National Defense Industrial Association
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Lightweight Small Arms Technologies
Top 5 Soldier Weight Contributors

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
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

Light Machine Gun Demonstrator

5.56mm Telescoped Ammunition

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

- 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

System 38.3

Weapon

Ammo: 600 Rds + Pkg

CTA 44%

CLA 52%

23.6

21.5

18.6
Lightweight Small Arms Technologies
Concurrent & Leveraging Activities

Spiral Development Approach
• Each spiral represents successively higher system integration levels
• Exit criteria- Subsystem maturity sufficient for integration in next spiral
• Spiral duration varies per subsystem
Lightweight Small Arms Technologies
AAI Contractor Team Members

Lightweight Small Arms Technologies (LSAT)

Prime Contractor
- System Integrator
- IPT Leads
- Caseless Weapon Action
- Integrated Weapon

ARS Inc.
- Design and Test of Cased Telescope Weapon Action and Cartridge

Battelle
- Material Investigation
- Selection of Lightweight High Strength Materials
- Analysis of Virtual Weapons and Ammunition Concepts
- Prototyping Services

OMEGA TRAINING GROUP INC.
- Evaluation of design concepts for feasibility, functionality, user interface, human factors, training concepts and doctrine

St. Marks Powder
- Propellant for cased telescoped ammo
- Study application of LOVA propellant for caseless ammunition

JHU / APL
- Caseless Interior Ballistics Analysis

Veritay
- Thermal Testing and Analyses

MSC
- Weapon Kinematic Modeling

PTI
- Polymer Materials and Fabrication

TBD
- Weapon Producer

ATK
- Caseless ammunition (H&K/DN)
- Cased telescoped ammo LAP "Green" ammunition concepts

Phase II - Add Weapon Producer

Veritay
- Thermal Testing and Analyses

MSC
- Weapon Kinematic Modeling

PTI
- Polymer Materials and Fabrication

TBD
- Weapon Producer

NDIA Small Arms
May 2006
Lightweight Small Arms Technologies
Integrated Product Team Organization

Lightweight Small Arms Technologies (LSAT)

LMGA Executive Council

Program Management IPT

System Engineering Integration & Test (SEIT) IPT
SE Mgt Working Group
Materials Working Group

Weapon IPT

Ammunition IPT
CL Ammo Working Group

Supportability IPT
HSI Working Group
ILS Working Group
Training Working Group

NDIA Small Arms
May 2006
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

Both M855 ball and M856 tracer bullets provide lethality equivalent to M249

Both cased telescoped and caseless configurations

Both M855 ball and M856 tracer bullets provide lethality equivalent to M249

Fluted, Quick Change Barrel
High stiffness and heat capacity
No tools for barrel change

Rotating Chamber provides in-line push thru feed/eject

Muzzle Compensator (Option)

Folding Front Sight

Top mounted flip open feed tray

Vented Foregrip

Detachable Back up Iron Rear Sight

Structural attachment points for mounting rails provided on both sides and top of foregrip

100 Round Ammo Soft Pouch (150 for Caseless)

Semi or Full Auto Fire @ 600 rd/min

Full Loop Polymer Links

Rounds Counter improves maintainability

Multiple Sling attach points for mission tailoring

Long stroke, soft recoil improves controllability

Improved maintainability
Lightweight Small Arms Technologies
Ammunition Design Features

**Lightweight Small Arms Technologies (LSAT)**

### 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

### Ammunition Design Features

<table>
<thead>
<tr>
<th></th>
<th>M855</th>
<th>LSAT CT</th>
<th>LSAT CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight 600 linked pkg'd rnds</td>
<td>20.8 lbs</td>
<td>14.0 lbs</td>
<td>10.2 lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33% reduction</td>
<td>51% reduction</td>
</tr>
<tr>
<td>Muzzle velocity (78 ft)</td>
<td>3,020 ft/sec</td>
<td>3,020 ft/sec</td>
<td>3,020 ft/sec</td>
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<tr>
<td>Length</td>
<td>2.25 inches</td>
<td>1.6 inches</td>
<td>1.6 inches</td>
</tr>
<tr>
<td>Diameter</td>
<td>0.38 inches</td>
<td>0.45 inches</td>
<td>0.35 inches</td>
</tr>
<tr>
<td>Primer</td>
<td>Percussion</td>
<td>Percussion</td>
<td>Percussion</td>
</tr>
</tbody>
</table>
Cased and Caseless Telescoped Ammunition

Design and Development Status
Lightweight Small Arms Technologies

Ammunition Features

**Lightweight Small Arms Technologies (LSAT)**

- 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 Telescopied Ammunition Status (1)

**Lightweight Small Arms Technologies (LSAT)**

- **Technology demonstration with std 5.56mm bullet**
- **Completed Activities**
  - Development of “Weapon Function Cartridge”
  - All telescopied 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)

- **Interior ballistics results**
  - Achieved performance equivalent to M855 baseline (ie, Propellant Wt, Pch, Vm)
  - 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
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
• **Overview of ATK Streamlined HlTP Process**
  – Fourteen D-N processing steps were significantly reduced, resulting in significant reduction in cycle time and production costs
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

Good surface finish and feature control possible
Lightweight Small Arms Technologies
Completed 5.56mm HTP 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

Very uniform surface finish

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 (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](image)

- ATK Measured Data
- Extrapolated from ATK Data
- ACR Report Data (HITP)
- ACR Report Data (NC)
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
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
Cased and Caseless Weapon

*Design and Development Status*
Lightweight Small Arms Technologies
CT Weapon Kinematic Model (2)

• 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
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
Example of Link
Forces vs Time

Example of Slide
Displacement and
Velocity vs Time
Lightweight Small Arms Technologies
Cased Telescoped Weapon Status

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

- **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

![Thermocouple Measurements](image)

![Burst fire analysis temperature profile](image)
Lightweight Small Arms Technologies (LSAT)

- **Objective**- eliminate or reduce need for weapon lubrication
- Completed extensive tribological testing of candidate lubriousious 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 (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?