



ONR's Advanced Gun Barrel Technologies Program

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Outline



- **Background**
- **Objectives**
- **Approach**
- **Technologies**
- **Transition Criteria**
- **Concluding Remarks**



Background



- A new five-year program to be executed during FY03-FY07 as part of Time Critical Strike Future Naval Capabilities (FNC)
- Program supported by PMS500, DD(X) Program Office, for transition into Advanced Gun System (AGS) Program upon successful completion of defined transition criteria

SPONSORS/PERFORMERS:

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Advanced Gun Barrel Technologies



Objectives

- Identify & develop Gun Barrel Technologies that enable upgrades to existing barrel capabilities for Naval gun propulsion missions
 - *Increased Gun Barrel Erosion & Fatigue Life*
 - *Improved Gun Barrel Thermal and Ballistic Performance*
 - *Reduced Life Cycle Cost*

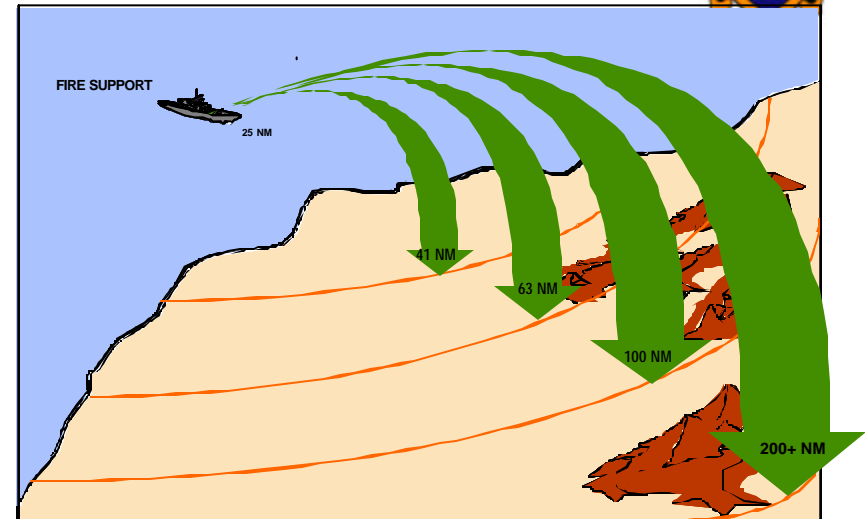
Payoffs

- Increased Gun System Availability
- Improved Ballistic Capability (Higher KE for increased range)
- Lower Life Cycle Cost

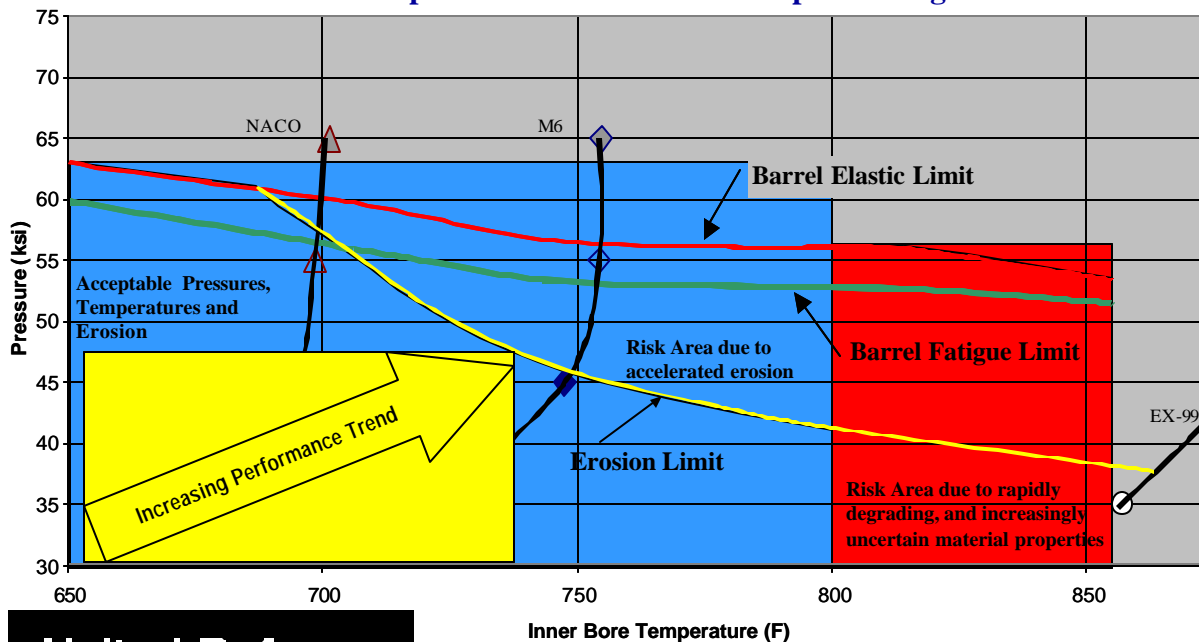
Technologies

- Refractory Barrel Materials / Coatings
- Composite Materials & Manufacturing Technology
- Advanced Integrated Barrel Design

- The trend of gun performance requirements has been for increased range and rate of fire for centuries
- Wear and thermal management limit system performance
- High energy propelling charge and advanced projectile solutions are precluded by barrel limits
- Improving wear, erosion or thermal management yields increased system performance



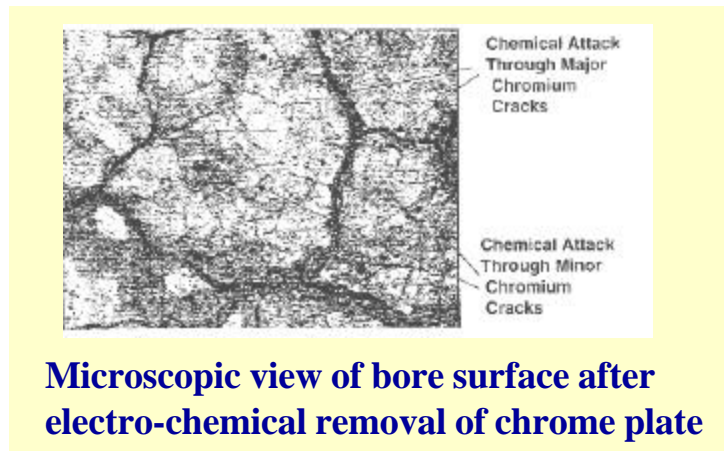
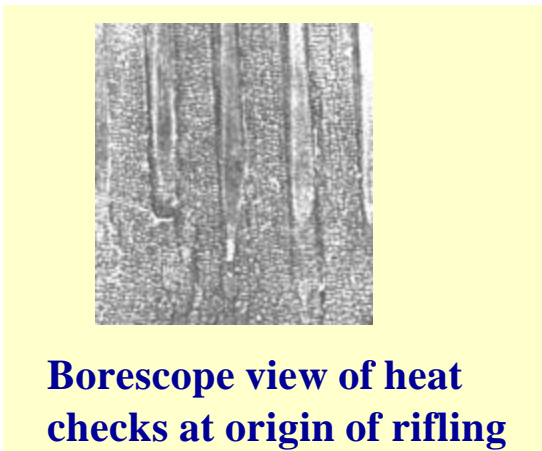
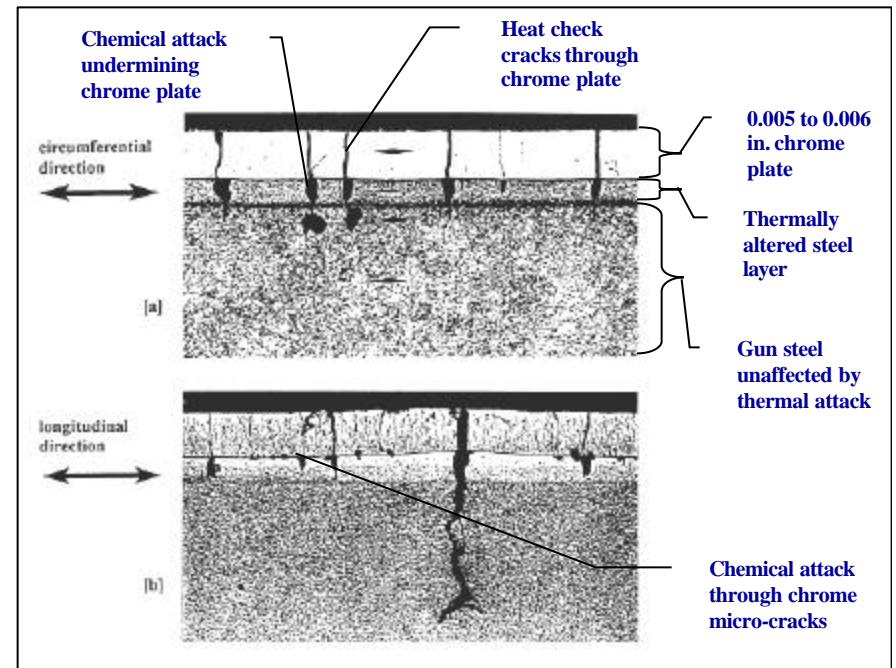
Pressure and Temperature Limits for a Conceptual Design



• Barrel Design Space Limits

- Elastic strength
- Fatigue strength
- Max bore temperature
- Wear and erosion

- Gun firing thermal loads generate heat check cracks
- Substrate steel is thermally altered by extreme high temperature spike from gun firing
- Heat check cracks expose steel substrate to chemical attack from combustion gases
- Chrome plating is thermally and chemically attacked until it strips off and exposes the substrate
- Steel substrate is rapidly eroded from aggressive chemical attack at high temperature





Advanced Gun Barrel Technologies Plan



Develop Two Advanced Barrel Technologies Concurrently

1- Refractory / Steel Barrel : Focus on the technologies providing longer barrel erosion and fatigue life.

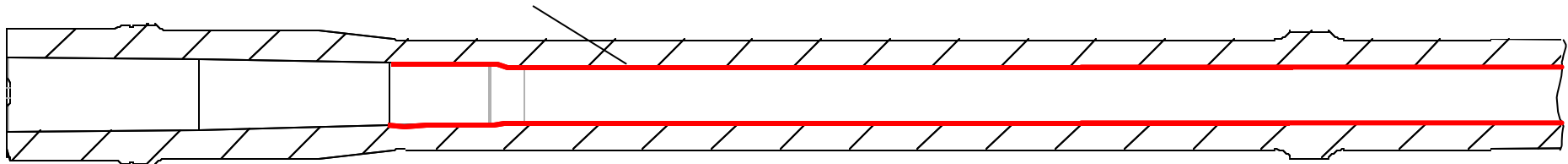
- Develop and apply alternate coating materials

2- Composite Barrel : Develop Composite gun Barrel for improved thermal management and wider design space for enhanced ballistic performance for current and future gun barrels

- Technologies such as Metal Matrix Composites that provide more flexibility in achieving desired material properties in radial and axial directions in the barrel.

Each technology path will provide increased barrel life and if both successful, will be combined for substantial barrel life improvement

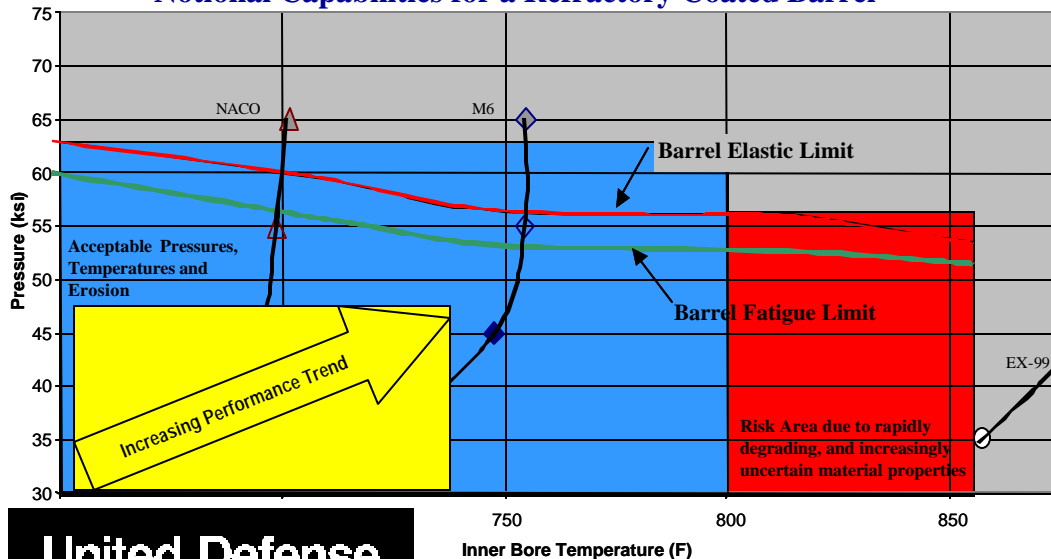
Refractory Bore Surface



Refractory Bore Surface Provides Increased Erosive Life

- Provides a surface that is tolerant of highly transient high temperature spike and the associated thermal shock
- Provides a surface that is non-reactive with the aggressive chemical environment
- Provides a thermal buffer layer to protect the gun steel from thermal attack

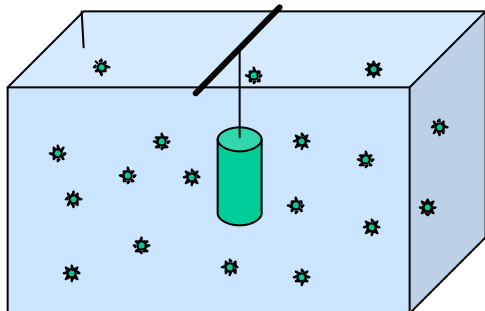
Notional Capabilities for a Refractory Coated Barrel



BENEFITS

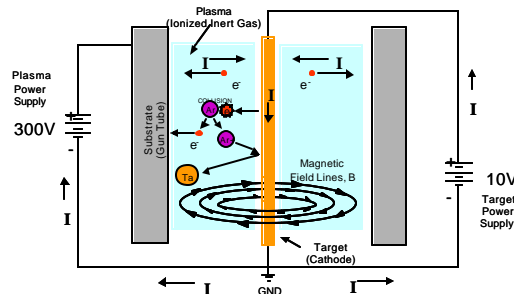
- Removes the wear and erosion limitation
- Applicable to existing systems
- Supports higher energy propelling charges and increased muzzle velocity

Electroless Nickel-Boron



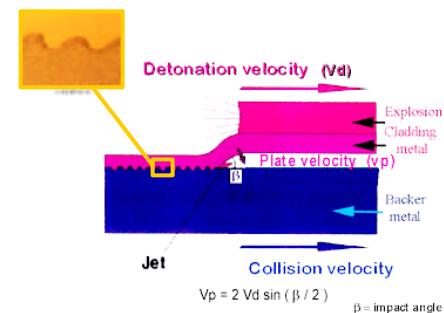
Catalytic plating process produces extremely uniform coating even on complex geometries

Cylindrical Magnetron Sputtering



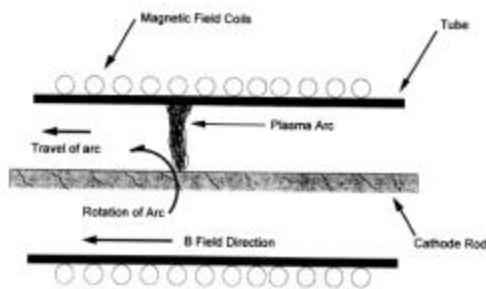
Tantalum is sputtered, from a coaxial target, uniformly over the inside diameter of the barrel

Explosive Cladding



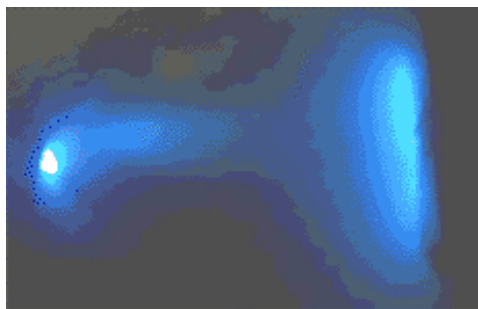
Tube of refractory metal is mechanically bonded with the gun barrel in a collision driven by an explosive detonation

Coaxial Energetic Deposition



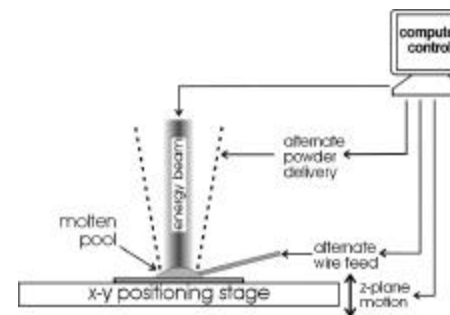
Plasma arc rotates around center conductor and travels along its length depositing material

Ion Implantation



Chromium or chromium nitride coatings can be enhanced by ion implantation

Solid Free-Form Fabrication

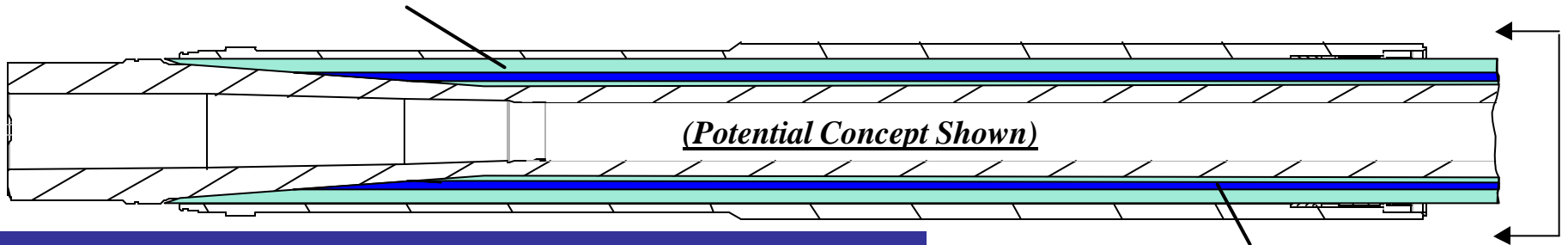


Engineered material is created by alloying of powdered and/or wire-fed metals

Advanced Composite Barrel



Composite Sleeve Improves Barrel Strength & Thermal Management



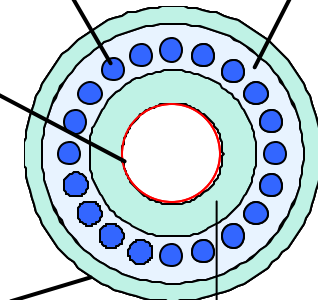
Composite Barrel Provides Increased Capabilities

- Composite structure could be optimized for:
 - Increased fatigue life at higher pressures
 - Increased thermal management
- Optimum configuration determined through system level analysis and trade studies

Integral Cooling Channels

Refractory Bore Surface
(Potentially from refractory barrel development)

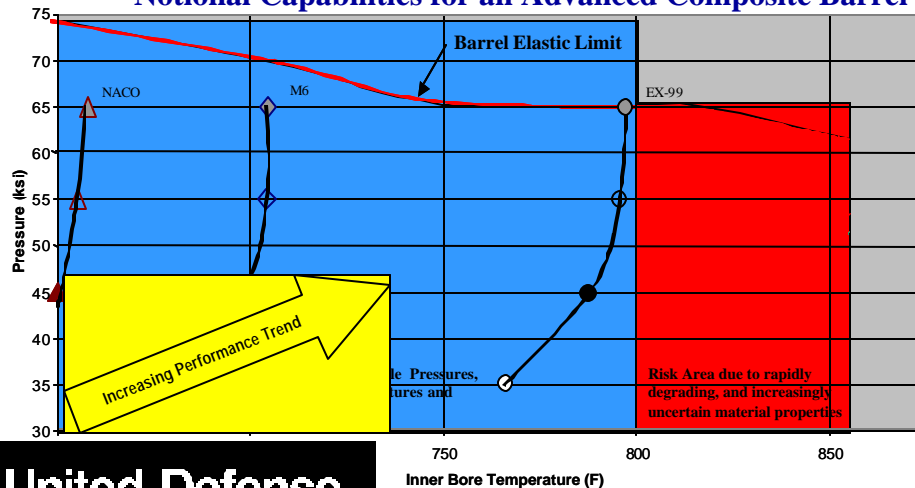
Composite



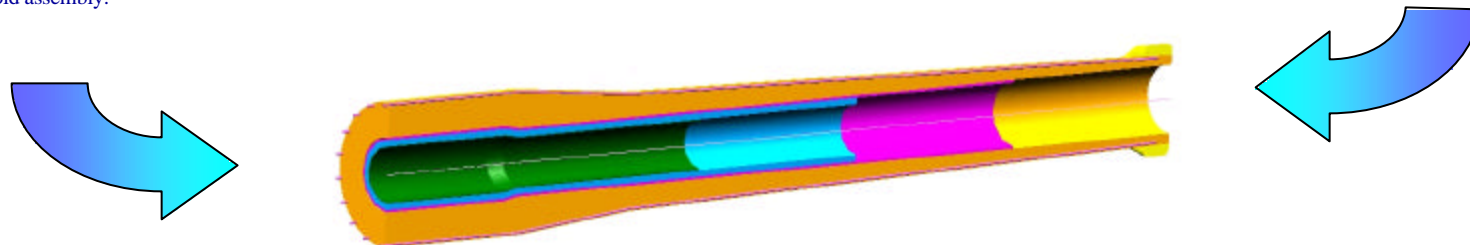
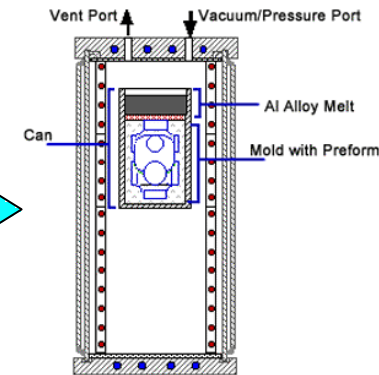
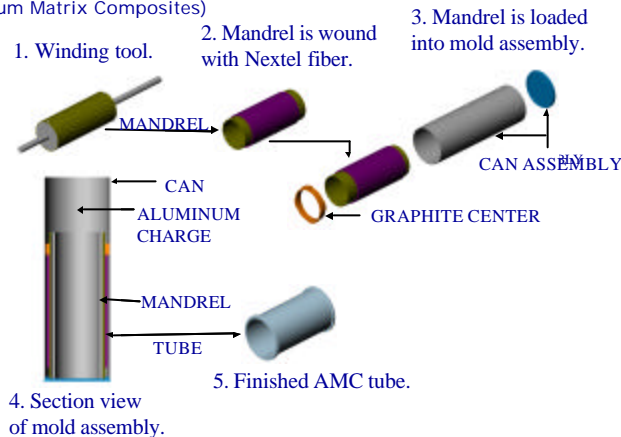
AGS Barrel Sleeve

Thin-walled Barrel for Improved Heat Conduction to Composite

Notional Capabilities for an Advanced Composite Barrel



AMC Tube Fabrication (Aluminum Matrix Composites)

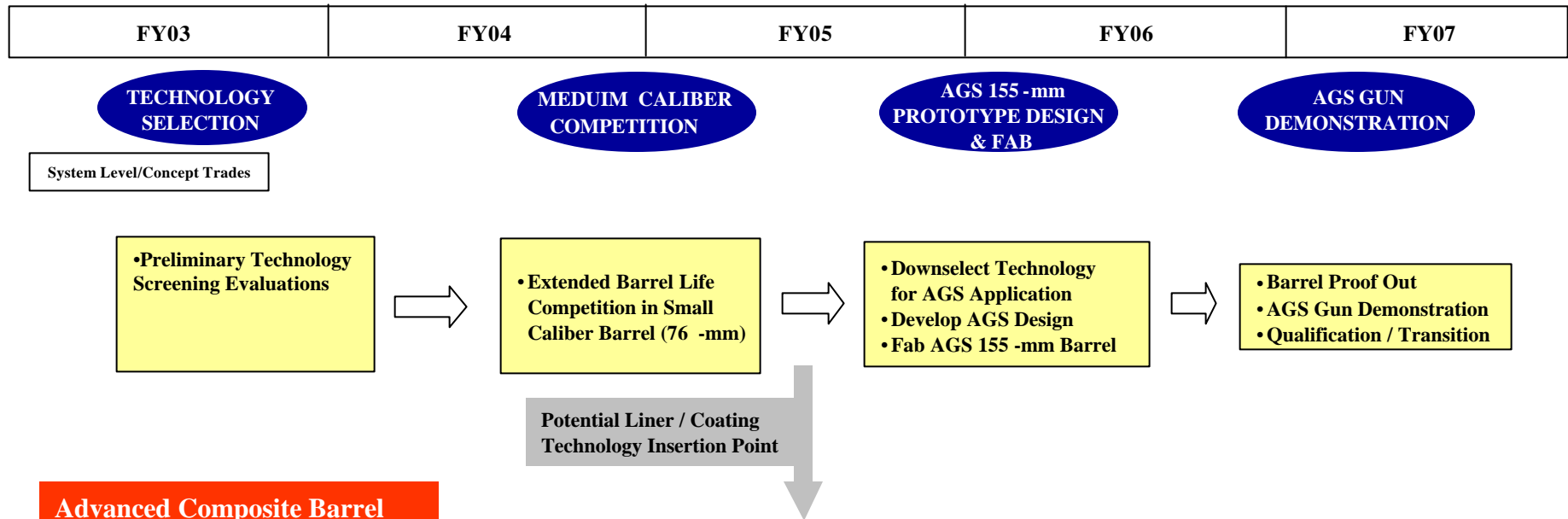


- Assembled both radially and axially from pre-fabricated sections
- Materials, fiber contents, and fiber placement angles can be varied to produce desired characteristics
- Multiple materials can be built into Functionally Graded assemblies to produce desired barrel characteristics
- Manufacturing processes affect properties and must be a principal part of the design
- Proper final assembly designs can compensate for specific material weaknesses
- Can produce barrels with very high strength-to-weight ratio and high thermal conductivity
- Composite barrels demonstrated on Firebox program

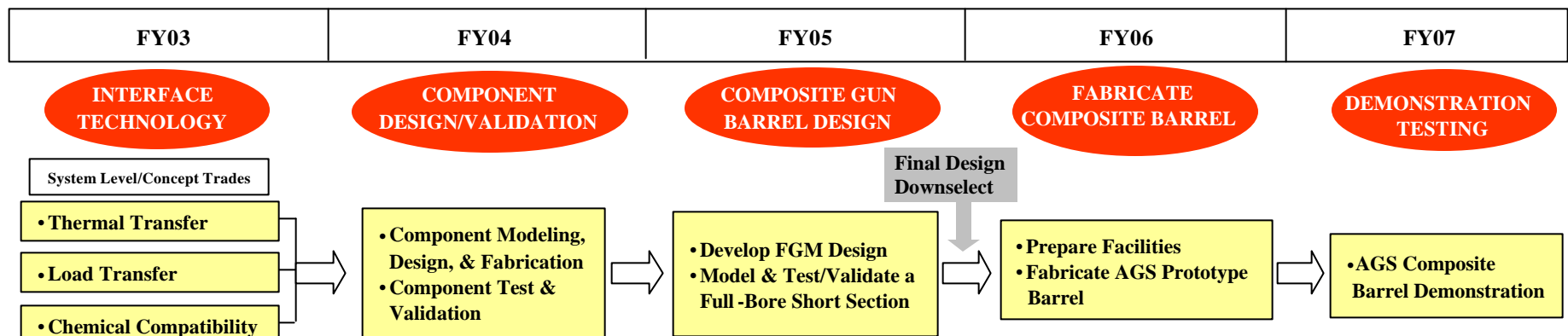
Composite technologies provide the means to dramatically increase the gun barrel design space

Refractory Lined / Coated Steel Barrel

Technical Approach



Advanced Composite Barrel





Transition Criteria



- 1 - Compliance with AGS Interface Control Document (ICD)**
- 2 - Equivalent Ballistic Performance to Baseline AGS Barrel**
- 3 - 50% Improvement in Barrel Life Over Baseline AGS Barrel**
- 4 - Reduced Life Cycle Cost Compared to Baseline AGS Barrel**
- 5 - Production and Gun Fire Testing of Full-scale Prototype**



Concluding Remarks



- **Advanced Gun Barrel Technologies Program will address critical needs for current and future Naval Fire Support and Land Attack missions**
- **Program plan devised to maximize gains in gun barrel technology while minimizing development risks**
- **Success in this FNC program will result in substantial improvements for current Naval guns and provide increased future naval capabilities**