Factors Affecting Dispersion of M118LR Sniper Ammunition

Zach Krogstad, Chris Drake (ARDEC)
Dan Meierhofer, Dustin Triebel (Orbital ATK)
Jeff Siewert (ArrowTech)

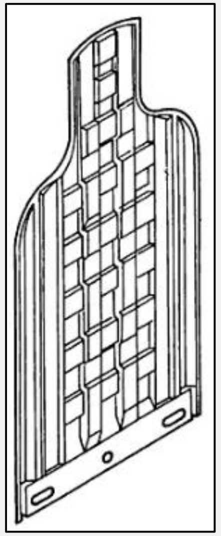
4 May 2017

If you can't get a bigger target...

Problem Statement

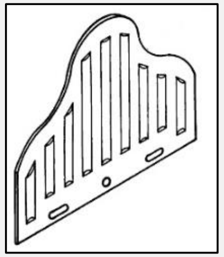
- Snipers demand compact weapon systems that shoot small groups
- The 7.62mm Compact Semi-Automatic Sniper System (CSASS) was developed for use with M118LR ammunition to achieve these requirements
- PM-MAS initiated an effort to discover the cartridge design, test, and manufacturing factors that could improve M118LR dispersion

M110 SASS



E-Type Target

M110E1 CSASS



F-Type Target

Test Execution Approach

PRE-TEST:
Charge weight establishment

→

TEST PHASE 1:
Interior ballistics

→

TEST PHASE 2:
Exterior ballistics

Phase 1: Interior Ballistics

- Evaluate velocity standard deviation and propellant temperature sensitivity in pressure/velocity (EPVAT) barrels
- Establishes charge weight for "even-handed" assessment of factors
- Down-select factors to include in exterior ballistics phase

Phase 2: Exterior Ballistics

- Evaluate dispersion in accuracy barrels
  - Production acceptance barrel
  - CSASS w/ and w/o suppressor
- Shoot groups at short and long ranges
  - 100 & 300 meters (simultaneous) indoors
  - 1000 yards outdoors

Test Design

- Team of subject matter experts (ARDEC, Orbital ATK, ArrowTech, Sierra) defined a long list of factors likely to improve dispersion
- Two phases executed using highly efficient designed experiments capable of screening factor main effects and selected 2-factor interactions
  - ~41,000 factor combos tested in 46 rows at each range (Phase 2)
- Utilized computer-generated D-optimal split plot designs
  - Highly customizable in complex factor environment (especially when dealing with pesky hard-to-change factors like barrel type)
  - Cutting edge design on the forefront of the DOE field
  - Allows maximum information gain with minimum expense

- Case/Cartridge (6)
  - Case type
  - Primer
  - Propellant
  - Etc.

- Bullet (8)
  - Boat tail angle
  - Weight
  - Jacket hardness/thickness
  - Etc.

- Manufacturing process (5)
  - Neck crimp
  - Neck de-burr & re-size
  - Bullet seating datum
  - Etc.

- Weapon factor (1)
  - Barrel type/suppressor combo

- Mission factor (1)
  - Target range (100 & 300 m, 1,000 yds)

- Noise factors (2)
  - Rounds on barrel
  - Ammo conditioned temperature

U.S. ARMY RDECOM

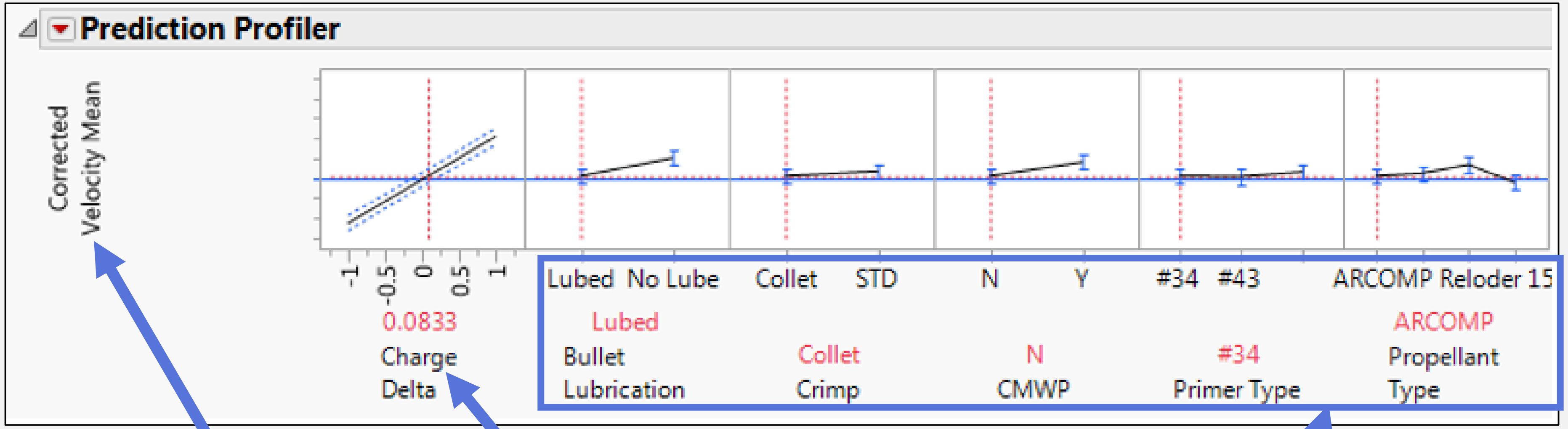
Charge Weight Establishment

Always a Step Ahead ARDEC ARMAMENTS

- Evaluated factors that were known to affect charge weight
- Established charge for nominal velocity out of EPVAT barrel
- Use test results to fit a predictive model to identify charge weights for each cartridge configuration used in subsequent tests

Test factors:

1. ***Charge delta***
2. Propellant
3. Primer
4. Bullet lubrication
5. Case mouth waterproofing
6. Case neck crimp



Model predicts "charge delta" needed to meet velocity requirement while accounting for other test factors

Interior Ballistics Test

Evaluate propulsion repeatability affecting muzzle exit conditions (velocity variability, bullet yaw rates)

- Identified critical propulsion factors to test in exterior ballistics testing
- Identified factors for reduced temperature sensitivity

Significant factors affecting velocity SD:

Effect Summary

Source	LogWorth	PValue	
CondTemp	11.981	0.00000	
Propellant Type	7.117	0.00000	
CondTemp*Primer Type	2.492	0.00322	
EPVAT Barrel Type*Propellant Type	2.317	0.00482	
CondTemp*CondTemp	2.192	0.00643	
Primer Type	2.052	0.00888	^
CondTemp*Propellant Type	1.840	0.01446	
Case Type	1.591	0.02565	
Bullet Lubrication	1.298	0.05039	
CMWP*Propellant Type	0.926	0.11858	
Primer Type*Propellant Type	0.845	0.14288	
CMWP	0.762	0.17296	^
EPVAT Barrel Type	0.279	0.52592	^

Test Factors:

1. Propellant
2. Primer
3. Case type
4. Case neck crimp
5. Bullet lubrication
6. Bullet seating method
7. Rounds on barrel
8. Temperature
9. Barrel type
10. Case mouth waterproofing

Exterior Ballistics: Test

Designed test to evaluate dispersion

- 46 test configurations shot (2 locations for a total of 1,380 rounds)
  - 100 & 300 m, fly-through (indoor)
  - 1,000 yd (outdoor)
  - 16” barrel (w/ and w/o suppressor), 26” barrel
- Digital target data at all 3 ranges used to assess multiple performance metrics:
  - Extreme spread, horiz./vert. SD, mean radii, velocities @ 5 ft., 100 & 300 m

Test factors:

1. Ogive shape
2. Meplat diameter
3. Boat tail angle
4. Bullet heel
5. Bullet lubrication
6. Case neck crimp
7. Propellant
8. Case type
9. Neck preparation
10. Primer
11. Barrel type
12. Case mouth waterproofing

Exterior Ballistics: Results

Mean radius model: 100 & 300 meters

Effect Summary

Source	LogWorth	PValue
Primer	5.987	0.00000
Propellant	5.291	0.00001
Ogive	3.189	0.00065
Bullet Heel	2.323	0.00476
Case Type	2.194	0.00639
Barrel Type	1.551	0.02813
CMWP	1.123	0.07537
Case Resize	0.912	0.12249

Mean radius model: 1000 yards

Effect Summary

Source	LogWorth	PValue
Bullet Heel	2.167	0.00681
Propellant	1.784	0.01645
Barrel Type	1.426	0.03752
Bullet Lube	1.246	0.05669
Collet Crimp	1.195	0.06380
Ogive	1.144	0.07172
CMWP	0.993	0.10174

- Test data analysis generates an analytical model for all factor level combos
  - Enables optimization

Changes to current production baseline for improved dispersion:

1. Propellant type
2. Bullet heel
3. Case type
4. Case mouth waterproofing
5. Case neck preparation
6. Charge weight variability

Conclusions and Recommendations

- Conclusive results to prioritize effort going forward
- Screened a comprehensive list of factors to prioritize dispersion effects using a novel, highly efficient D-optimal split plot test design approach
- Broadly applicable to screening tests with lots of factors where interactions are understood

Acknowledgements

Project Manager PM MAS Maneuver Ammunition Systems — Reliable, Precise, Lethal

ARDEC Armaments — Always a Step Ahead

Project Manager Soldier Weapons

Sierra — The Bulletsmiths®

Orbital ATK

Arrow Tech — *If you can't get a bigger target...*