# PLASMA TRANSFER ARC FABRICATION OF ENHANCED PERFORMANCE BARRELS

NSAC/NSATC ARMY CONTRACT W15QKN-05-9-0200 -0007
ANTIMATERIEL SNIPER RIFLE BARREL
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NDIA JOINT SERVICES SMALL ARMS SYMPOSIUM

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# PRESENTATION OUTLINE

- Weapon System Enhancement Requirements
- Solution Approach
- Enabling Technology - Plasma Transfer Arc (PTA)
- Prior PTA Barrel Work
- 50-Cal Antimateriel Sniper Rifle barrel Work
- Technology Future Potential

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# WEAPON SYSTEM ENHANCEMENT REQUIREMENTS

- Ease of portability
  - Lighter Weight
- Long effective range
  - Hotter propellants
- Accuracy (one-shot-one-kill)
  - Barrel Structural Integrity (Reduced Flexure)

# SOLUTION APPROACH

- Fabricate a composite barrel
  - liner + over-wrap
- Grade the component materials functionally
  - Erosion resistant refractory metal (Mo-Re or Ta- W alloys)
  - Or monolithic ceramic (SiAlON) liner.
    - Hotter propellant requirement
  - Light weight metal (Ti) over-wrap
    - Light weight requirement

# SOLUTION APPROACH (CONT'D)

- Create a continuous interface between the two components
  - Eliminates thermal impedance
    - Thermal management – hotter propellant requirement
  - Provides a continuous and symmetric load transmission
    - Structural integrity – reduced flexural deflection – accuracy requirement

# SOLUTION APPROACH (CONT'D)

- Maintain the liner in compression
  - Functionally equivalent to autofrettage
  - Counteracts the propellant gas pressure to reduce stress in the liner
    - Counteracts the mechanical stress component of erosion/wear
    - Erosion/wear resistance – hotter propellant requirement
  - Reduces stress on the over-wrap for better barrel structural integrity
    - Structural integrity improvement – accuracy requirement

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# ENABLING TECHNOLOGY - (PTA)

- Melts and deposits any metal selectively to form a near net shape feature
- Both liner and over-wrap can be formed
- Current barrel work is limited to depositing the over-wrap over an existing refractory metal or ceramic liner
- As the over-wrap metal cools down, it forces the liner into a tri-axial state of compression
- The interface between the liner and the over-wrap is continuous
  - Metallurgical bond for refractory metal
  - Perfect overlay for ceramic

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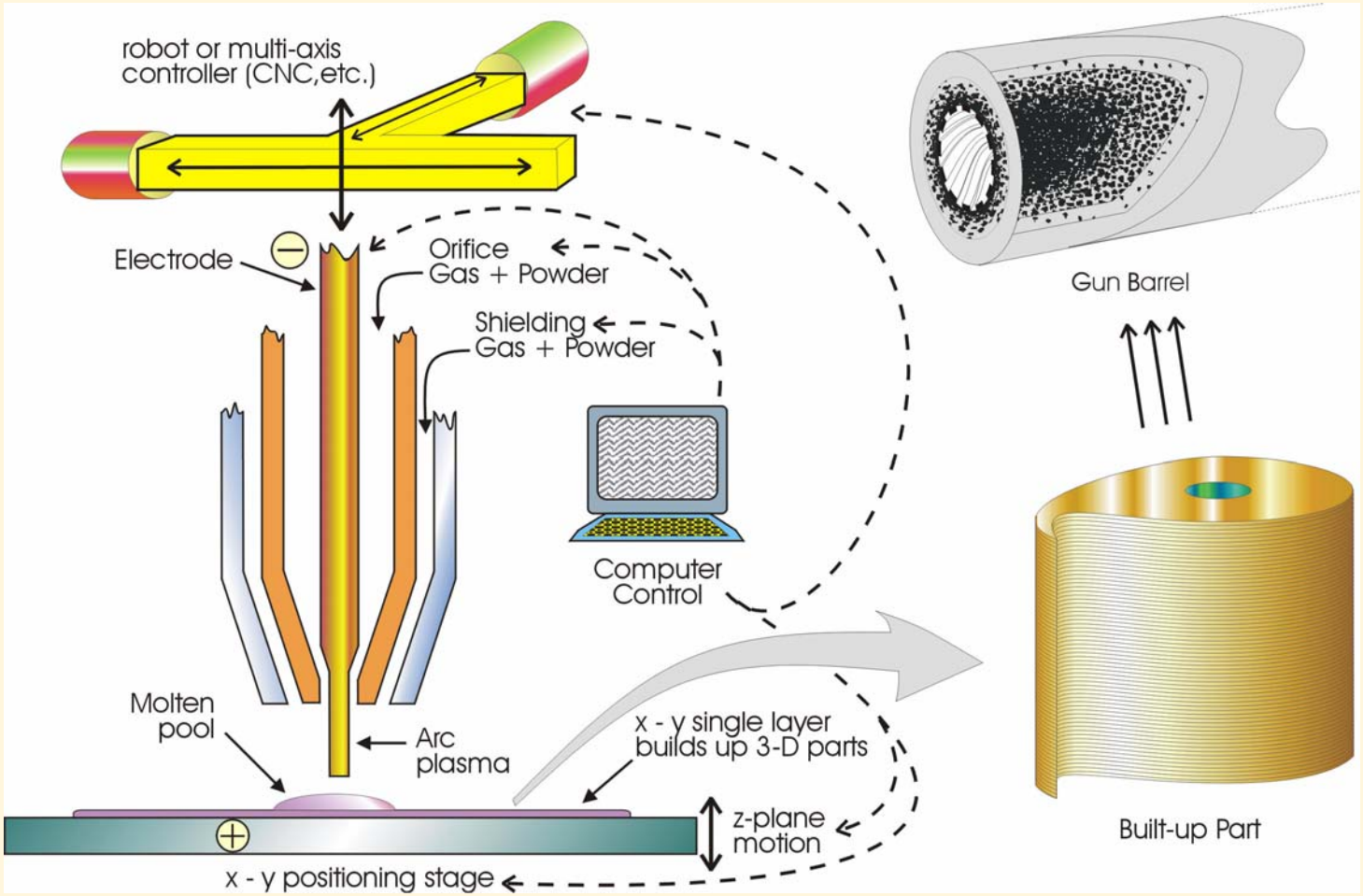
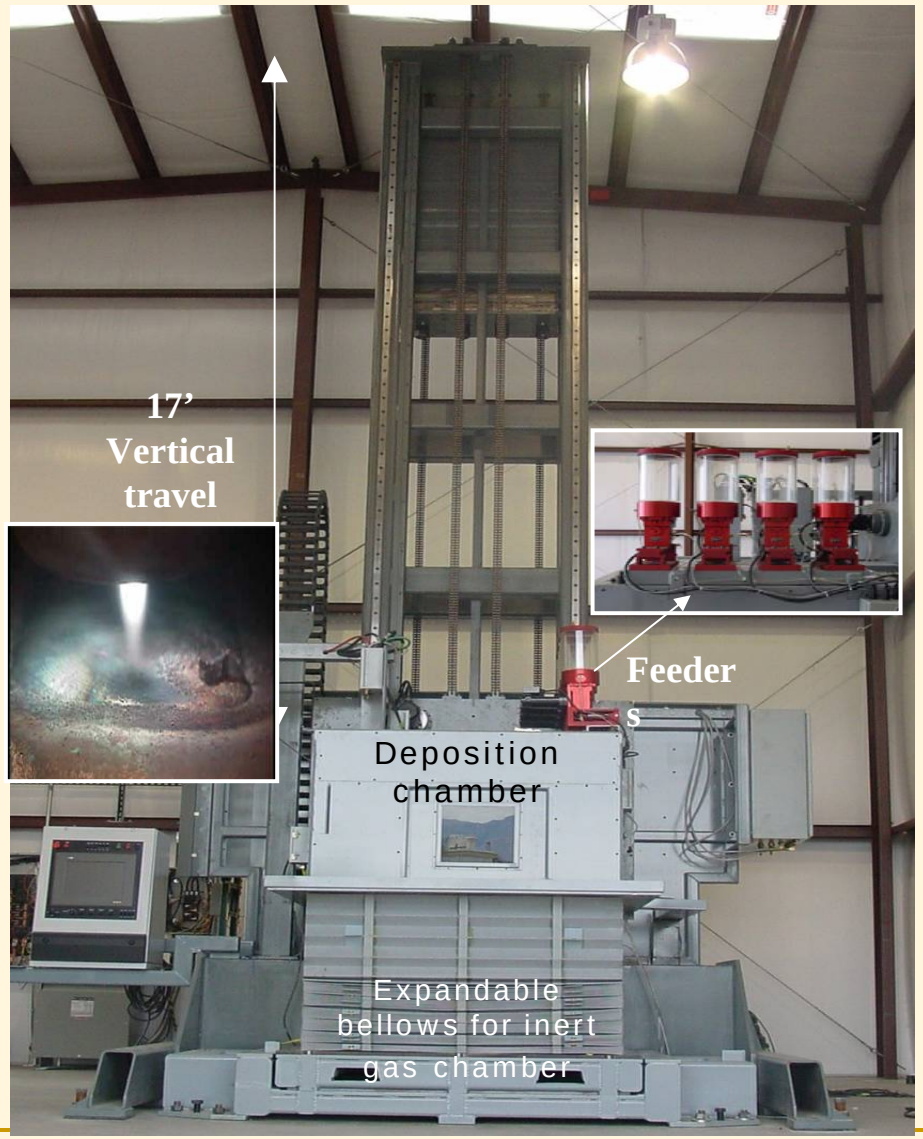
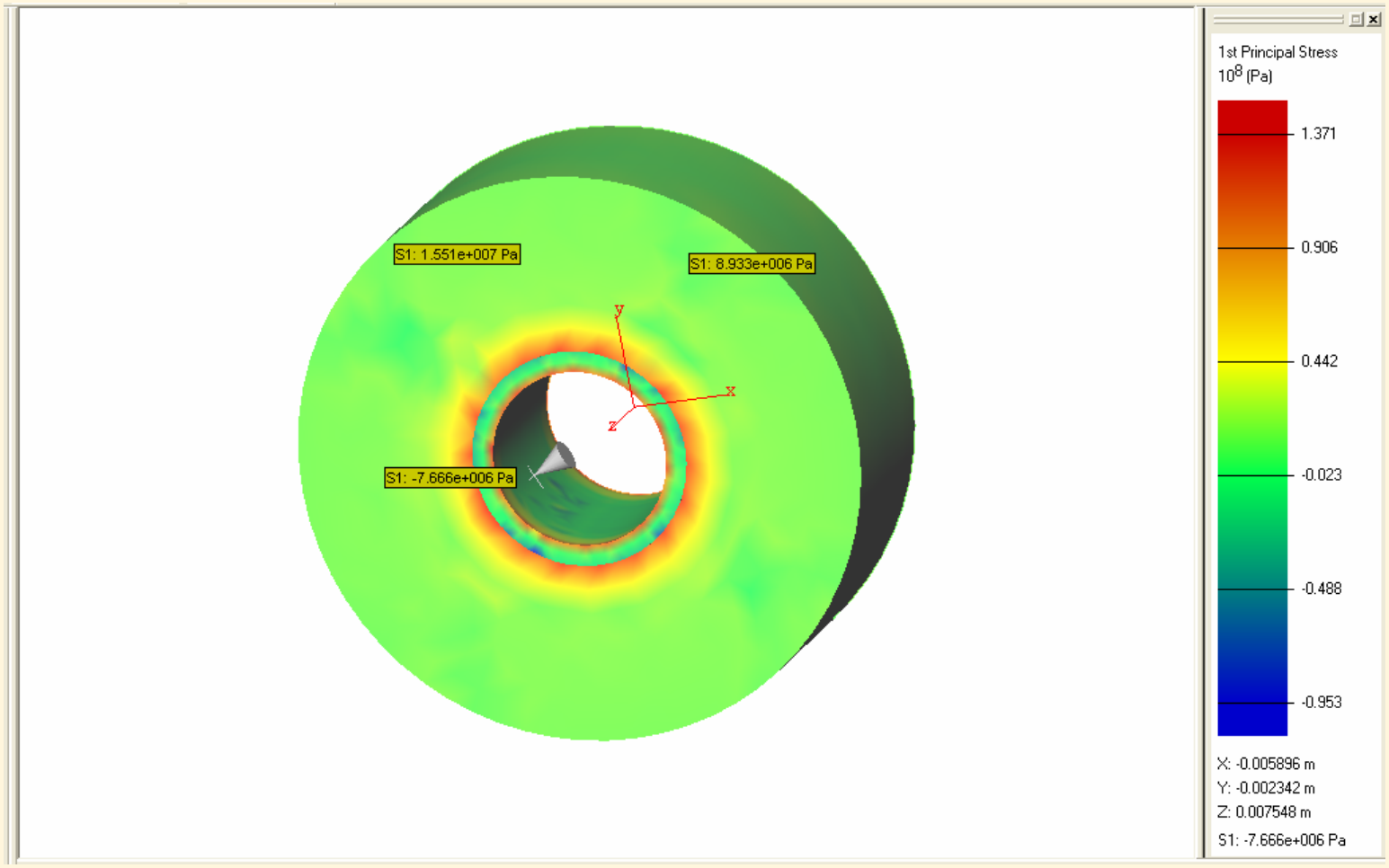
# PTA SCHEMATIC



# PTA SFFF SYSTEM

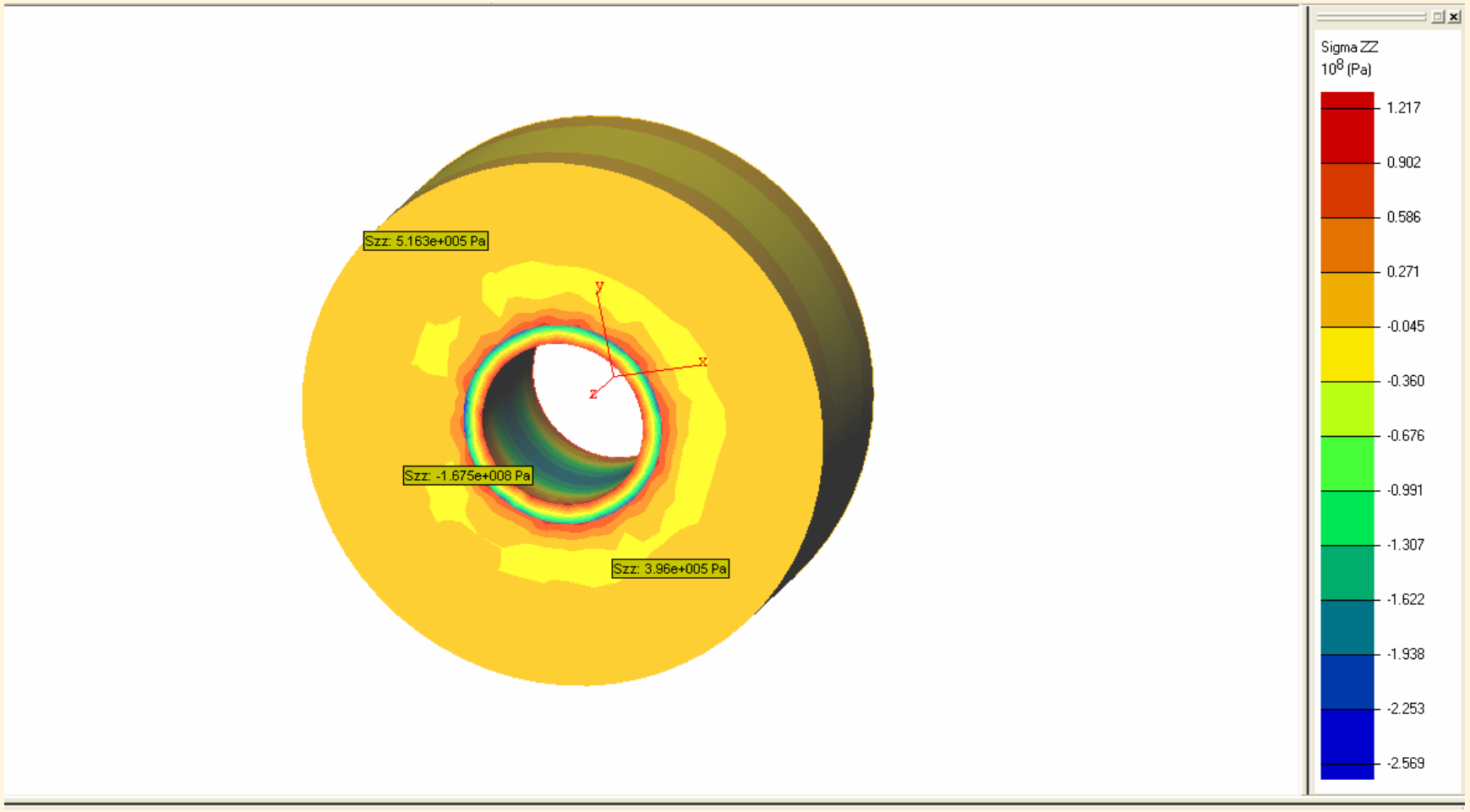


# 50 CAL Mo-Re LINER WITH PTA Ti OVER-WRAP
## Liner is in Compression- Negative 1st Principal Stress

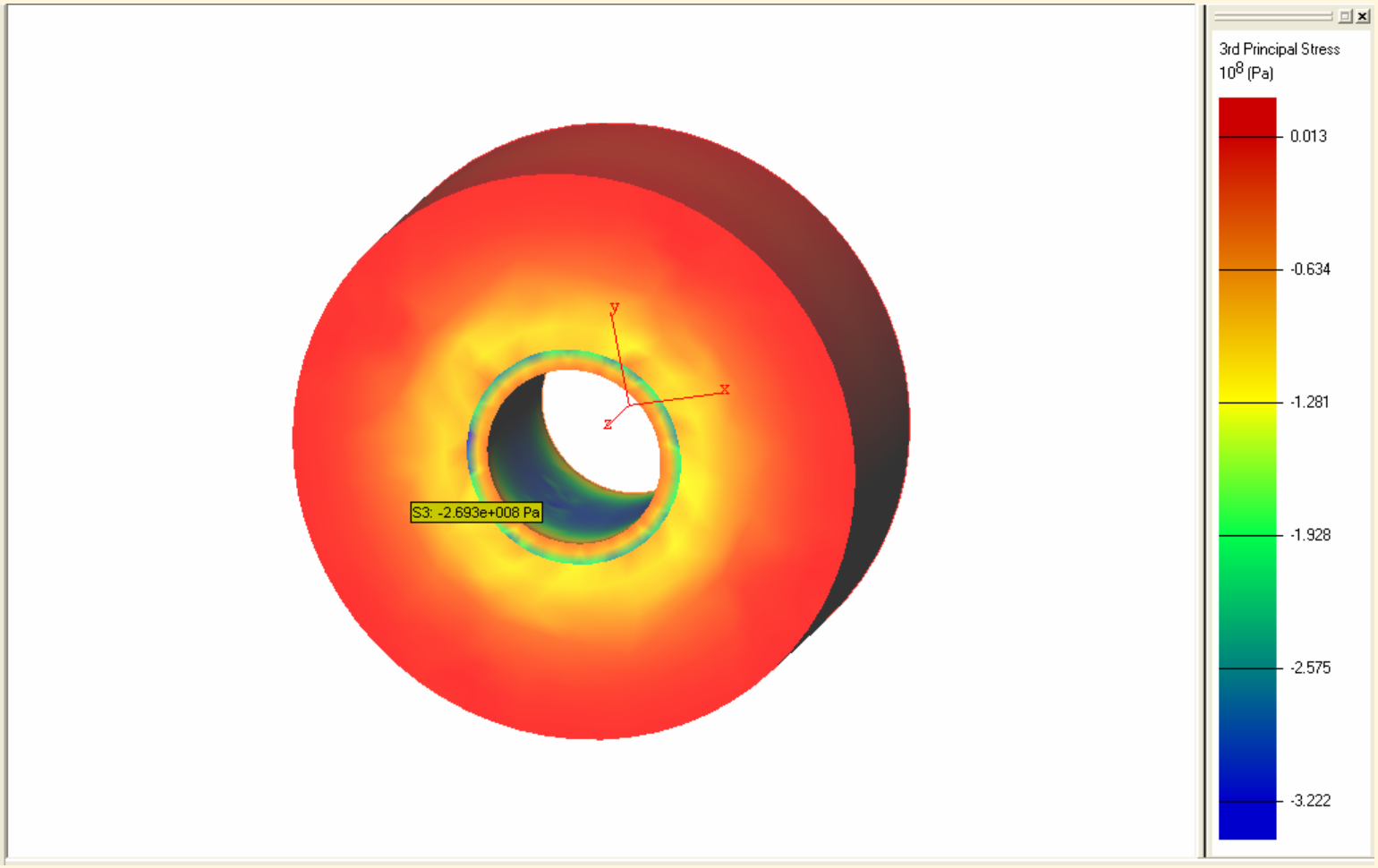


# 50 CAL Mo-Re LINER WITH PTA Ti OVER-WRAP

## Liner in Compression- Negative $\sigma_{zz}$ Stress



# 50 CAL Mo-Re LINER WITH PTA Ti OVER-WRAP
## Liner in Compression- Negative 3rd Principal Stress

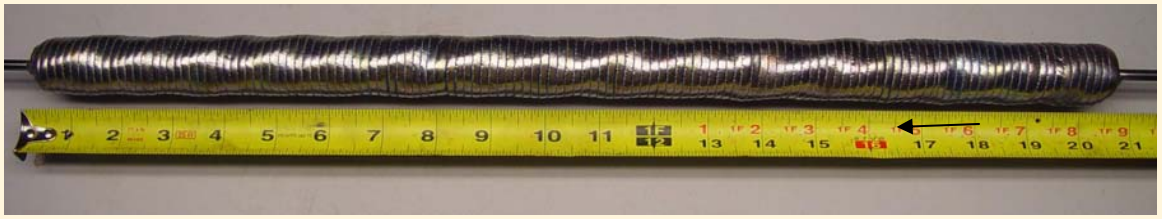


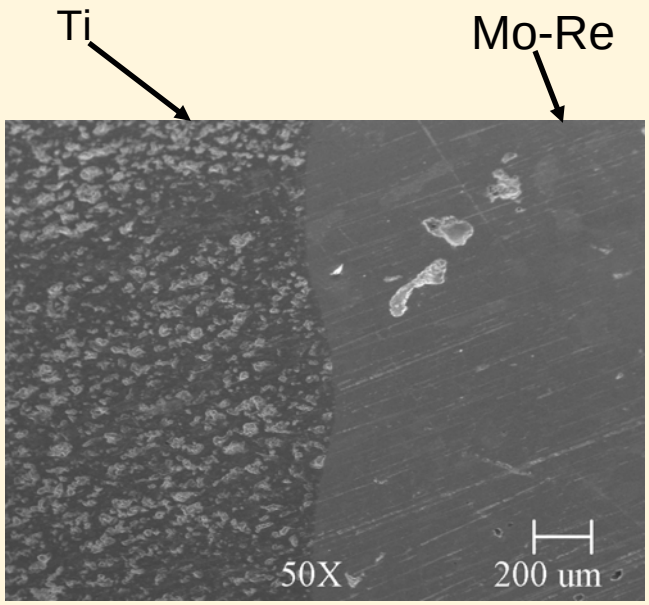
# PRIOR WORK (M249 BARREL)

- M249 with Mo-47.5Re liner and PTA titanium over-wrap
  - SEM images show a continuous interface between liner and over-wrap
  - Tested to about 1800 rounds using 50, 100, and 200 bursts
  - Numerous stoppages due to poor surface finish on the chamber
  - No signs of cook-off at 200 round burst
  - Barrel OD temperature comparable to that of a standard M249 barrel.

# M249 REFRACTORY METAL LINER (Mo-Re) WITH PTA Ti OVER-WRAP

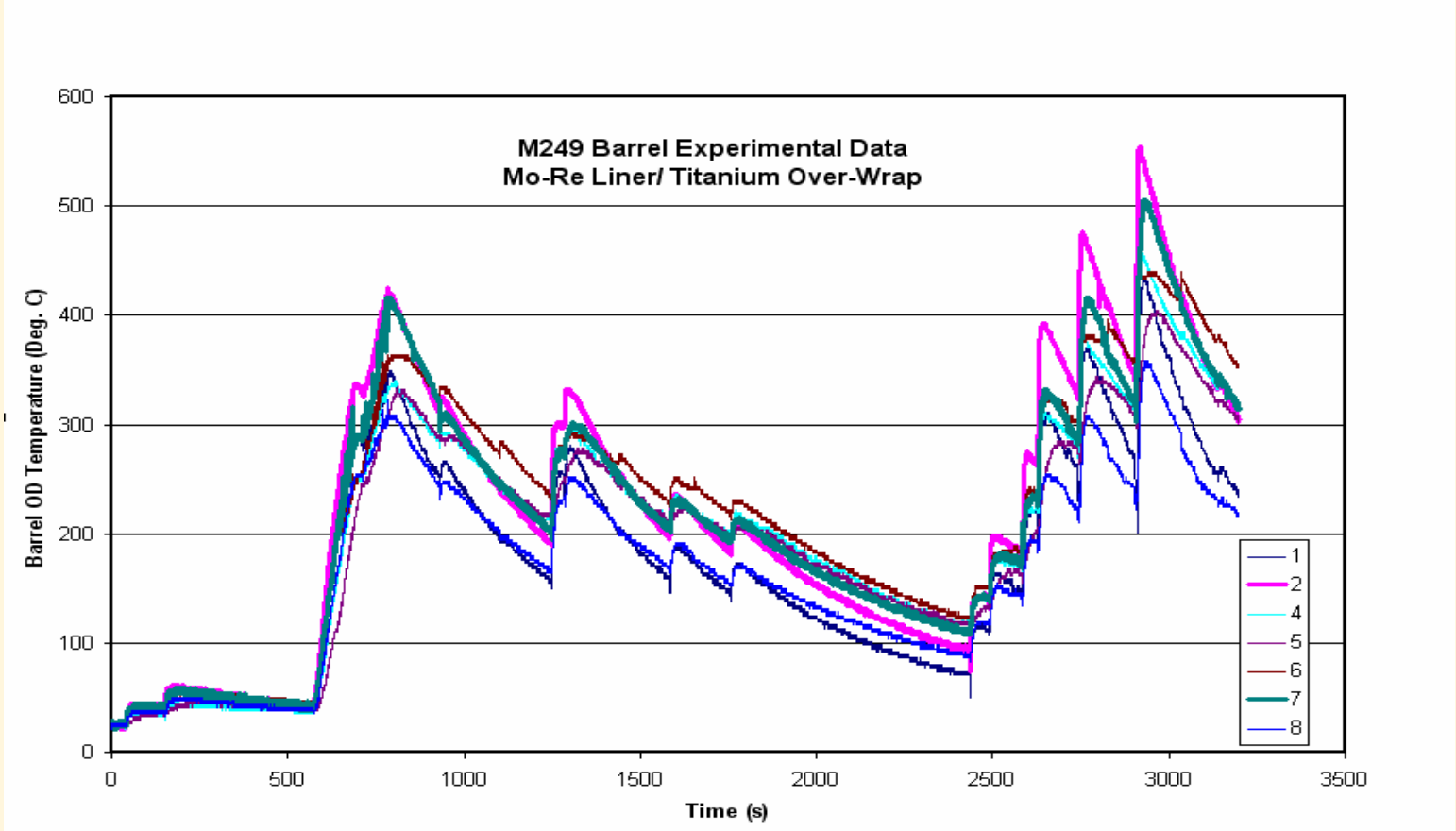
As-produced






After machining OD

# M249 BARREL LIVE - FIRE TESTING



# 50-CAL ANTIMATERIEL SNIPER RIFLE BARREL WORK CERAMIC LINER VERSION

- Monolithic Ceramic (SiAlON) Liner
  - In-situ rifling - proved feasibility in another project
- PTA Ti over-wrap
  - Proved feasibility in depositing titanium without cracking the ceramic
  - Titanium low thermal conductivity may not be a great issue in a sniper rifle

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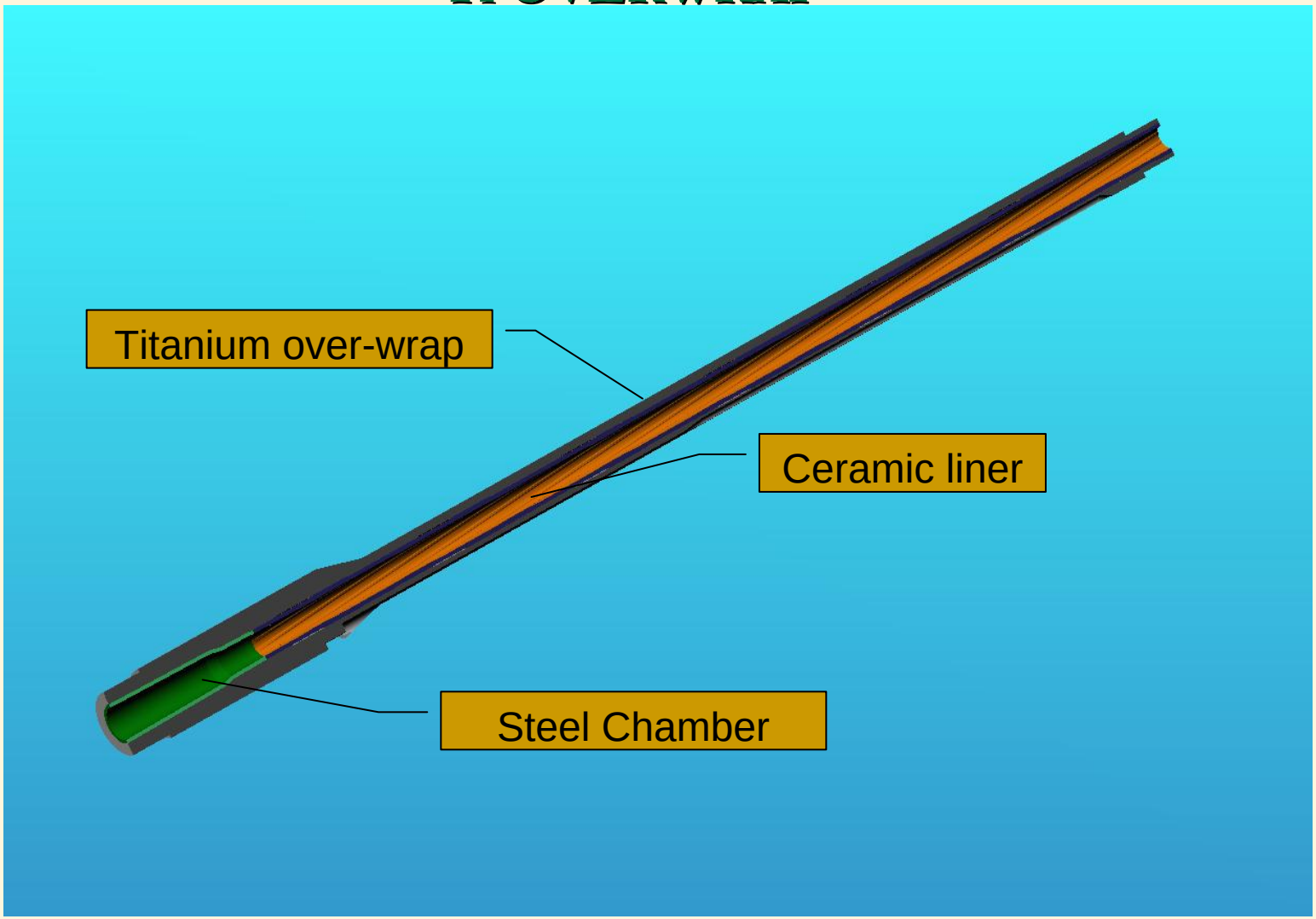
# 50-CAL MONOLITHIC CERAMIC LINER WITH PTA Ti OVERWRAP

SiAlON 50-Cal liner before and after PTA over-wrap

# MONOLITHIC CERAMIC LINER WITH PTA Ti OVERWRAP



# 50-CAL ANTIMATERIEL SNIPER RIFLE BARREL WORK REFRACTORY METAL LINER VERSION

- Ta-10W or Mo-47.5Re Liner
  - Mo-47.5Re can be rifled routinely with ECM
  - Ta-10W may be rifled with single point rifling
- PTA Ti over-wrap
  - PTA titanium does not affect features in the Ta-10W bore
  - Liner is in compression by virtue of the PTA process
  - Titanium low thermal conductivity may not be a great issue in a sniper rifle

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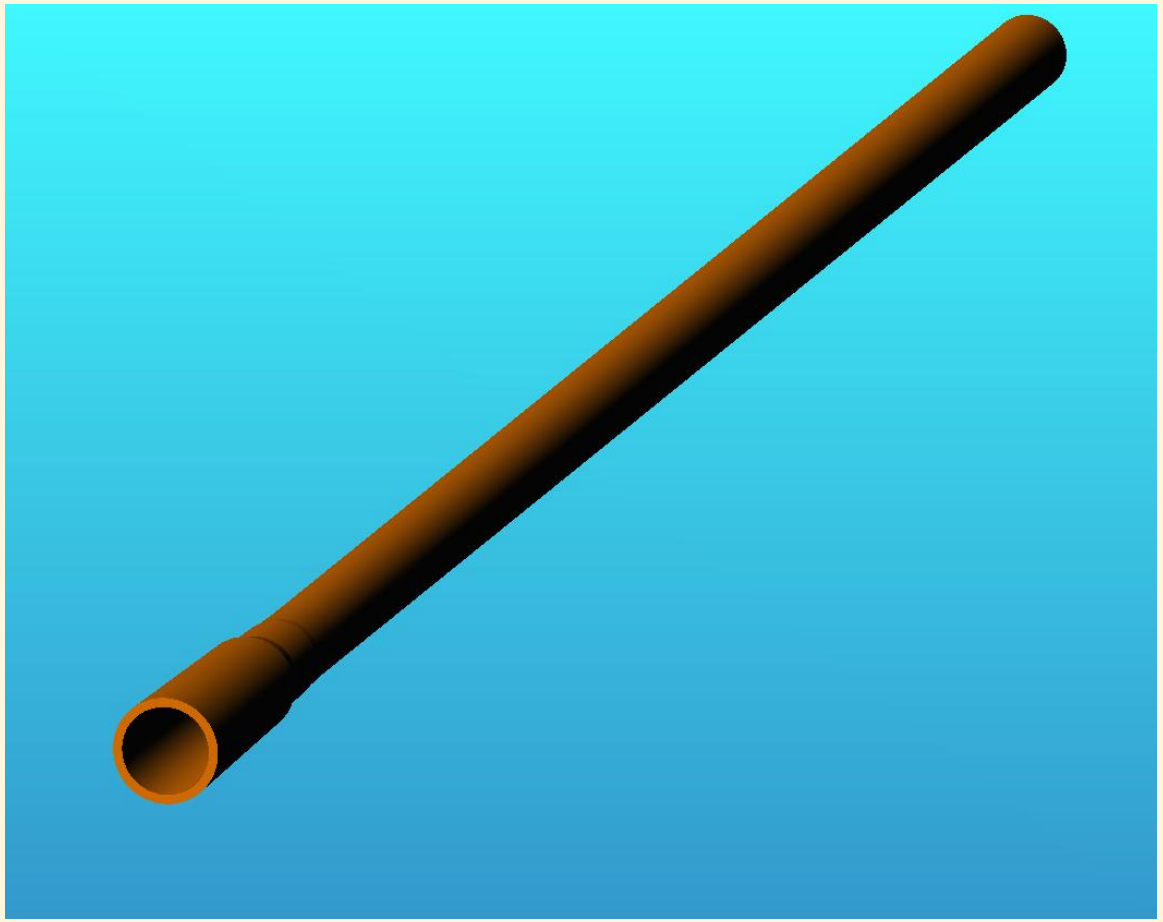
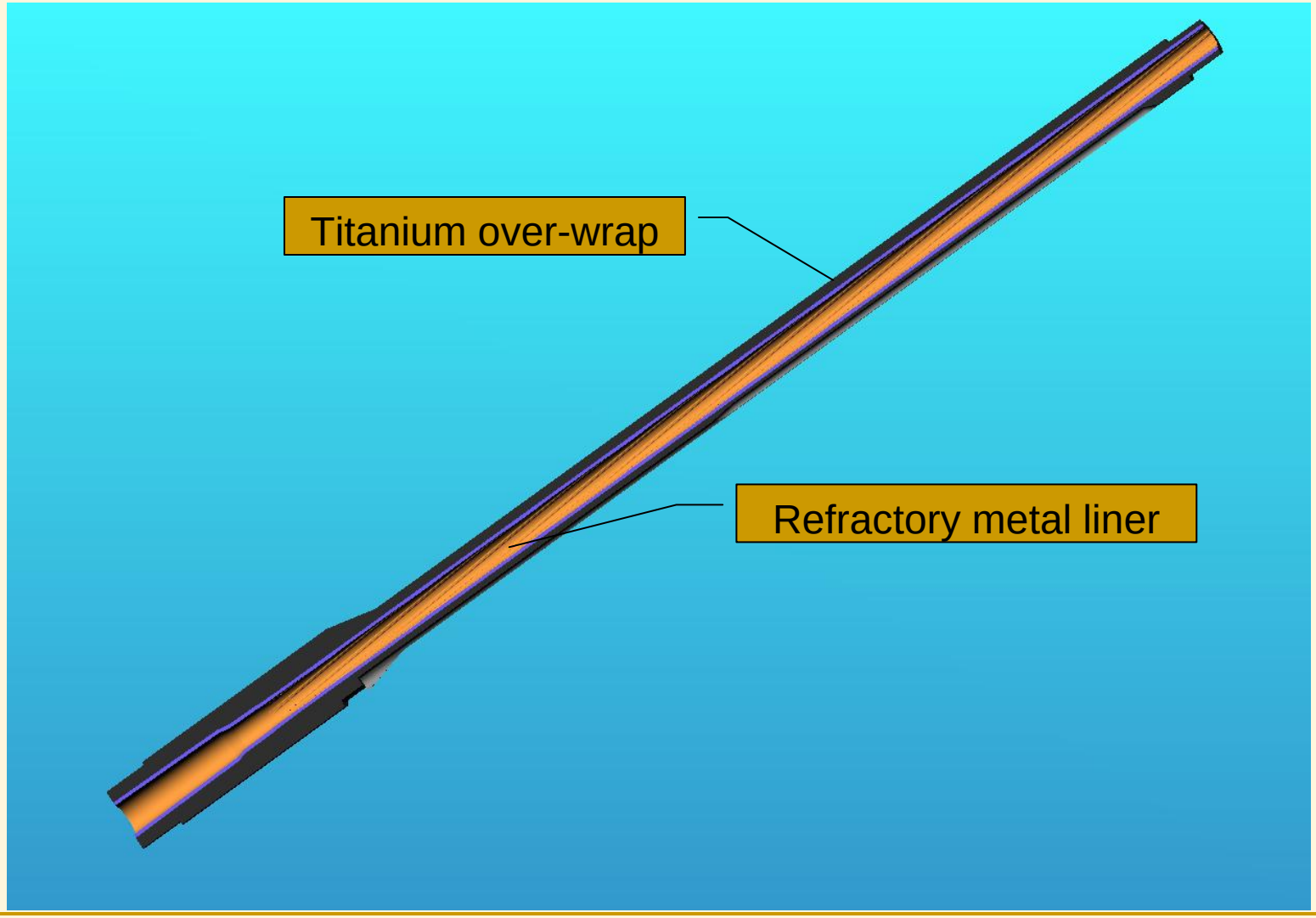
# FORMED REFRACTORY METAL LINER



# REFRACTORY METAL LINER WITH PTA Ti OVERWRAP



# TECHNOLOGY FUTURE POTENTIAL

- Form the entire barrel (titanium) over a mandrel to generate in-situ rifling
- Form a ceramic (titanium nitride) layer on the bore of a titanium barrel which grades continuously into the titanium barrel body.
- Generate a lubricious Ti-N alloy layer at the bore
- Titanium low thermal conductivity may not be a great issue in a sniper rifle

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# TECHNOLOGY FUTURE POTENTIAL (CONT'D)

**Ti-N Alloy Lubricious Layer Functionally Graded with a Ti64 Part**