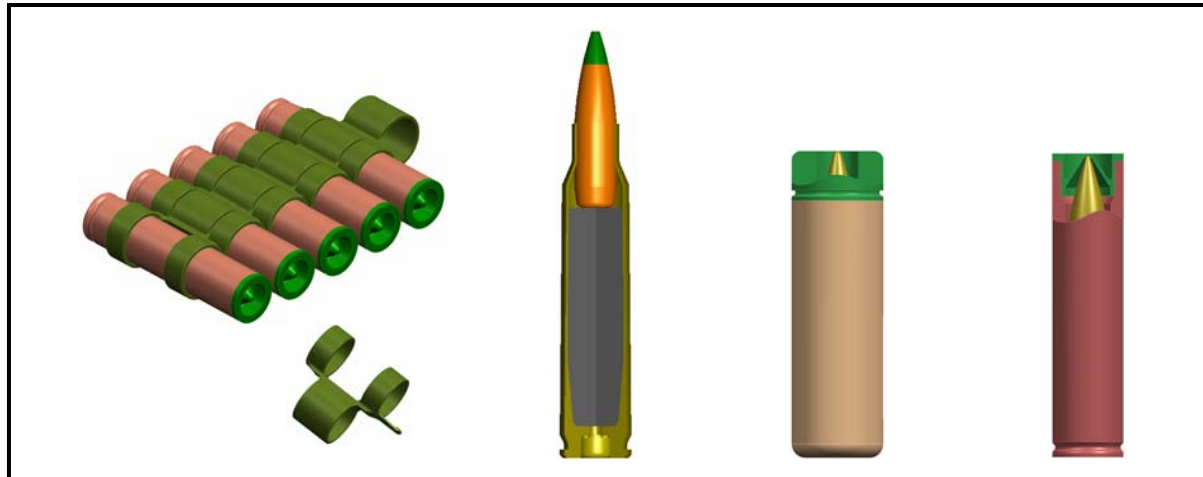
Key technologies

- Use of telescoped ammo-cased and caseless
- Lightweight materials & structural configuration
- Thermal management for weight reduction
 - Barrel
 - Caseless chamber components
- Caseless chamber sealing
- Human factors- firing controllability
- Integration of electronics



Lightweight Small Arms Technologies Ammunition Design Features

Lightweight Small Arms Technologies (LSAT)



	M855	LSAT CT	LSAT CL
Weight 600 linked pkg'd rnds	20.8 lbs	14.0 lbs <i>33% reduction</i>	10.2 lbs <i>51% reduction</i>
Muzzle velocity (78 ft)	3,020 ft/sec	3,020 ft/sec	3,020 ft/sec
Length	2.25 inches	1.6 inches	1.6 inches
Diameter	0.38 inches	0.45 inches	0.35 inches
Primer	Percussion	Percussion	Percussion

- ### Key Technologies
- Telescoped cartridge
 - Cased Ammunition
 - Polymer cartridge case and endcap
 - Compacted propellant (tracer rd)
 - Caseless Ammunition
 - High Ignition Temperature Propellant
 - Booster assisted interior ballistics
 - Demonstrate in 5.56mm
 - Address producibility
 - Consider scalability



Lightweight Small Arms Technologies (LSAT)

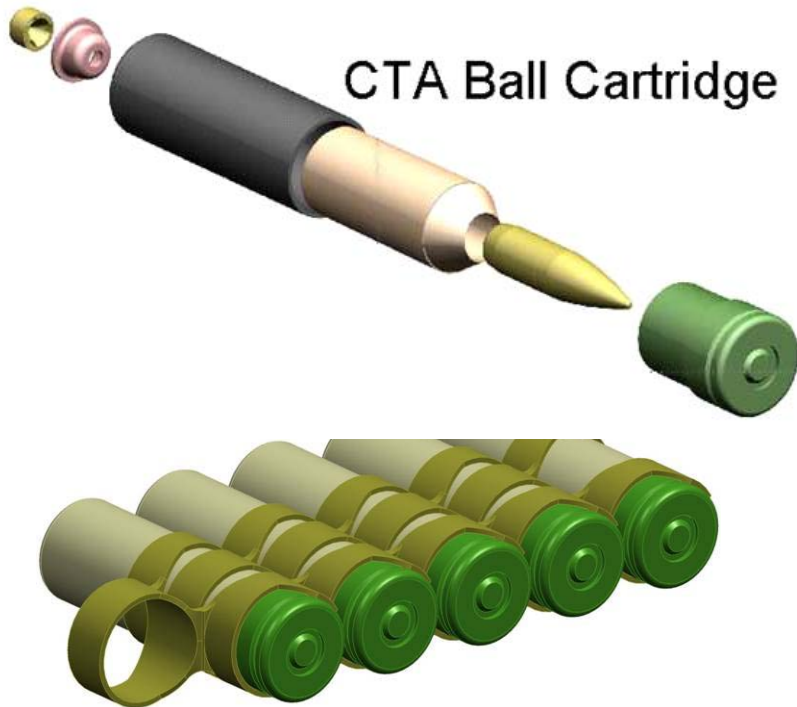
Cased and Caseless Telescoped Ammunition

Design and Development Status



Lightweight Small Arms Technologies Ammunition Features

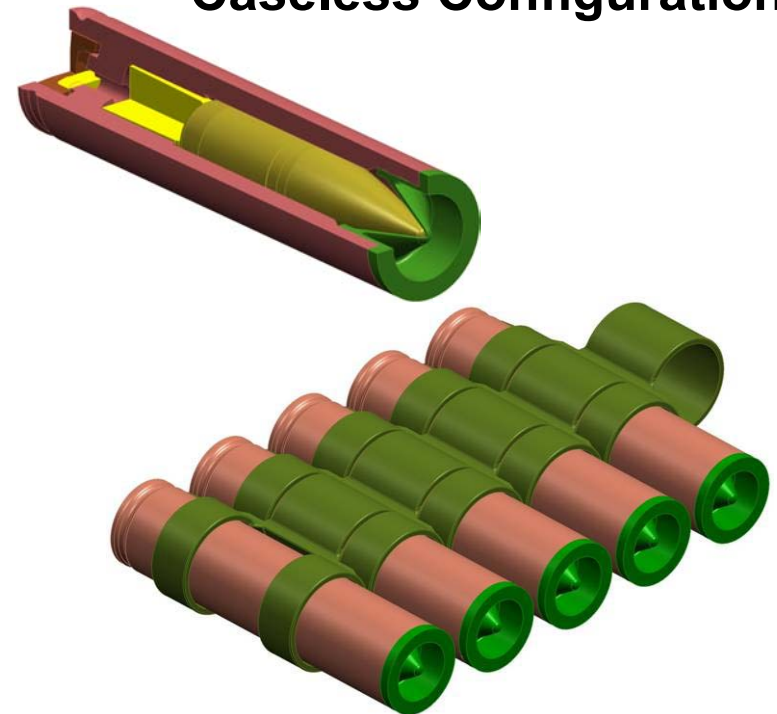
Lightweight Small Arms Technologies (LSAT)



CTA Ball Cartridge

- Conventional technology in telescoped configuration
- Significant weight reduction
- Lower Risk

Caseless Configuration



- High Ignition Temperature Propellant Technology
- Higher Weight Reduction
- Higher Risk



Lightweight Small Arms Technologies Cased Telescoped Ammunition Status (1)



Lightweight Small Arms Technologies (LSAT)

- *Technology demonstration with std 5.56mm bullet*
- *Completed Activities*
 - Development of “Weapon Function Cartridge”
 - All telescoped ammunition features, but not optimized for weight/size
 - Used to support initial weapon testing (SN CT1)
- *Activities nearing completion*
 - Development of “Optimized Cartridge”
 - Reduces cartridge weight/size
- *Approximately 750 rds fired to date*
 - Both Mann Barrel and Weapon
 - Temperatures ranging from -65F to +145F



Lightweight Small Arms Technologies Cased Telescoped Ammunition Status (2)

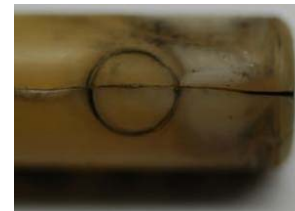


Lightweight Small Arms Technologies (LSAT)

- *Interior ballistics results*
 - Achieved performance equivalent to M855 baseline (ie, Propellant Wt, P_{ch} , V_m)
 - Primer initiation parameters differ significantly from metallic case
- *Case/End Cap material and geometry results*
 - Approximately 15 materials tested using injection molded cases.
 - Numerous geometry variations tested- primer interface, bullet interface, cartridge sealing, case thickness profile
 - Baseline selected, currently preparing final test series



Molded Case Material Examples



Cracked Case



Successful Case



Lightweight Small Arms Technologies Caseless Ammunition Status (1)



Lightweight Small Arms Technologies (LSAT)

- *Significant level of cooperative test and analysis activities between ARDEC and contractor team*
- *Objectives*
 - Characterize chemical and physical characteristics of High Ignition Temperature Propellant (HITP)
 - Replicate HITP to match ballistic and mechanical properties of ACR ammunition
 - Demonstrate HITP production feasibility
 - Process simplification
 - Process control
 - Process scalability
 - Deliver prototype 5.56mm caseless ammunition for ballistic demonstration



Lightweight Small Arms Technologies Caseless Ammunition Status (2)

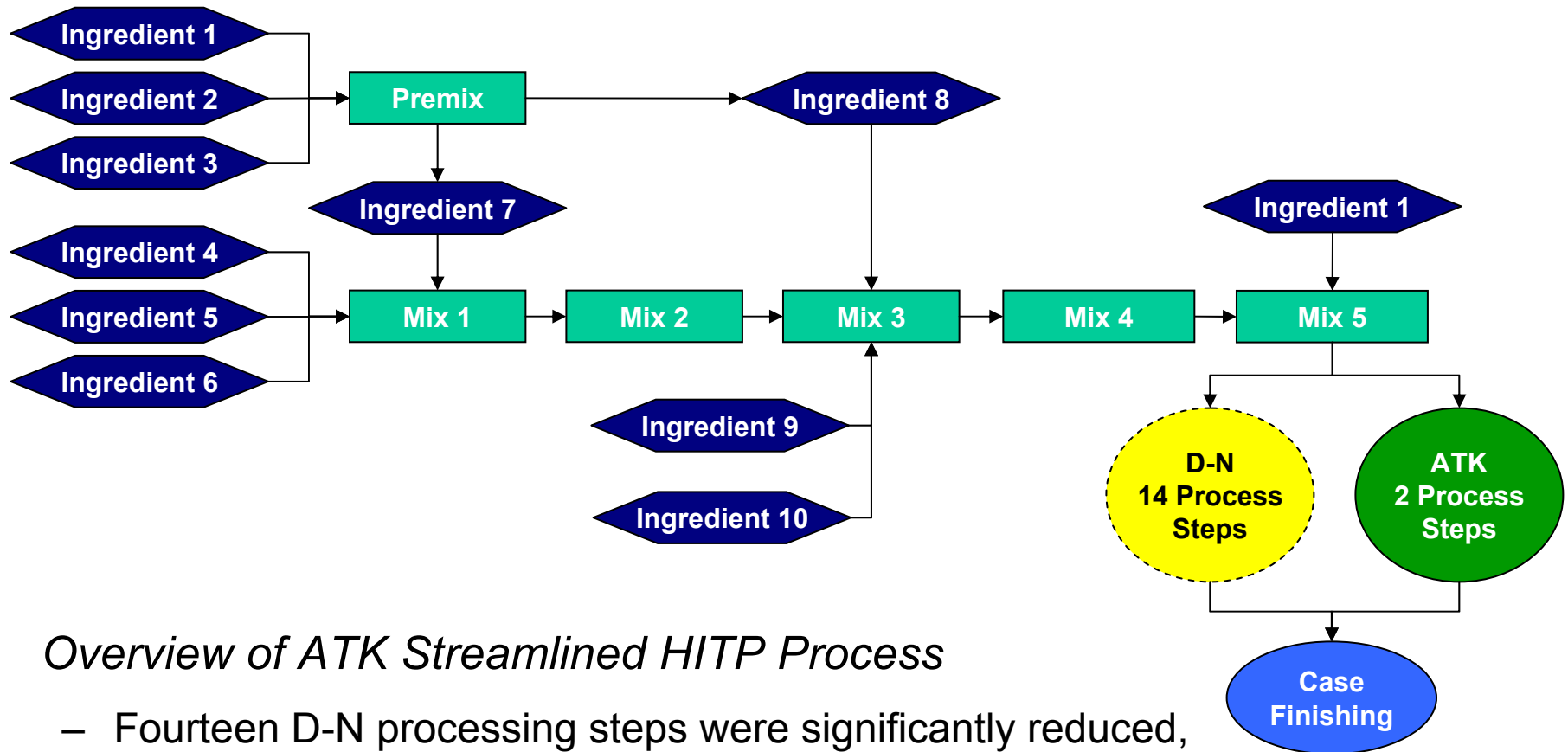


Lightweight Small Arms Technologies (LSAT)

- *HITP Materials & Process Development*
 - ✓ Characterize safety & physical properties of raw materials
 - ✓ Identify material sources and/or synthesize
 - ✓ Develop propellant mixing & fabrication process
 - ✓ Characterize and replicate HITP thermal & ballistic characteristics
- *Integrated Cartridge Demonstration*
 - ✓ Design & build proof-of-concept tooling for fabrication studies
 - Fabricate both 4.92mm (ACR) and 5.56mm cases
 - Fabricate primer cups
 - Fire 4.92mm cartridges in Mann Barrel for comparison with ACR ammo
 - Match ballistic performance through process & formulation improvements
 - Use 4.92mm cartridge fabrication process as baseline for 5.56mm cartridge production

Lightweight Small Arms Technologies Caseless Ammunition Fabrication Process

Lightweight Small Arms Technologies (LSAT)



- *Overview of ATK Streamlined HTP Process*

- Fourteen D-N processing steps were significantly reduced, resulting in significant reduction in cycle time and production costs



Lightweight Small Arms Technologies Completed 4.92mm HTP Cartridge Bodies

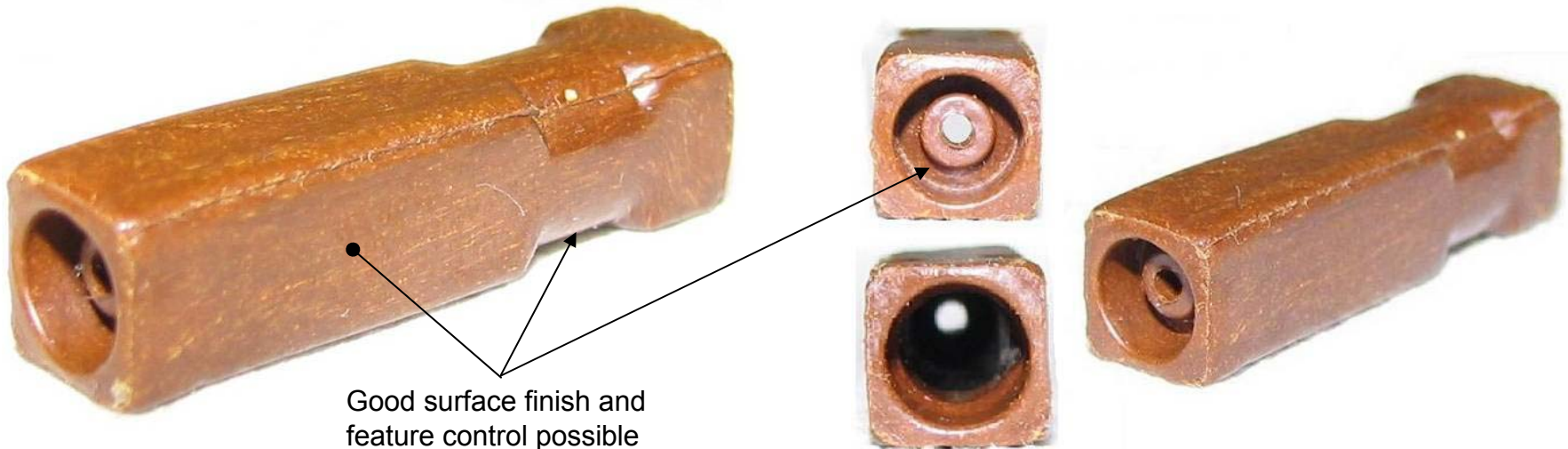


Lightweight Small Arms Technologies (LSAT)

- *Fabricated using improved process*
- *Duplicates ACR configuration*
 - Demonstrated good dimensional match to ACR ammunition with improved process approach
 - Preparing to conduct ballistic comparison testing vs. residual ACR ammunition



Assembled ACR





Lightweight Small Arms Technologies Completed 5.56mm HITP Cartridge Bodies



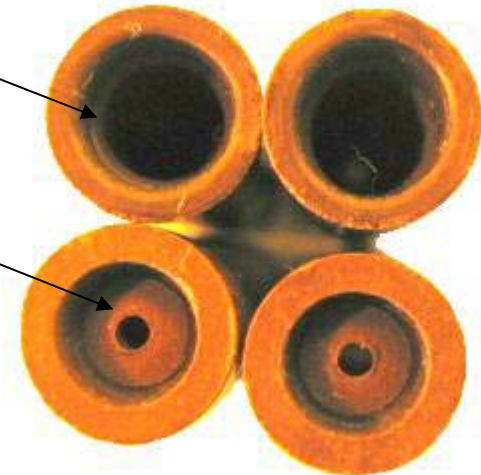
Lightweight Small Arms Technologies (LSAT)

- *Fabricated using improved process, cylindrical 5.56mm cartridge configuration*
 - Demonstrated good dimensional control
 - Preparing to conduct ballistic testing once 4.92mm cartridge demonstration testing complete



Formed
End Cap
seat

Formed
Primer Cup
Nozzle



Lightweight Small Arms Technologies Completed HITP Primer Cups

Lightweight Small Arms Technologies (LSAT)

- *Specialized HITP formulation developed for Primer Cup*
 - Cups are loaded with off-the-shelf primer composition and inserted into caseless cartridge bodies
 - Cups are sized to universally fit into 4.92mm or 5.56mm case configurations
- *Demonstrated good dimensional control and good mechanical properties with processing that is amenable to high-rate production*
- *Preparing to conduct primer charging tests*



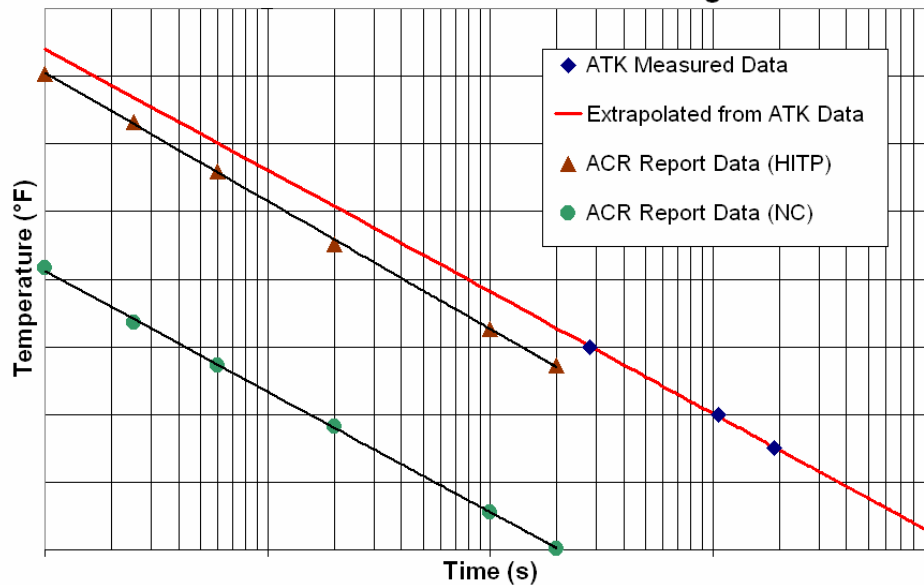
Primer Cup for both 4.92mm and 5.56mm case configurations

Lightweight Small Arms Technologies HITP Thermal Characterization

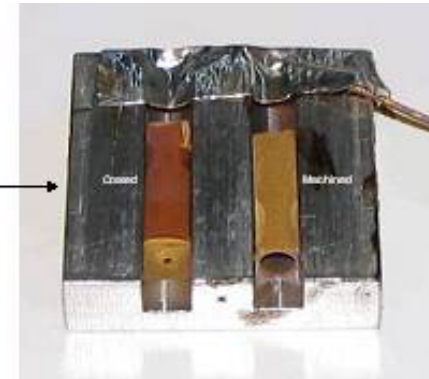
Lightweight Small Arms Technologies (LSAT)

- *Thermal stability and characteristics of HITP were studied through surface heat “hot-plate” cook-off testing*
 - Results compared well with published data
 - Threshold cook-off temperature was determined to be significantly higher than conventional NC ball powder

Time to Cook-Off for Caseless Cartridges



Hot-plate set-up





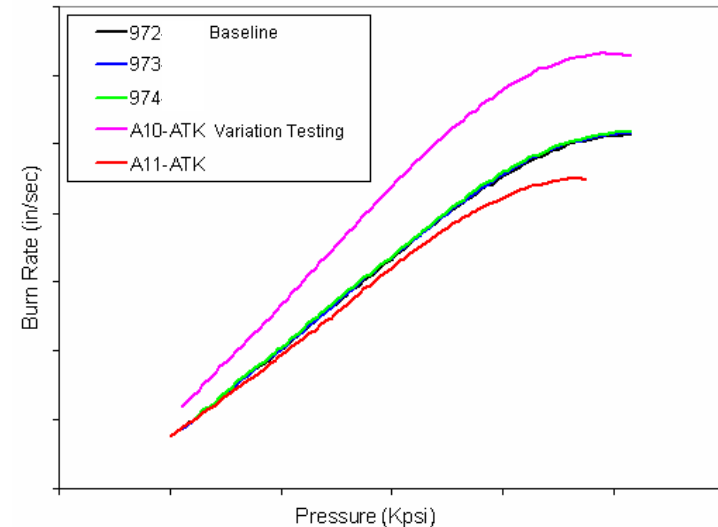
Lightweight Small Arms Technologies HITP Burn Rate Studies



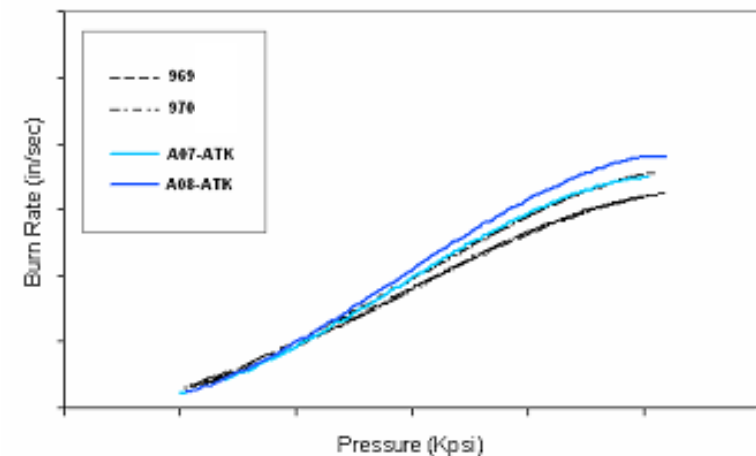
Lightweight Small Arms Technologies (LSAT)

- *High pressure closed bomb testing performed on HITP pellets & cartridges*
- *Effects of variation on burn rate being studied*
 - Process changes
 - Formulation changes
- *Optimal formulation testing continues*

Case CB BurnRate Comparison



Pressed Pellet CB Burn Rate





Lightweight Small Arms Technologies Caseless Ammunition Summary



Lightweight Small Arms Technologies (LSAT)

- *Caseless ammunition provides 50% weight reduction vs. standard ammunition*
- *Accomplishments*
 - Demonstrated ability to replicate ACR HITP
 - Demonstrated manufacture of dimensionally accurate propellant bodies and primer cups using a process scaleable to production
- *Upcoming Milestones*
 - Cartridge integration- 4.92mm & 5.56mm
 - Validation of integration of ATK 4.92mm cartridge performance vs. ACR cartridges using Mann Barrel
 - Firing of confidence cartridges to demonstrate scale-up to 5.56mm





Lightweight Small Arms Technologies (LSAT)

Cased and Caseless Weapon

Design and Development Status





Lightweight Small Arms Technologies

CT Weapon Kinematic Model (2)



Lightweight Small Arms Technologies (LSAT)

- *Weapon Kinematic Modeling Approach*
 - MSC ADAMS software
 - Model developed by MSC
 - All geometry derived from weapon and ammunition 3D solid models
 - All functional parts modeled- correct size, weight, stiffness, contacts
- *Purpose of Model*
 - Verify geometric clearances and component ranges of motion
 - Provide full kinematic characterization of weapon and ammo
 - Develop component loads for FEA analysis
 - Identify potential issues/solutions during design process
 - Validate based on test data, then support diagnosis/correction of problems identified during firings
 - Support integrated weapon analyses- drop, vibration etc



Lightweight Small Arms Technologies

CT Weapon Kinematic Model (3)



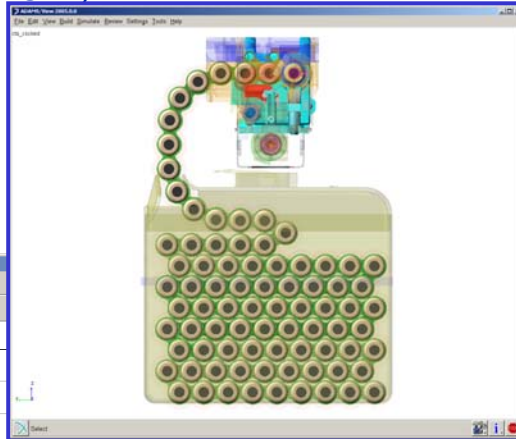
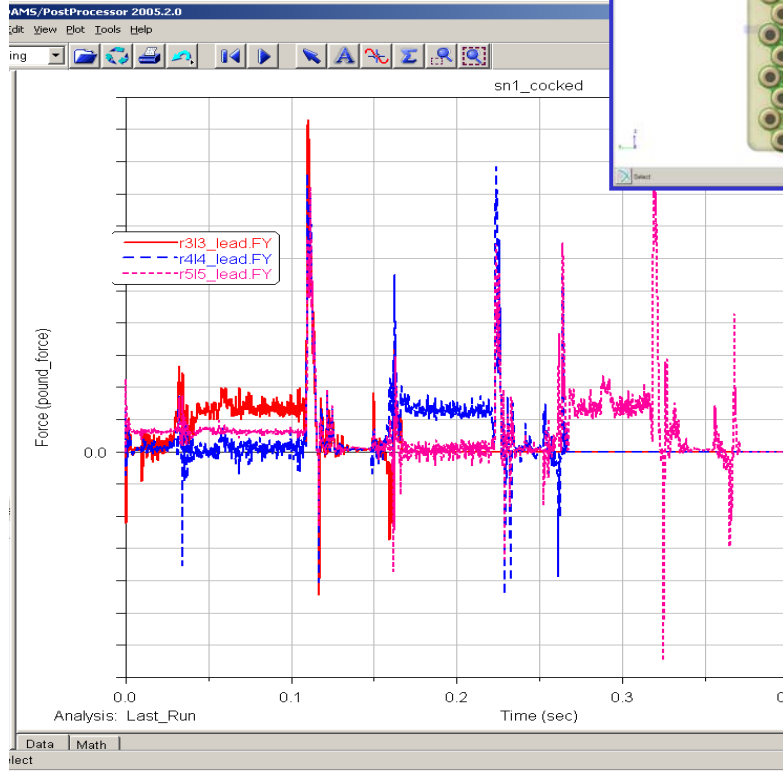
Lightweight Small Arms Technologies (LSAT)

- *Representative initial design issues identified via ADAMS model*
 - Feed pawl over-ride: corrected via revised pawl geometry
 - Rammer bounce: added lock to design
 - Chamber bounce: revised initial lock design
 - Inconsistent ejection: elected to monitor during tests
 - Significant belt whip: elected to monitor during tests
- *Representative design studies conducted using ADAMS model*
 - Sensitivity to friction
 - Effect of gas pulse profile
 - Link stiffness effects- stresses and belt pull
 - Belt support options
 - Integration with MSC NASTRAN and LS DYNA to evaluate stresses, deformations, and contact loads
- *Modeling enabled significant reduction in weapon development time*

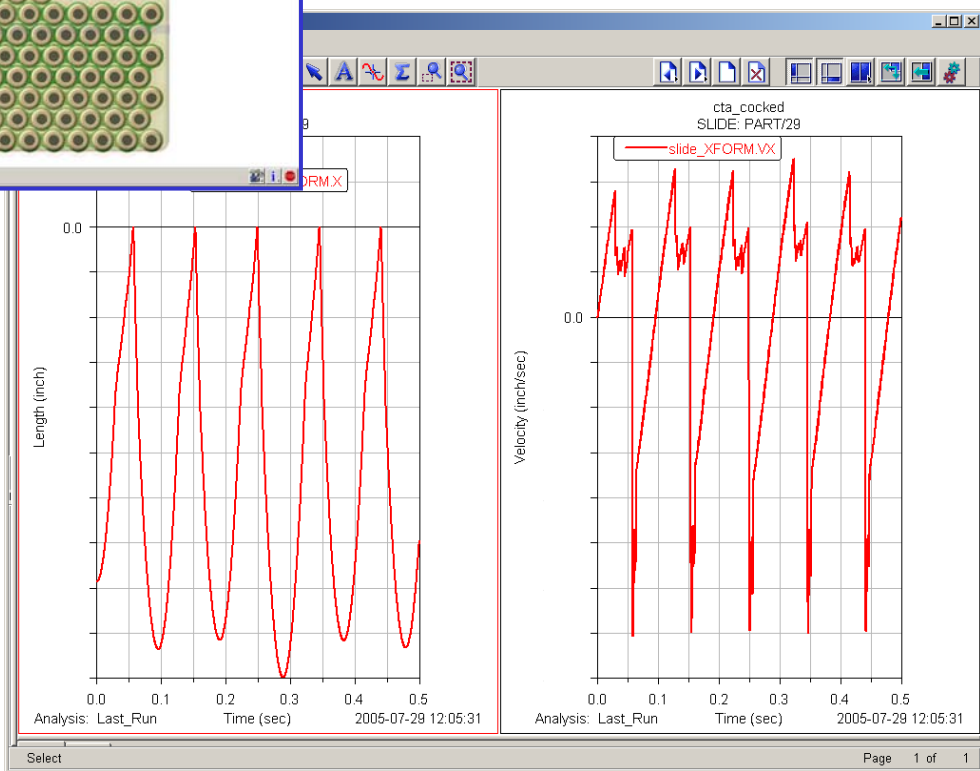
Lightweight Small Arms Technologies CT Weapon Kinematic Model (4)

Lightweight Small Arms Technologies (LSAT)

Example of Link Forces vs Time



Example of Slide Displacement and Velocity vs Time





Lightweight Small Arms Technologies Cased Telescoped Weapon Status



Lightweight Small Arms Technologies (LSAT)

Serial Number CT1

- Basic functionality demonstrated
 - Weapon Action in Dynamic Test Fixture
 - Integrated Weapon
- Fired approximately 400 rds to date
 - Validated ADAMS kinematic model
 - Resolved issues via combination of modeling and test data
 - Repeatable successful burst fire operation

Serial Number CT2

- Incorporates design mods based on CT1 experience
- Will utilize Optimized Ctg
- Hardware in-work





Lightweight Small Arms Technologies

Caseless Weapon Activities



Lightweight Small Arms Technologies (LSAT)

- *Design Status*
 - Developed design which maximizes commonality with CT weapon
 - Evaluated:
 - Chamber sealing and lock options
 - Firing pin arrangement
 - Weapon powering approach
 - Packaging for unique ammunition free volume requirements
- *Testing Status*
 - Utilized residual caseless ammunition from ACR program to support early weapon component design evaluations
 - Completed firing evaluation of chamber sealing concepts for effectiveness and durability
 - Developed firing fixture for evaluating caseless ammunition thermal outputs

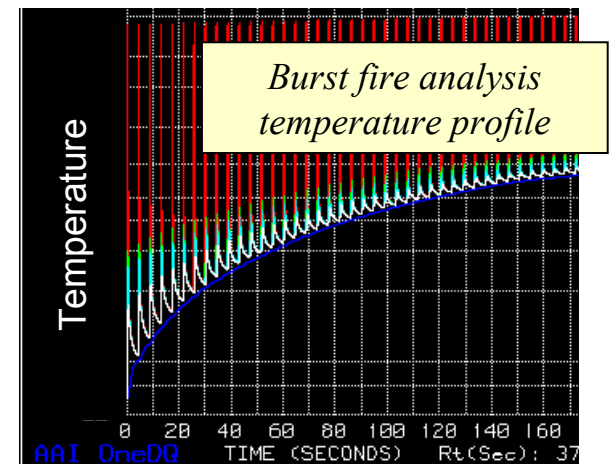
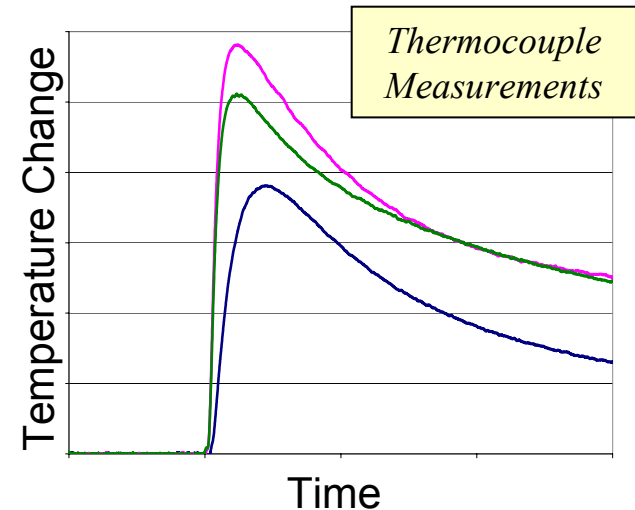


Lightweight Small Arms Technologies

General Weapon Technologies- Thermal Management

Lightweight Small Arms Technologies (LSAT)

- *Objective- Develop thermal management technologies applicable to caseless weapon action components and CT/CL barrels. Technology focus areas:*
 - High heat capacity materials
 - Insulating coatings/materials
 - Combustion thermal input reductions
- *Completed Activities*
 - Extensive review of literature and candidate material data
 - Characterized caseless ammunition thermal inputs to weapon
 - Developed and validated thermal analysis models (cooperative effort with Benet Labs)
 - Selected chamber and insulator materials for performance testing using caseless ammunition thermal measurement fixture

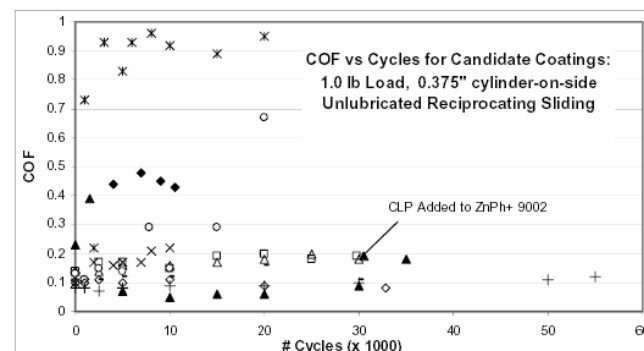
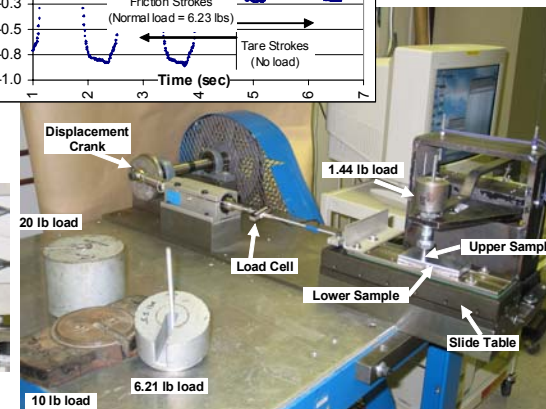
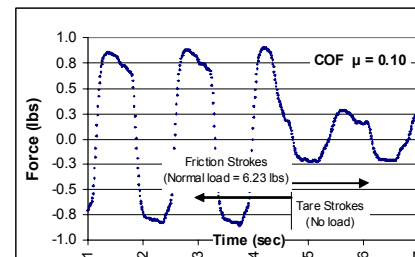
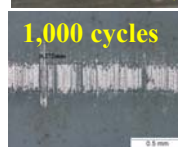


Lightweight Small Arms Technologies

General Weapon Technologies- Lubricious Coatings

Lightweight Small Arms Technologies (LSAT)

- Objective- eliminate or reduce need for weapon lubrication
- Completed extensive tribological testing of candidate lubricious coatings
- Utilized a variety of interface geometries and loading conditions
- Selected implementation approach





Lightweight Small Arms Technologies Supportability Activities



Lightweight Small Arms Technologies (LSAT)

- *Supportability Focus*
 - Evaluate technology implementation considerations
 - Fully integrated with development effort
- *Key Activities Currently Underway*
 - Logistics Support Analysis- Level of Repair analysis, Life Cycle Cost analysis, O&M task identification
 - Reliability, Availability, Maintainability- Failure modes and effects analysis, reliability tracking
 - Training analysis and materials- Training concept, training task analysis
 - Human System Integration- Human factors design support, fightability assessment, shootability assessment, system safety evaluations



Lightweight Small Arms Technologies Summary



Lightweight Small Arms Technologies (LSAT)

- System design meets all program requirements:
 - Exceeds weight goals
 - Improves lethality
 - Improves logistics
 - Improves ergonomics
 - Maintains comparable production costs
- Maintaining parallel, synergistic Cased Telescoped and Caseless development plan
 - Emphasizes commonality
 - Reduces program risk
- Scalable design provides significant modularity and commonality
- Cohesive Government/industry team ensures success in development, user acceptance, and production

Comments/Questions?