30mm x 113mm (LW30)
Target Practice Tracer (TP-T) Ammunition

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Outline

- Applications
- Performance Objectives
- Initial Development Phase
- Final Development Phase
- Summary

Applications

M230 Gun

- Currently on Apache helicopter


M230 Gun

M230LF (Link Fed) Gun

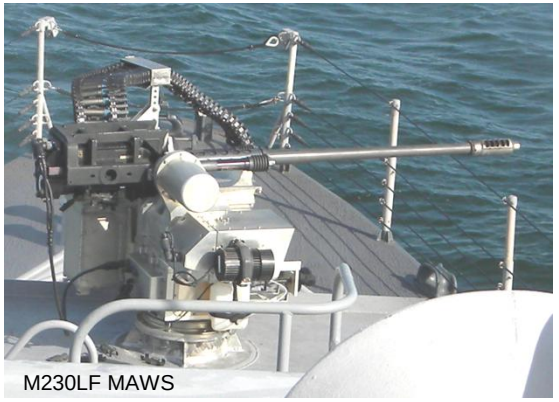
- Based on proven M230 gun
- Low-recoil design makes gun adaptable to many systems
- **Being implemented for ground applications**

ATK System Application Examples for M230LF

- Modular Advanced Weapon System (MAWS)
- Palletized Autonomous Weapon System (PAWS)
- Nobles Engineering Viper Gun System

Ground & shipboard applications require traced ammo


Apache Helicopter (www.boeing.com)


M230LF MAWS


M230LF PAWS

Performance Objectives

Flight Characteristics

- Ballistic match to M789 HEDP

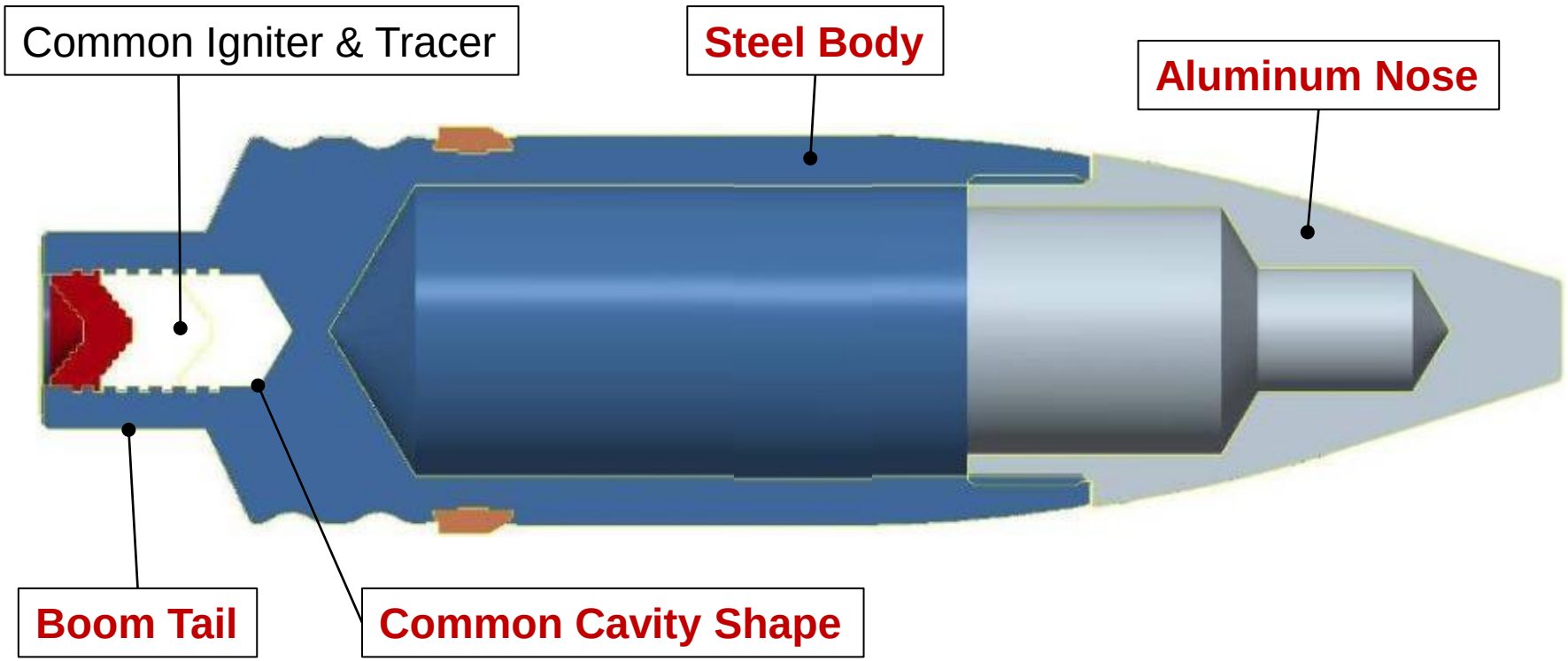
Desire direct drop-in addition to current LW30 ammo family

Tracer

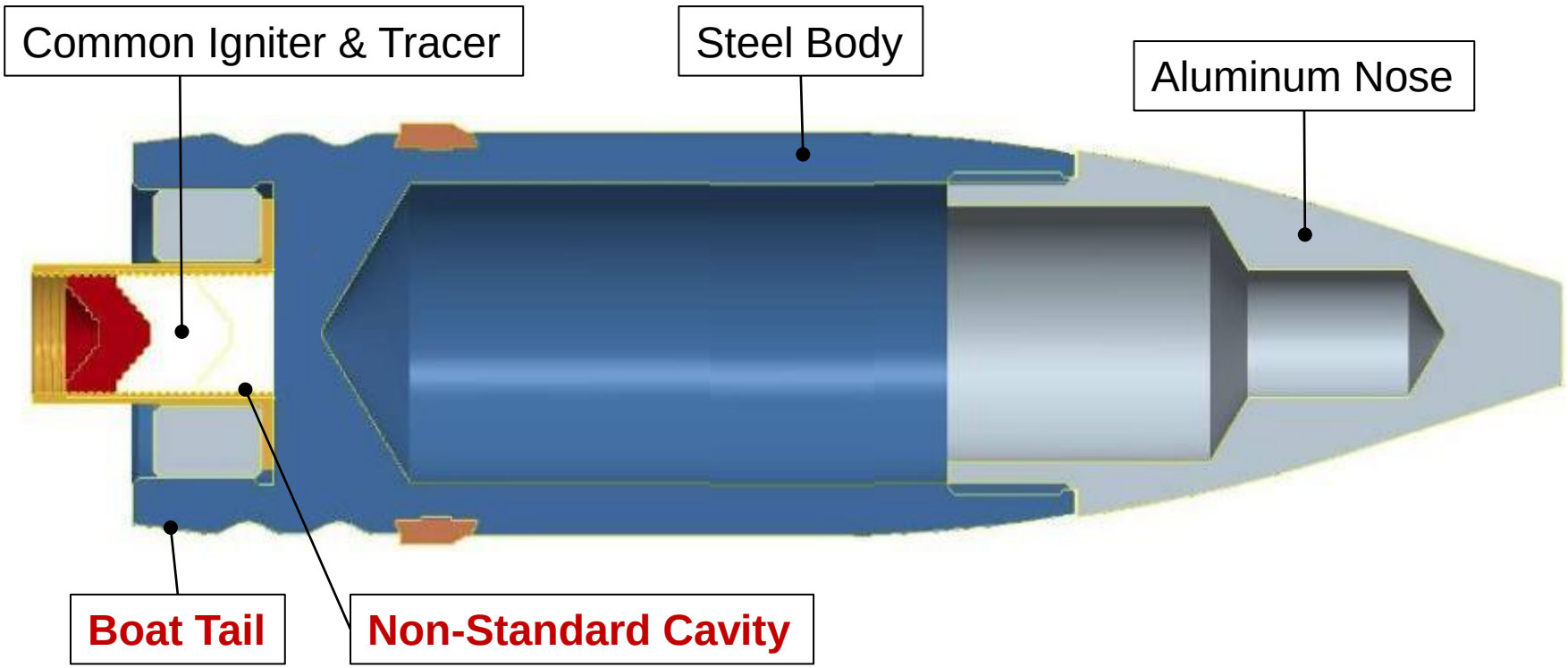
- Trace distance to 2000 meters
- Daylight & infrared visible

M789 HEDP M788 TP

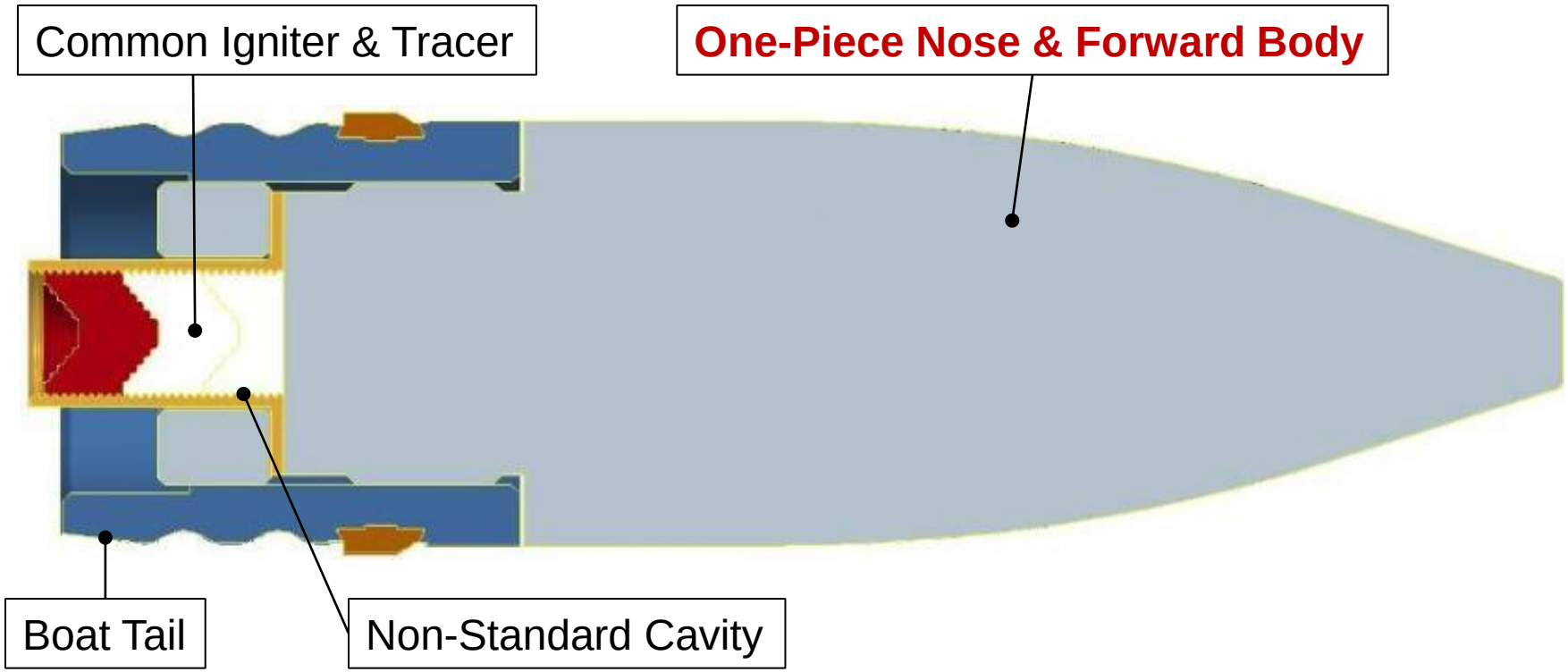
Initial Design – Option 1



Initial Design – Option 2



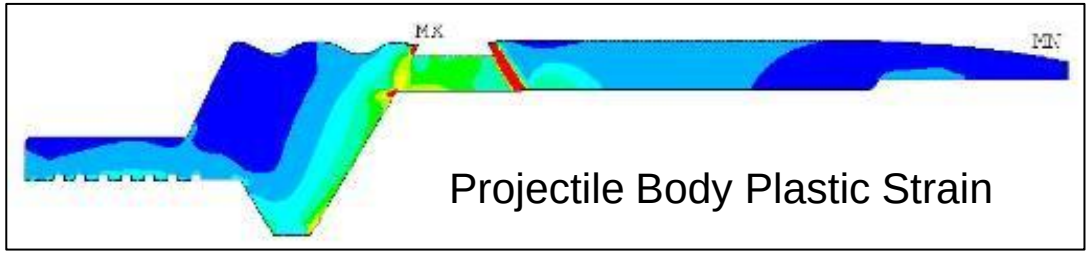
Initial Design – Option 3



Initial FEA Analysis – Setback

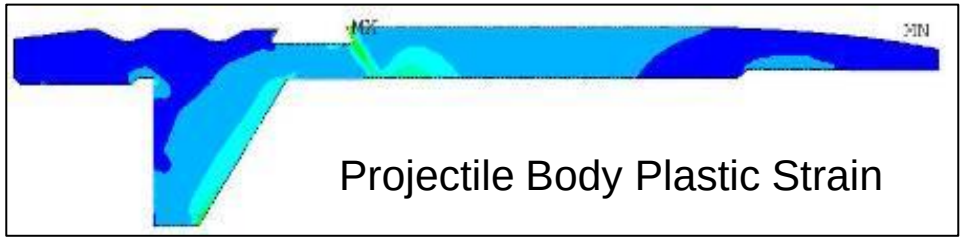
ANSYS Finite Element Analysis at Setback / Max Base Pressure at 71ºC (390 MPa)

- Option 1: Localized projectile body deformation – **Fracture not anticipated**



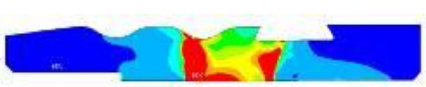
Projectile Body Plastic Strain

- Option 2: No projectile body deformation – **Robust**

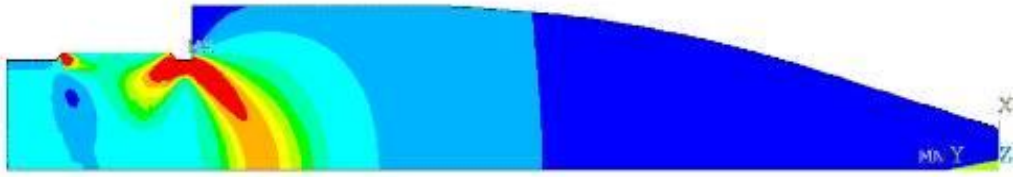


Projectile Body Plastic Strain

- Option 3: Localized nose and projectile body deformation – **Fracture not anticipated**



Projectile Body
Plastic Strain

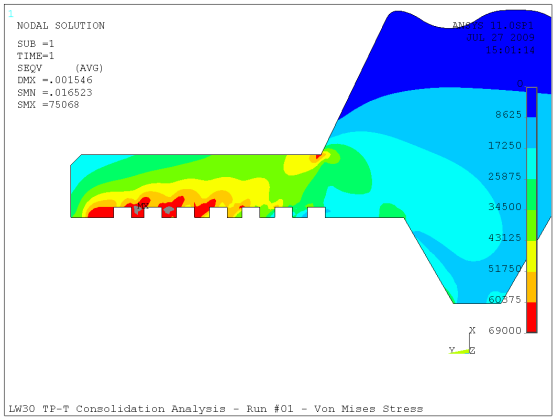


Nose Plastic Strain

Initial FEA Analysis – Tracer

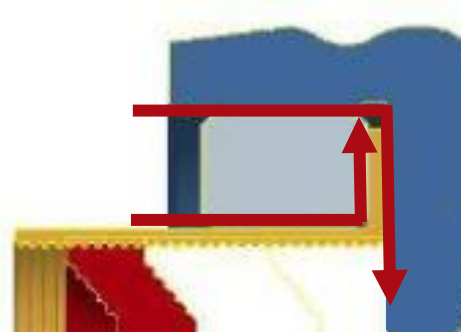
ANSYS FEA for tracer consolidation in Opt 1

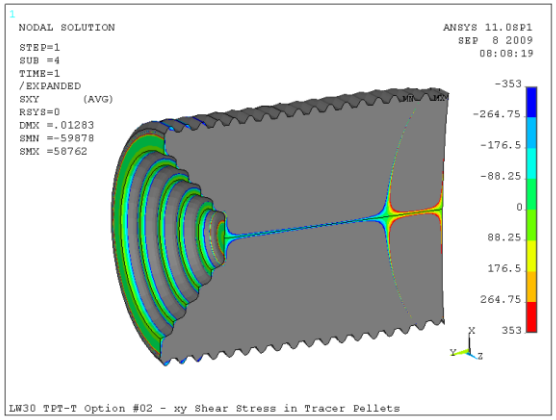
- Outcome: **Tracer boom will support consolidation**



ANSYS FEA for pressure leak for Opt 2 and 3

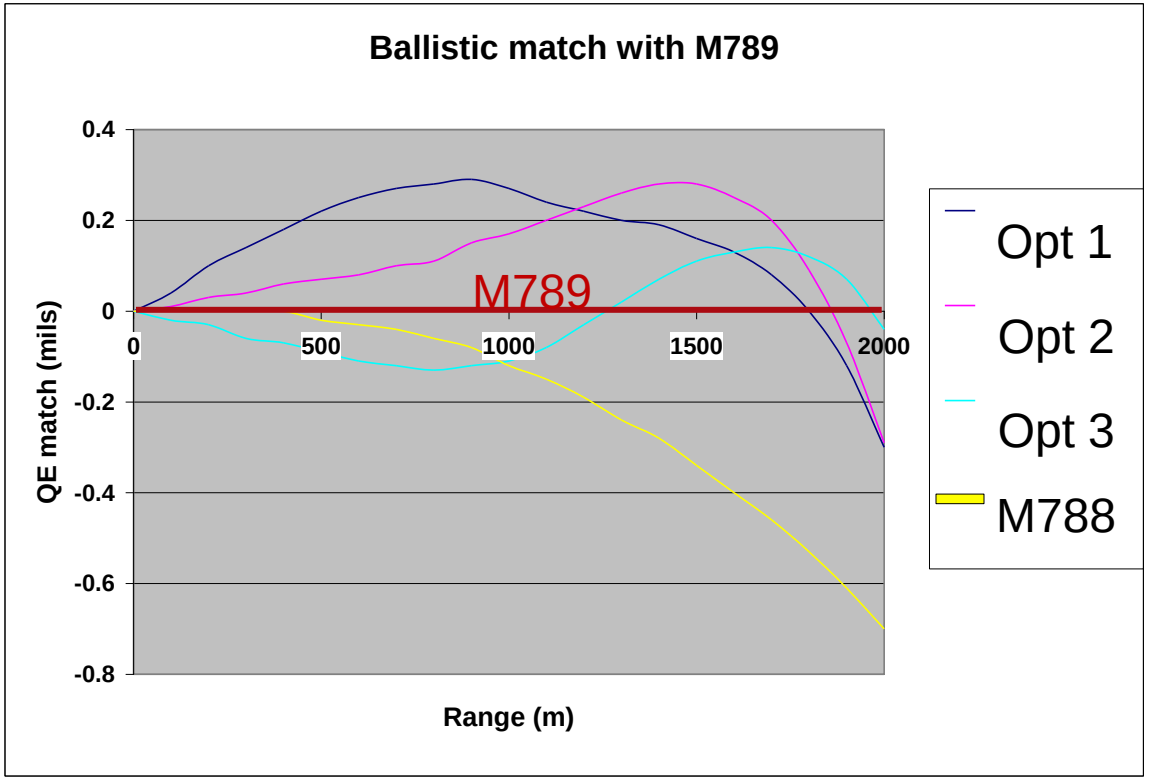
- Outcome: **Tracer will fail mechanically if gun pressure leakage occurs** (red arrows)
  - Led to development of more robust assembly process to prevent leakage





Initial Aeroballistic Analysis – Ballistic Match

PRODAS ballistics analysis of match to M789 out to 2000 meters



Projectile @ Velocity	QE Match (Drop in mils)
M788 @ 805 m/s	0.69
Option 1 @ 783 m/s	0.30
Option 2 @ 800 m/s	0.29
Option 3 @ 816 m/s	0.14

- Outcome: Option 1, 2, & 3 **ballistic match (drop) is within objective requirements**

Initial Aeroballistic Analysis (cont'd)

PRODAS ballistics analysis

Projectile	Gyro Stab Factor (2-3)	Muzzle Jump Factor	Predicted Yaw (deg)
M789	2.94	.025	3.5
M788	2.86	.028	3.5
Option 1	2.28	.023	2.5
Option 2	2.75	.021	4.5
Option 3	1.93	.026	4.5

- Outcomes: **Stability, dispersion, and yaw all predicted to be acceptable**

Initial Fabrication & Assembly

Option 1

Option 2

Option 3

Option 2 & 3 Tracer Assembly

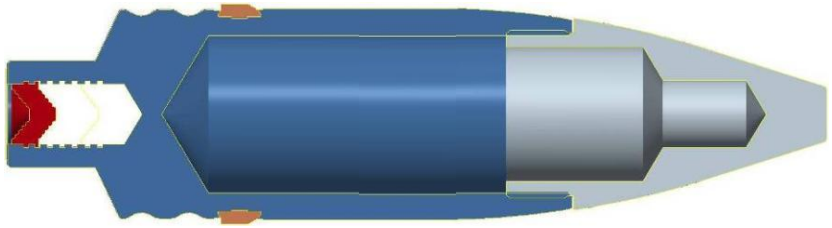
Initial Test Results – Radar, Drag to Max Range

- Radar and drag profile data collected and analyzed
  - Outcome: 'Tracer effect' less significant than estimated, resulting in slightly **higher drag and longer flight times to 2000 meters than predicted**
- PRODAS model updated based on empirical data
  - Outcome: **Ballistic match and required muzzle velocity predictions updated**

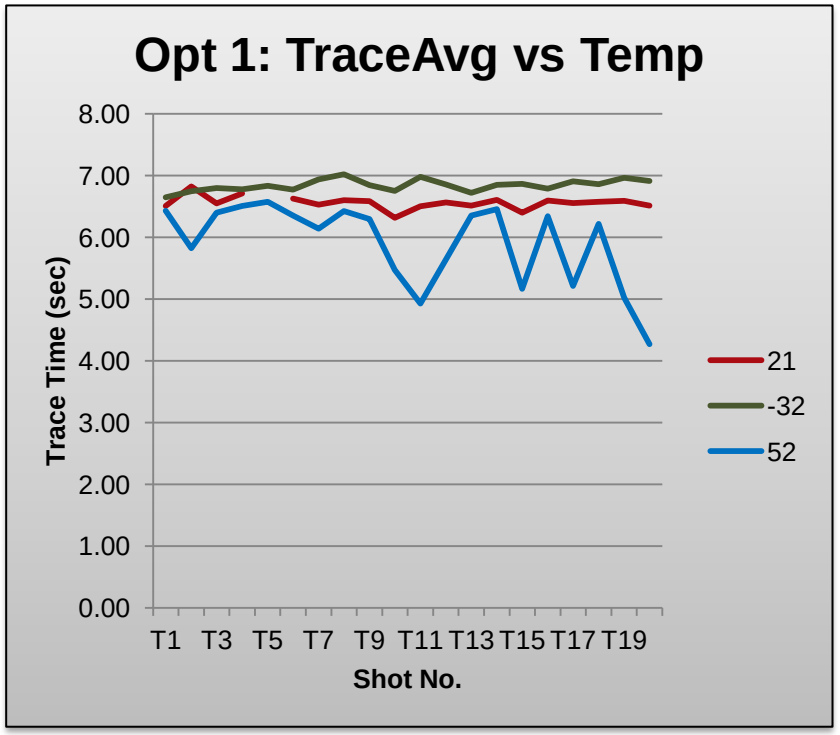
Projectile	Original QE Match (Drop in mils) @ Req'd Muzzle Velocity	Updated QE Match (Drop in mils) @ Req'd Muzzle Velocity
M788	0.69 @ 805 m/s	same
Option 1	0.30 @ 783 m/s	0.47 @ 817 m/s
Option 2	0.29 @ 801 m/s	0.28 @ 850 m/s
Option 3	0.14 @ 816 m/s	0.79 @ 856 m/s

Initial Test Results – Tracer – Option 1

- Ambient: **18/20** successful
  - Both failures ignited but were short burns (failures averaged 9 meters short)
- Cold: **20/20** successful
- Hot: **11/20** successful
  - All failures ignited but were short burns (failures averaged 152 meters short)
  - **High burn time variation**

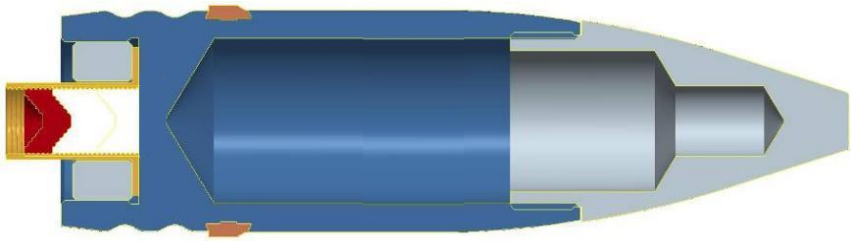


2km Flight Time (sec)≈	Ambient	Cold	Hot
	6.41	6.60	6.15

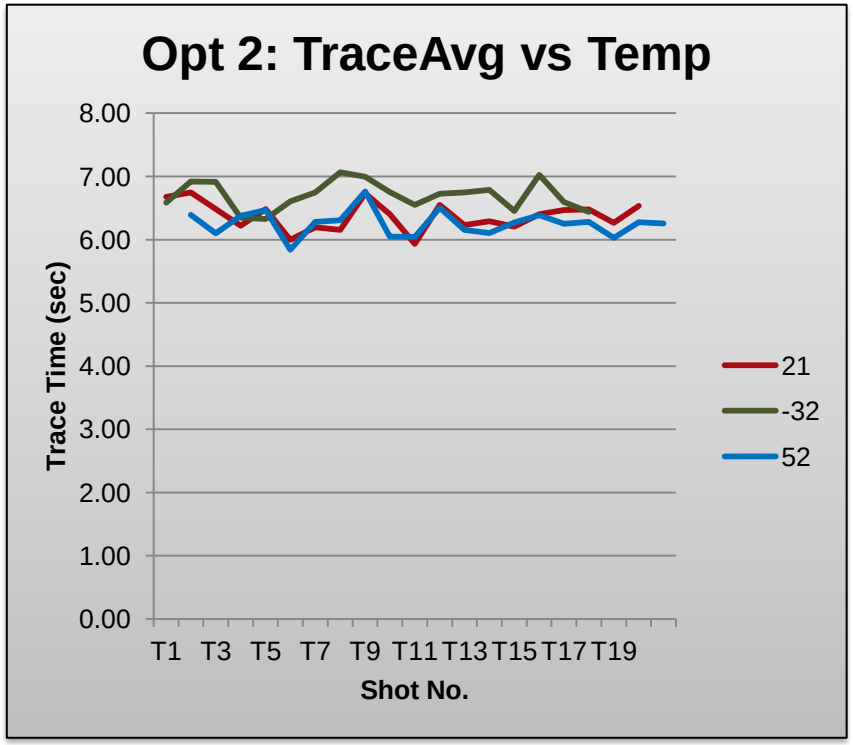


Initial Test Results – Tracer – Option 2

- Ambient: **17/20** successful
  - All failures ignited but were short burns (failures averaged 10 meters short)
- Cold: **15/20** successful
  - 4 failures ignited but were short burns (failures averaged 15 meters short)
  - 1 failure did not ignite
- Hot: **19/21** successful
  - 1 failure ignited but was a short burn (42 meters short)
  - 1 failure did not ignite
- All had **consistent burn time variation**

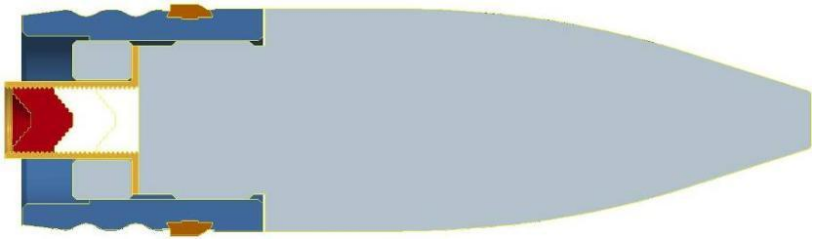


2km Flight Time (sec)≈	Ambient	Cold	Hot
	6.12	6.50	6.04

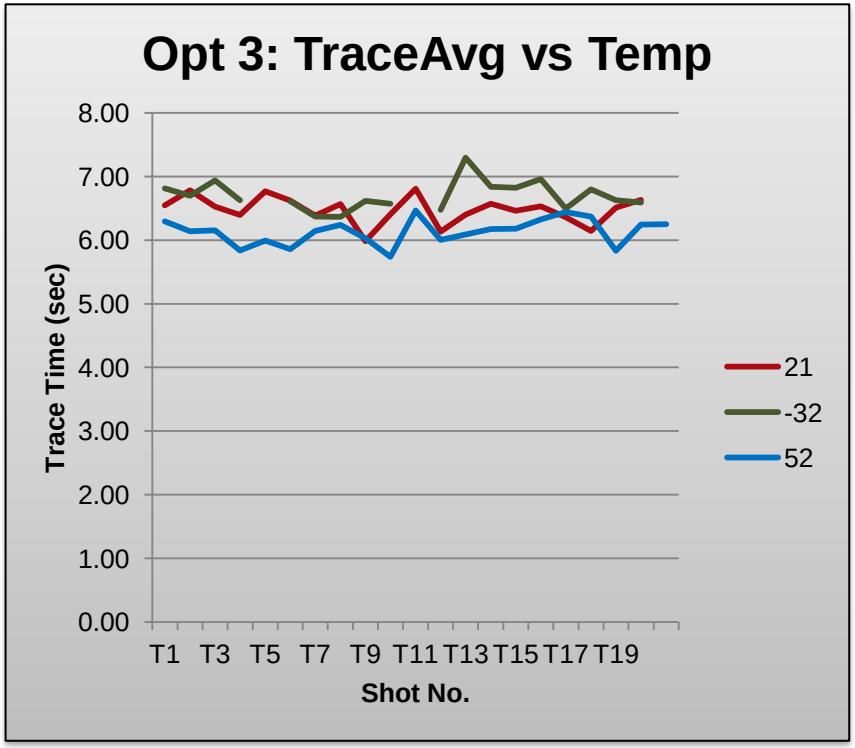


Initial Test Results – Tracer – Option 3

- Ambient: **7/20** successful
  - All failures ignited but were short burns (failures averaged 33 meters short)
- Cold: **4/20** successful
  - 14 failures ignited but were short burns (failures averaged 41 meters short)
  - 2 failures did not ignite
- Hot: **2/21** successful
  - All failures ignited but were short burns (failures averaged 62 meters short)
- All had **consistent burn time variation**



2km Flight Time (sec)≈	Ambient	Cold	Hot
	6.55	6.83	6.43



Initial Conclusions – Options 1, 2, & 3

Structural Integrity

- All designs survived gun launch at all temperatures
- Risk areas identified during FEA

Aeroballistic Performance

- All designs met threshold ballistic match objectives

Tracer Performance

- **All designs must have longer tracer burn times** to reliably meet objective trace distance of 2000 meters

Producibility

- Many improvement opportunities identified

An updated design was required to meet performance objectives

Constraints for Final Design

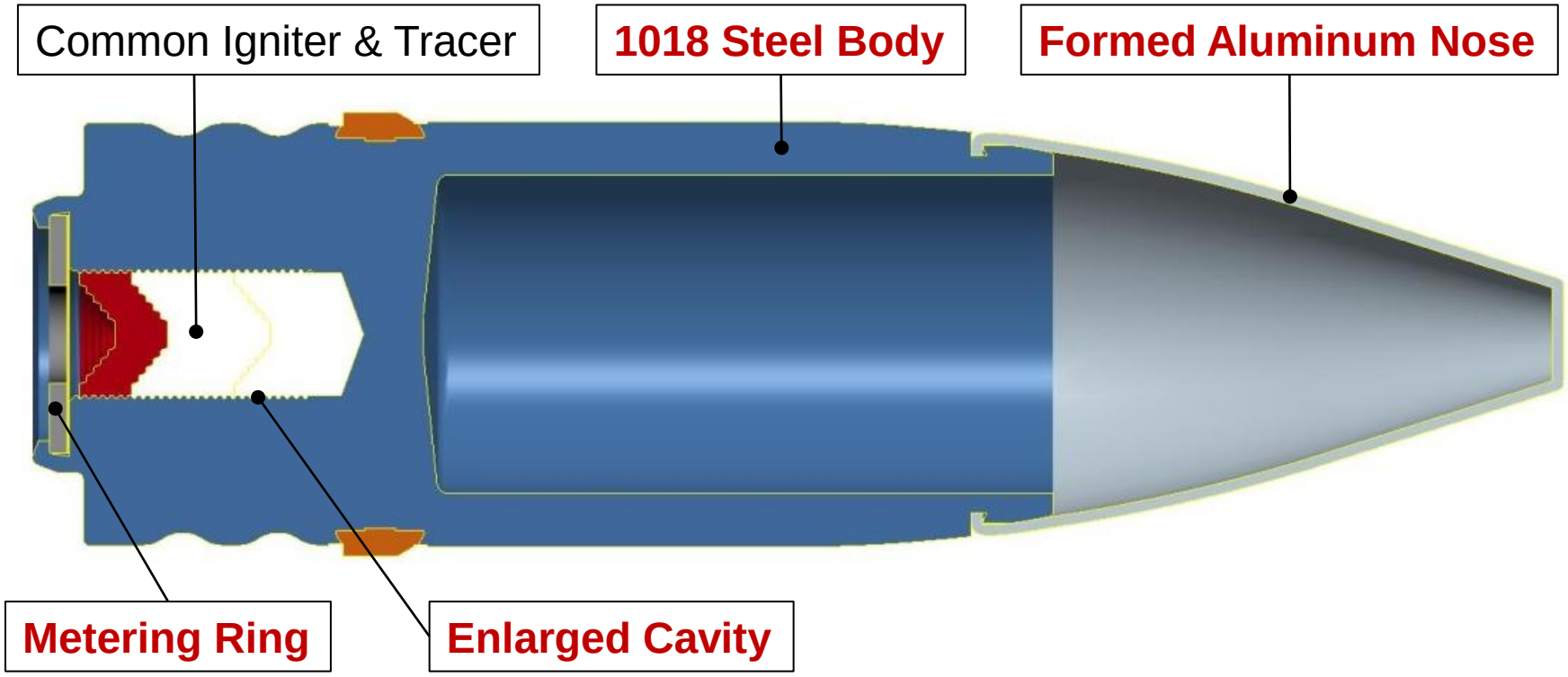
Threshold (Primary) Requirements:

- Continue to meet ballistic match and dispersion objectives
- **Reliably meet tracer burn distance requirements**
- Added requirement for **compatibility in alternate barrel design**
  - 42” with 6.5º rifling exit angle (most common barrel for M230 on Apache)
    - This is design used for all previous PRODAS simulations
  - 60” barrel with 6.2º rifling exit angles (most common barrel for M230LF)

Objective (Secondary) Requirements:

- Method to improve tracer ignition reliability
- Improve producibility & affordability

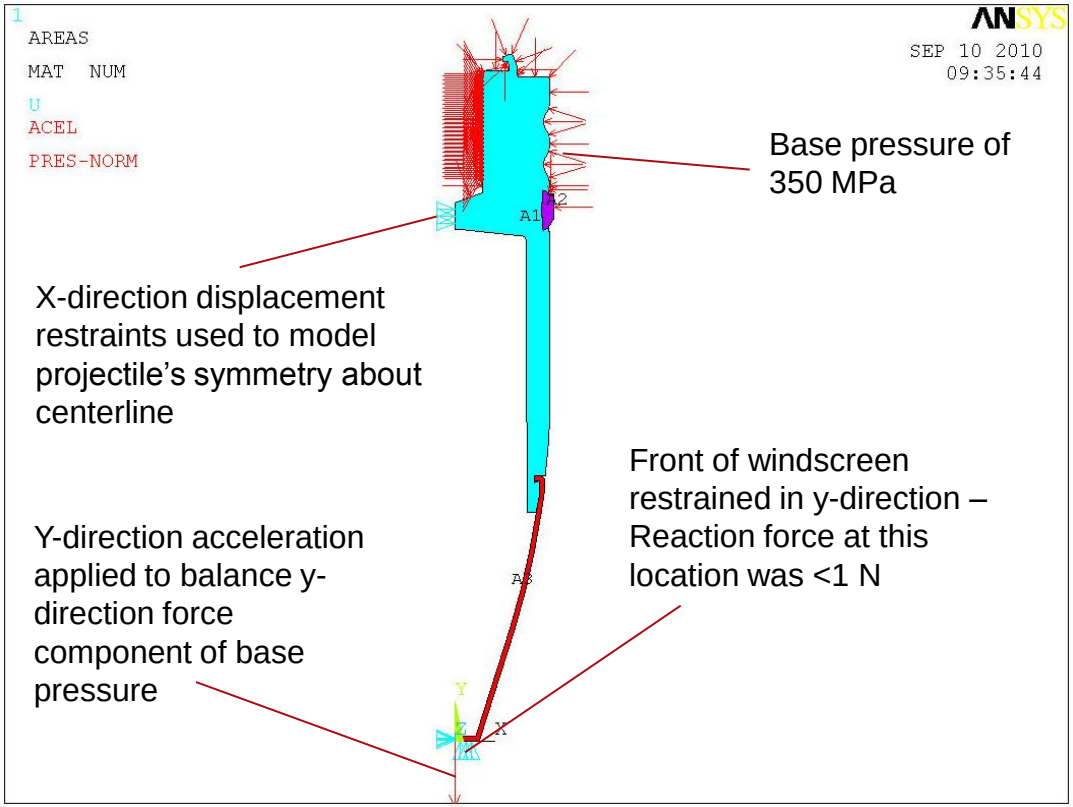
Final Design Summary



Final FEA Analysis – Conservative Inputs

ANSYS Analysis Input Summary

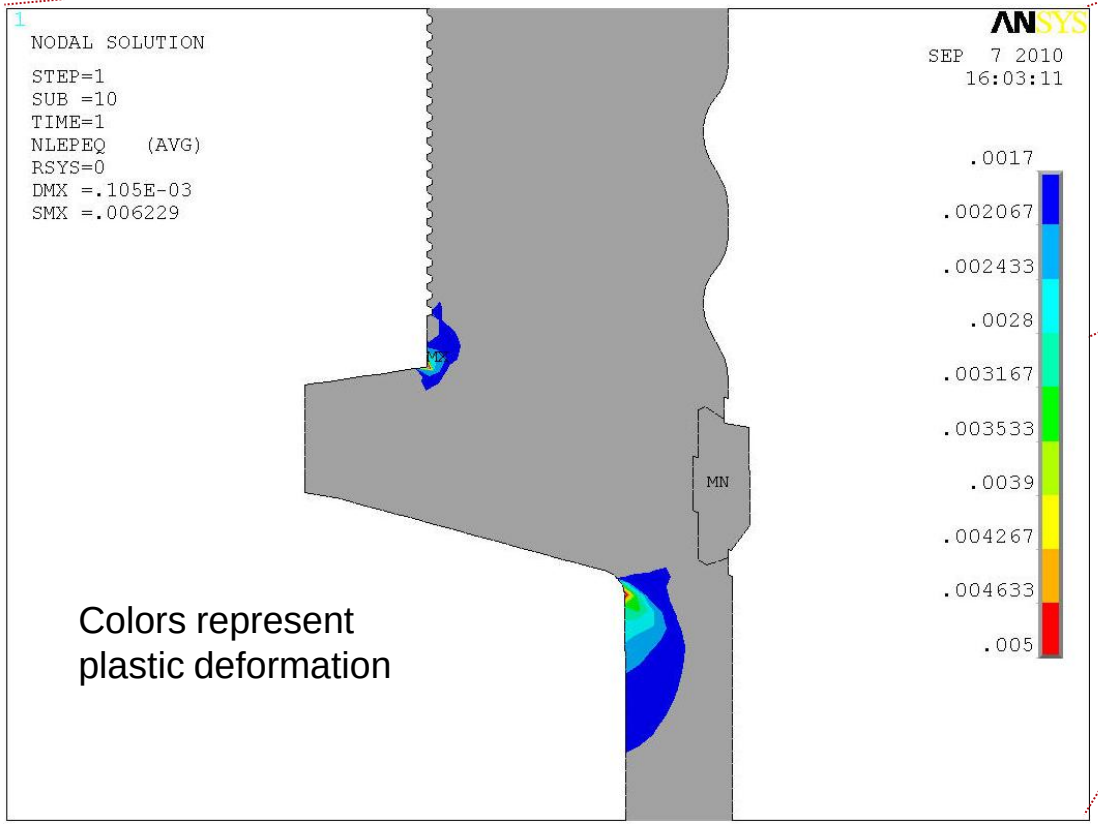
- Body & Nose Materials:
  - **Minimum allowable material properties**
- Base Pressure:
  - **350 MPa pressure (greater than predicted pressure at hot)** applied to aft exterior

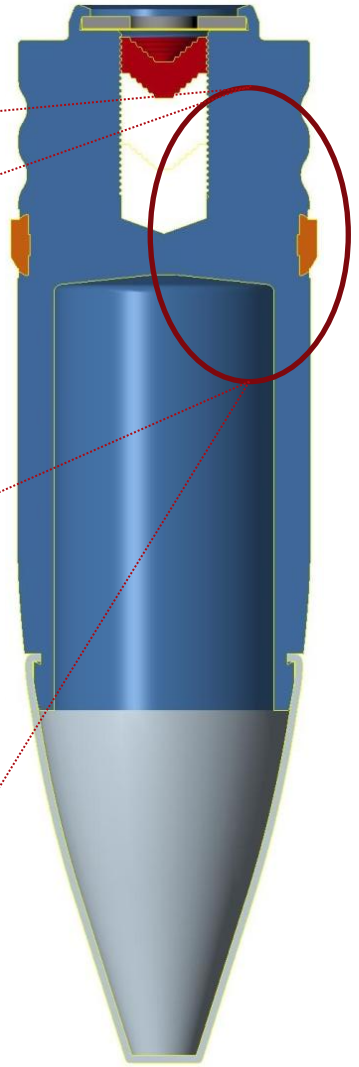


Final FEA Analysis (cont'd) – Robust Design

ANSYS Analysis

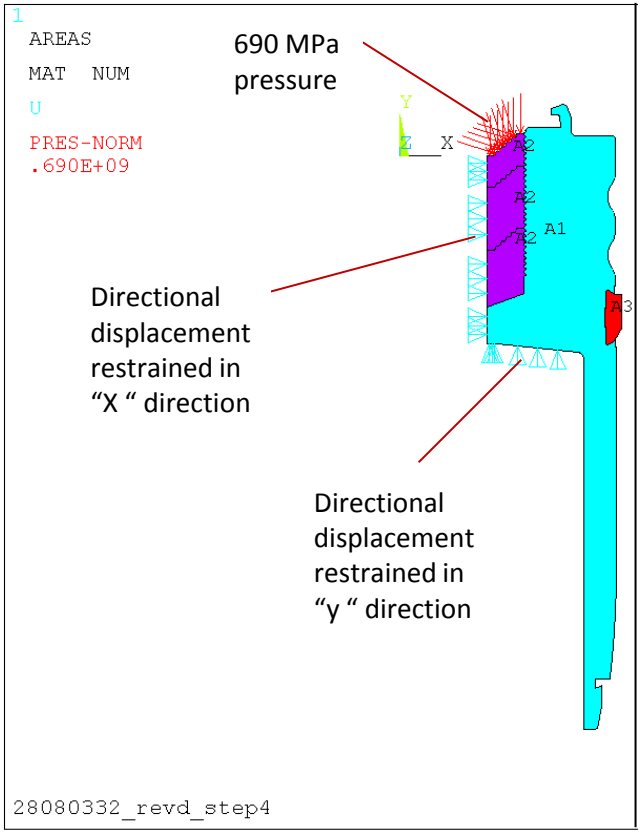
- Outcome: Localized projectile body deformation
  - **Fracture not anticipated**

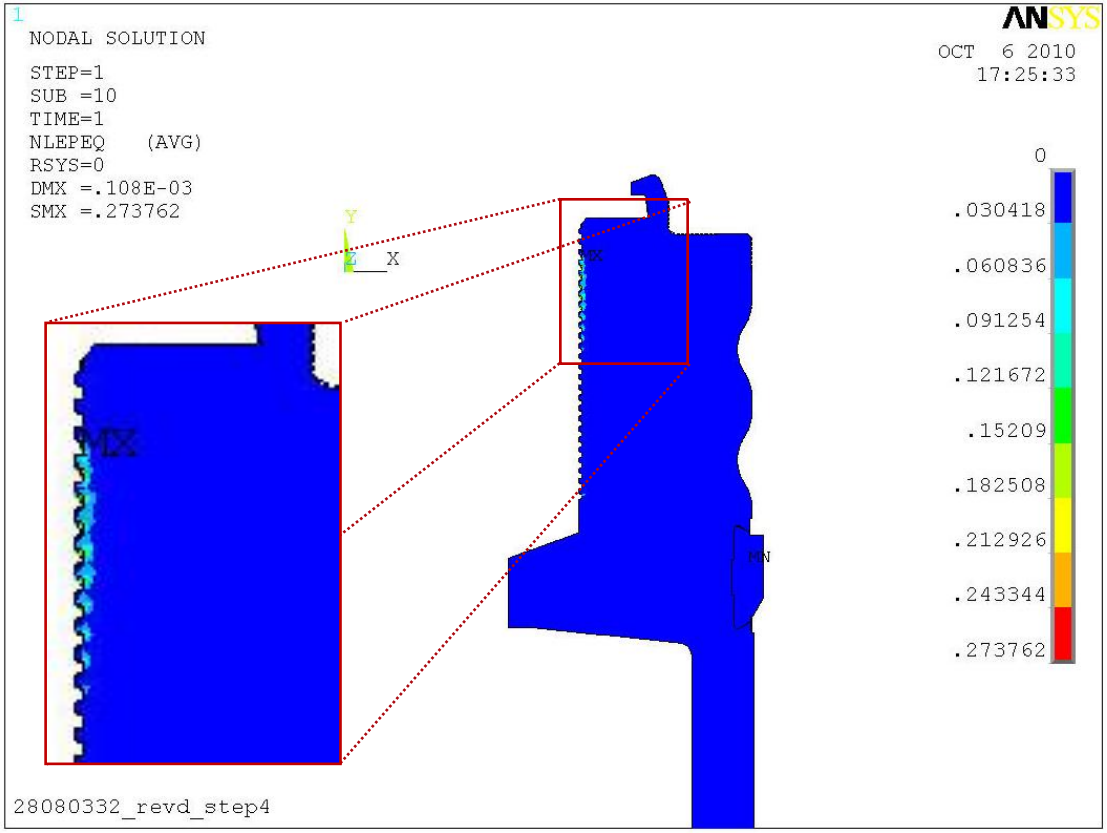




Initial FEA Analysis – Tracer

ANSYS FEA for tracer consolidation





- Outcome: **Projectile body will support tracer consolidation**

Final Aeroballistic Analysis – Ballistic Match

PRODAS ballistics analysis of match to M789 out to 2000 meters

- Simulations completed for both 42” and 60” barrel designs, and updated to account for radial match (a function of both drop and drift)

Projectile	42” Barrel, 6.5º Exit Angle	60” Barrel, 6.2º Exit Angle
	QE Match (Radial in mils) @ Req’d Muzzle Velocity	QE Match (Radial in mils) @ Req’d Muzzle Velocity
M788	0.10 @ 800 m/s	0.16 @ 839 m/s
Final	0.64 @ 769 m/s	0.60 @ 804 m/s

- Outcome: **Final design within objective requirements**

Final Aeroballistic Analysis (cont'd)

PRODAS ballistics analysis

Projectile	42" Barrel, 6.5º Twist	60" Barrel, 6.2º Twist	Either Barrel	
	Gyro Stab Factor (2-3)	Gyro Stab Factor (2-3)	Muzzle Jump Factor	Predicted Yaw (deg)
M789	2.94	2.74	.025	3.5
M788	2.86	2.66	.028	3.5
Option 1	2.28	-	.023	2.5
Option 2	2.75	-	.021	4.5
Option 3	1.93	-	.026	4.5
Final	3.01	2.74	.012	4.0

- Outcomes: **Stability, dispersion, and yaw all predicted to be acceptable**

Final Fabrication & Assembly

Completed:

- Nose caps
- Projectile Bodies (Figure 1), through banding (Figure 2), band trim, and plate/paint
- Tracer & igniter pellets
- Metering Discs

On-Going:

- **Final Assembly to be completed in near future**

Figure 1

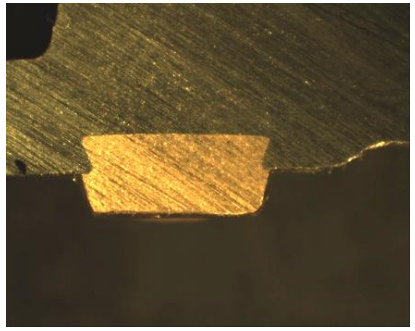
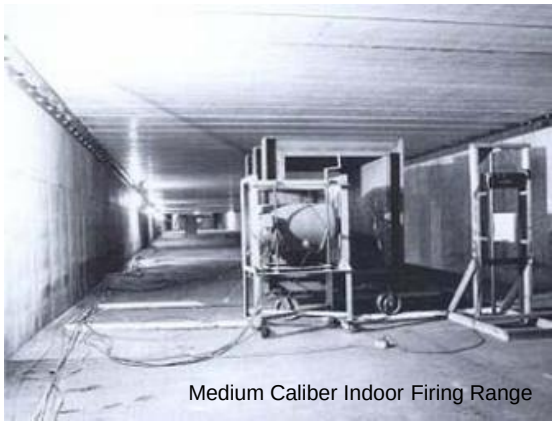


Figure 2

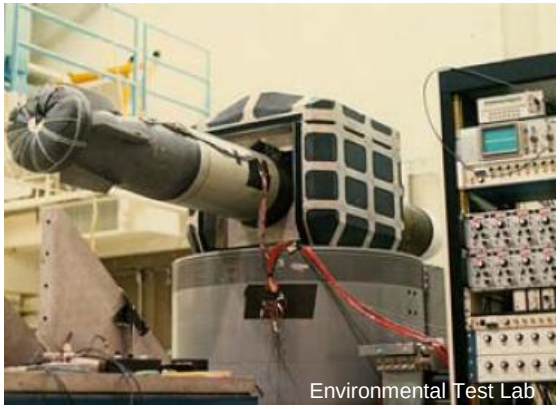
Final Test Plan

- Charge Establishment
- Charge Verification
- PVAT, Dispersion, Yaw, Mann Barrel Function & Casualty
- Max Range Tracer & Radar
- Autogun Function & Casualty
- Environmental then PVAT

Testing to be conducted in near future


Medium Caliber Indoor Firing Range


Medium Caliber Outdoor Firing Range


Environmental Test Lab

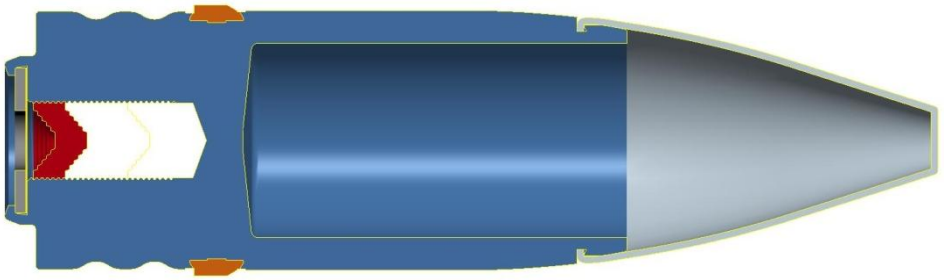
Summary

Initial 3 Designs

- Met ballistic match and flight objectives
- **Could not reliably meet tracer objectives**
- Had producibility and assembly concerns

Final Design

- Simulations indicate this **will meet ballistic and flight requirements**
- Additional tracer mix capacity and metering ring expected to provide **reliable tracing to 2km**
- **Structurally robust** design
- **Improved producibility** and cost savings



Questions?

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