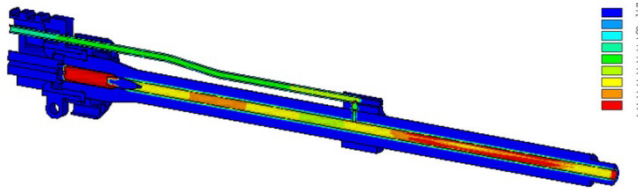
Advanced Thermal Management of Automatic Rifles



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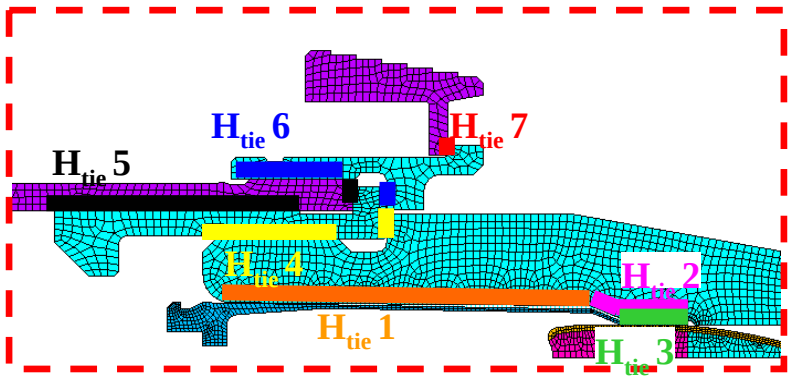
Previous Contract

Thermal Management for Automatic Firearms: 2007 Objectives

- Create a 2-D model to predict thermal characteristics of automatic weapon.
- Solve the cook-off problem in USMC IAR project



Current Contract

Tasks for Advanced Thermal Analysis:

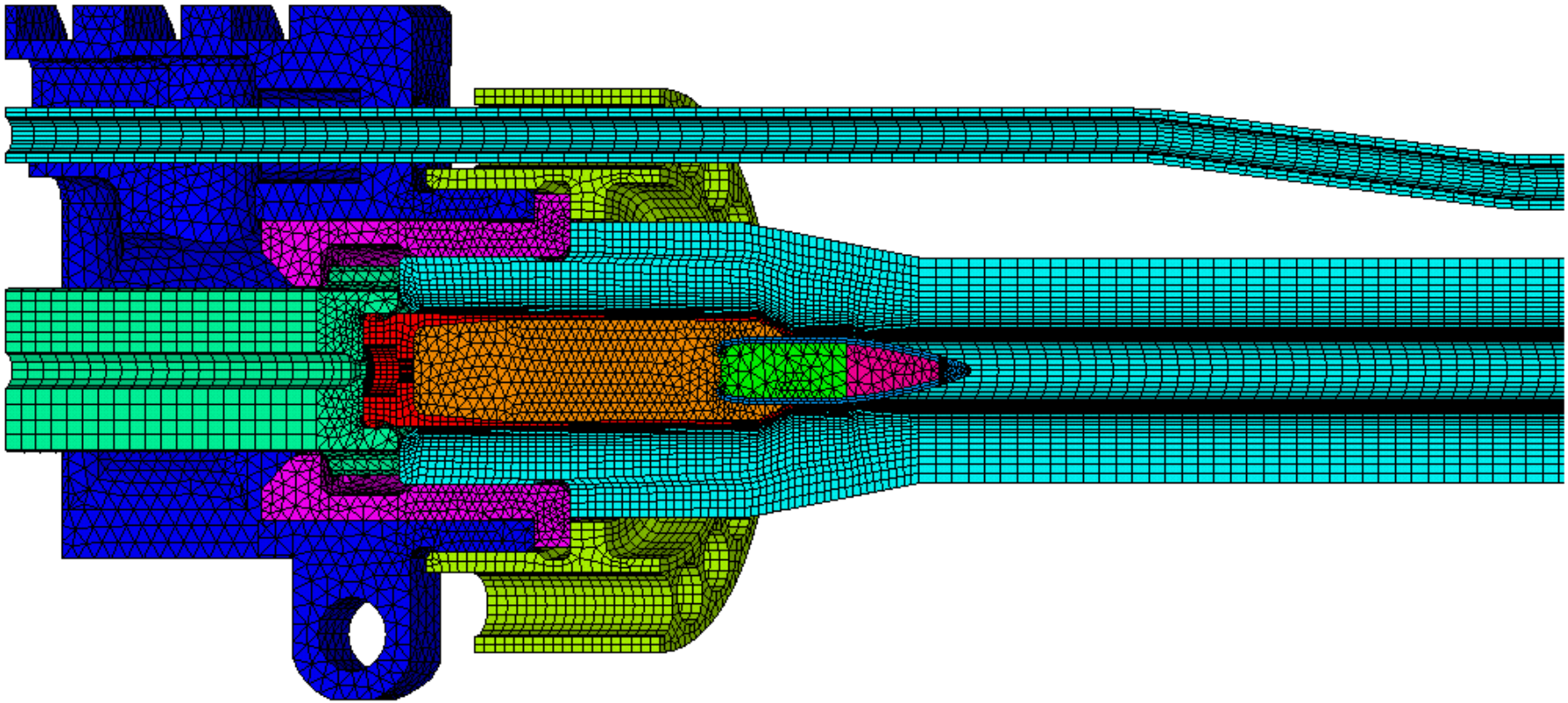
- Create a 3D model for improved accuracy and better connection to actual hardware
- Reduce the reliance on experimental data
  - Simulate the bore heat transfer during firing
  - Simulate the flow cooling the exterior of the weapon
- Determine the method for general use of these techniques
- Consider user needs:
  - How to apply advanced thermal management to improve both weapon function and usability.

Analysis Requirements

- Solid Model Geometry
- Boundary Conditions
  - Firing Schedule
  - Internal (Barrel Bore)
  - External
- Adequate Computing Resources
  - CFD model run time is measured in weeks
  - Thermal model run time is measured in days

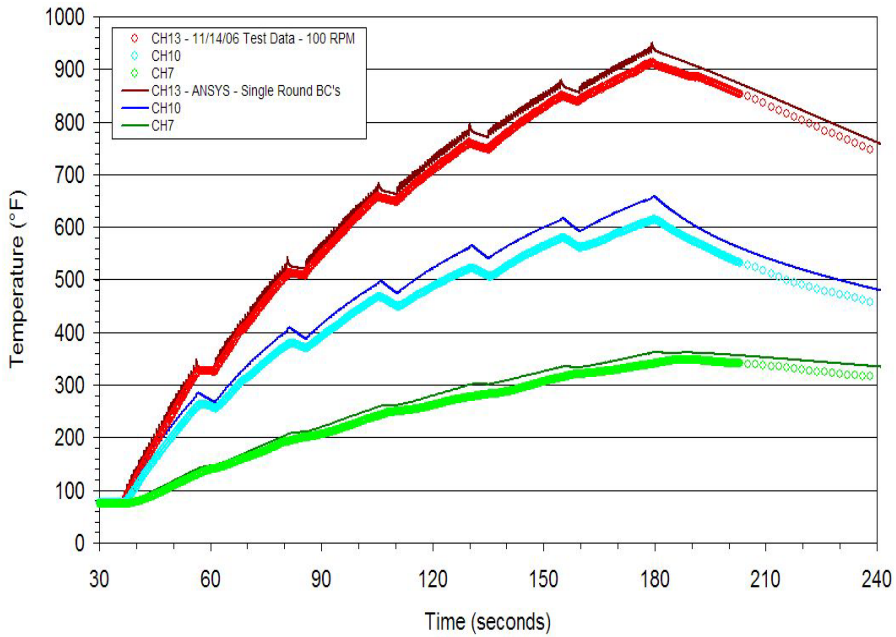
Solid Model to Analysis Model

- Solid model is meshed
  - Thousands of volumes used to solve the problem



Firing Schedule

- Firing schedule needs to be defined
  - Any firing rate can be specified
  - Any number of bullets
  - Any number of magazines



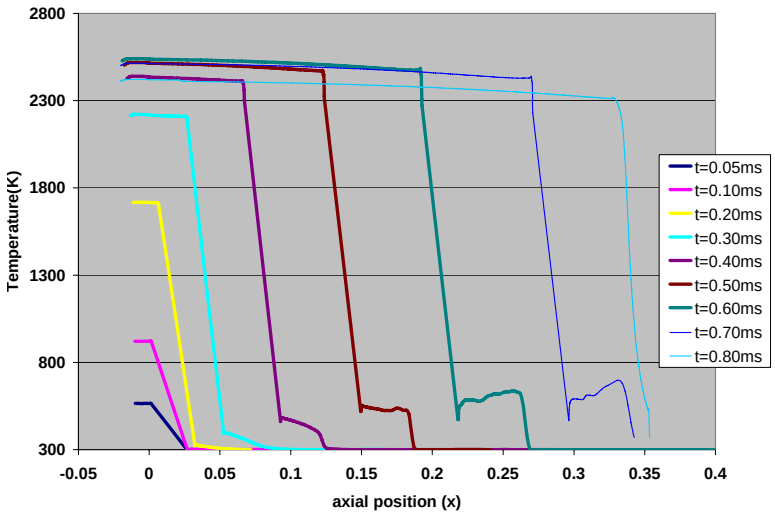
Test data vs Analytical--model by individual round

Bore Heat Transfer Simulation:

US. Army ARDEC CFD model:

- Simulate the bulk effects of combustion
- Transient solution captures the motion of bullet
- Cooling period after bullet firing is simulated
- Gas temperatures and heat transfer coefficients are input into the heat transfer model

Gas temp.



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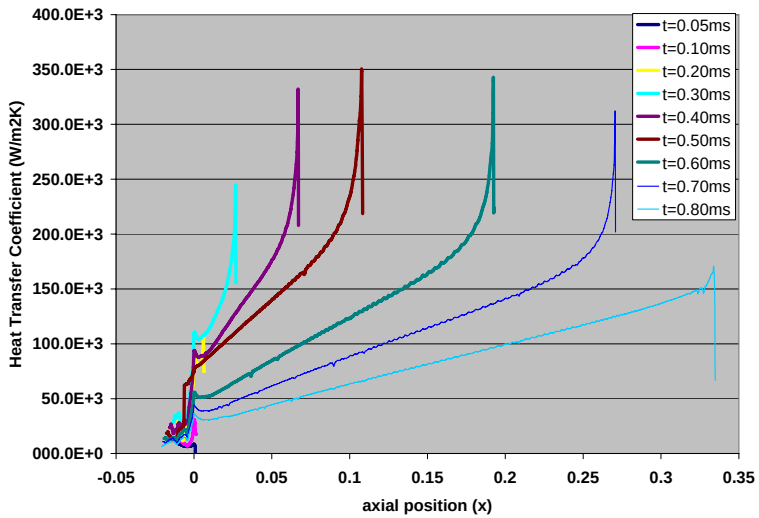
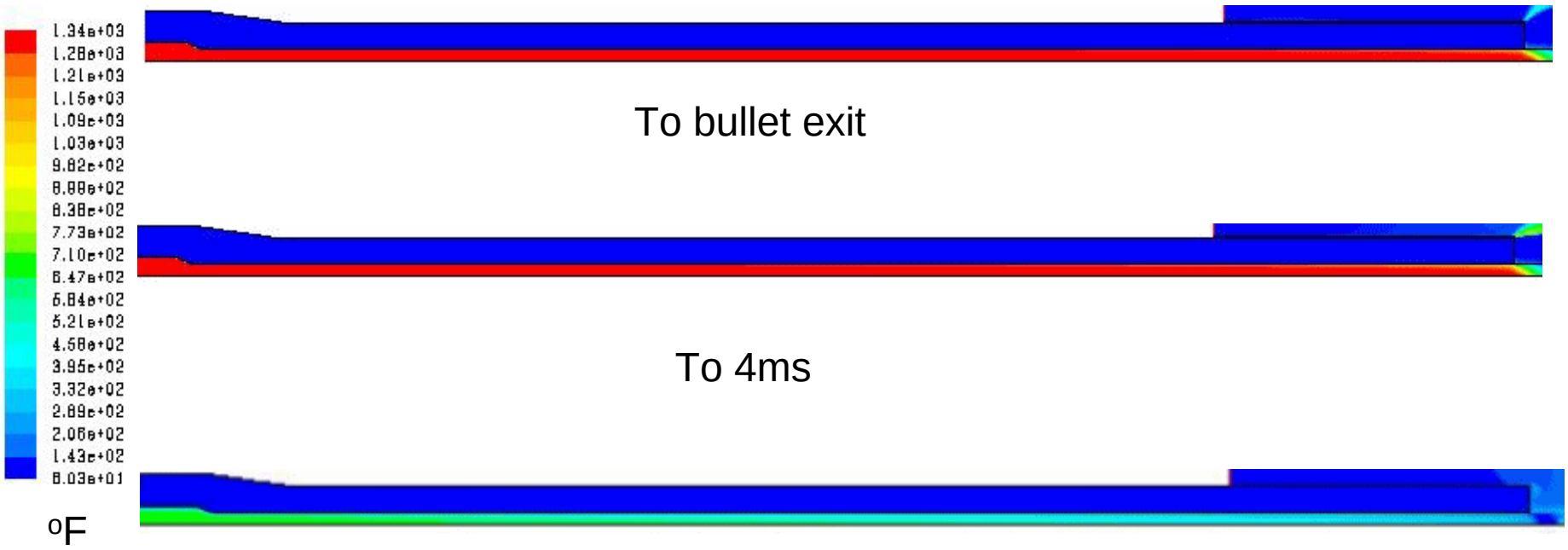


ARDEC Bore CFD Model

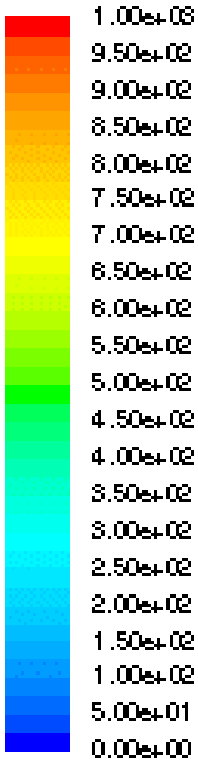
- Model used to calculate heat input to barrel

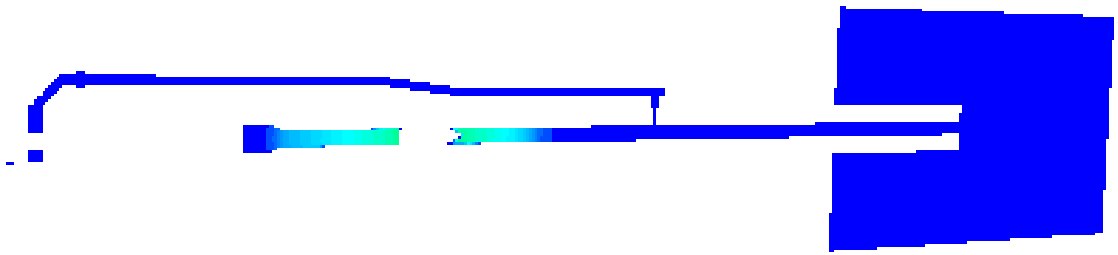


Temperature contour animations of firing one round

Boundary Condition Validation

- ARDEC CFD gas flow model used to estimate the flow rate, temperature, pressure of flow in gas tube to estimate heat transfer to gas tube



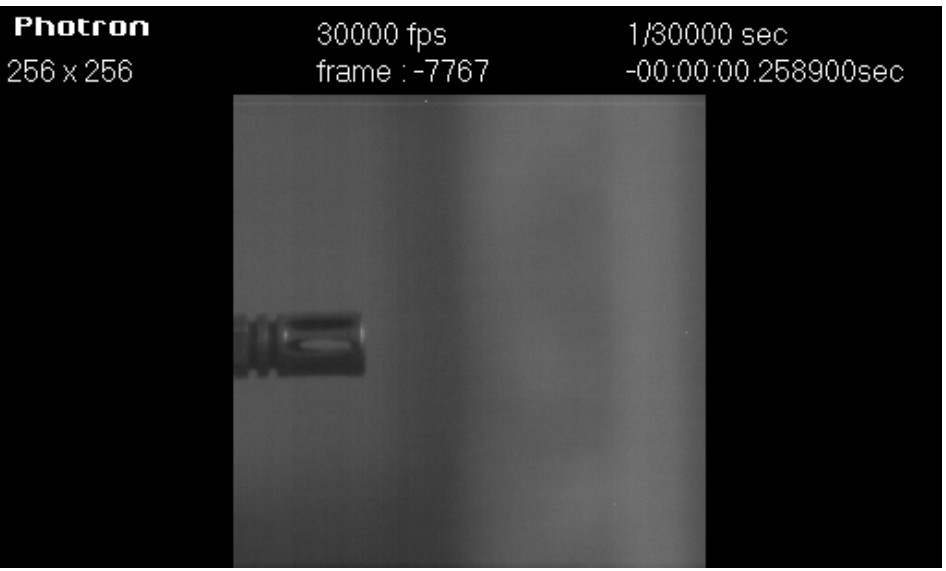


Gas flow velocity contour animation

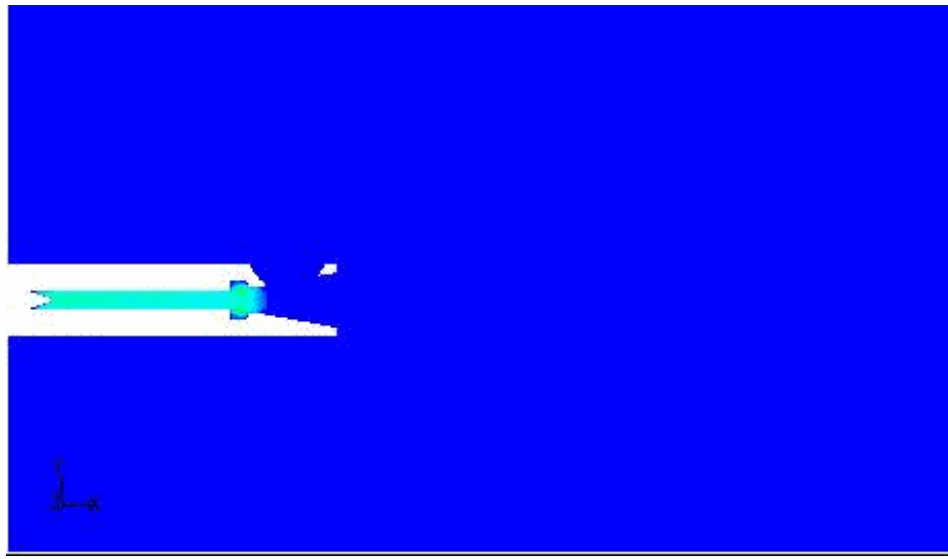
Boundary Condition Validation

- ARDEC Muzzle CFD model used to determine extent of effect of escaping gun gases on the external flow

High Speed Video

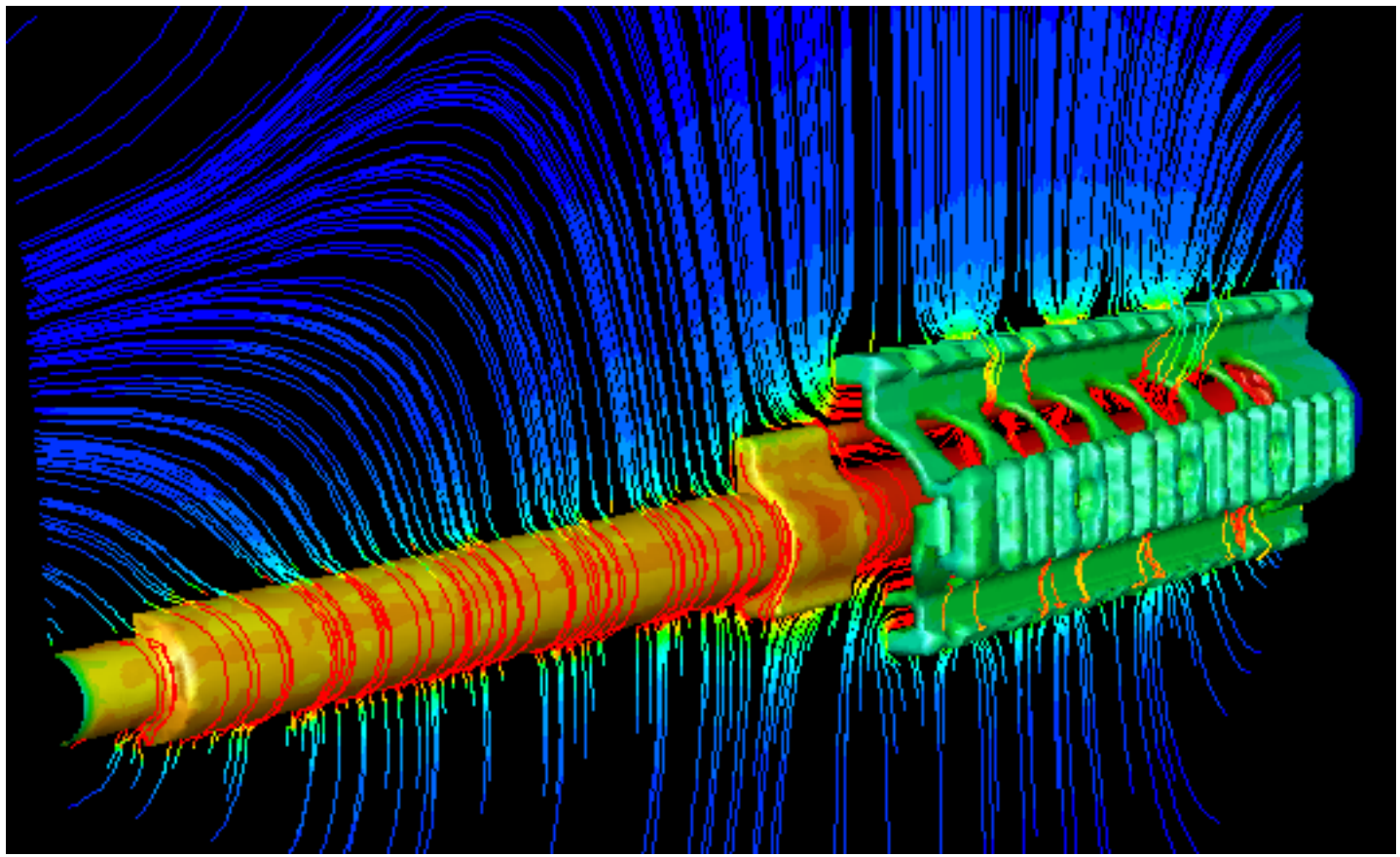


Velocity Contour Plot Animation

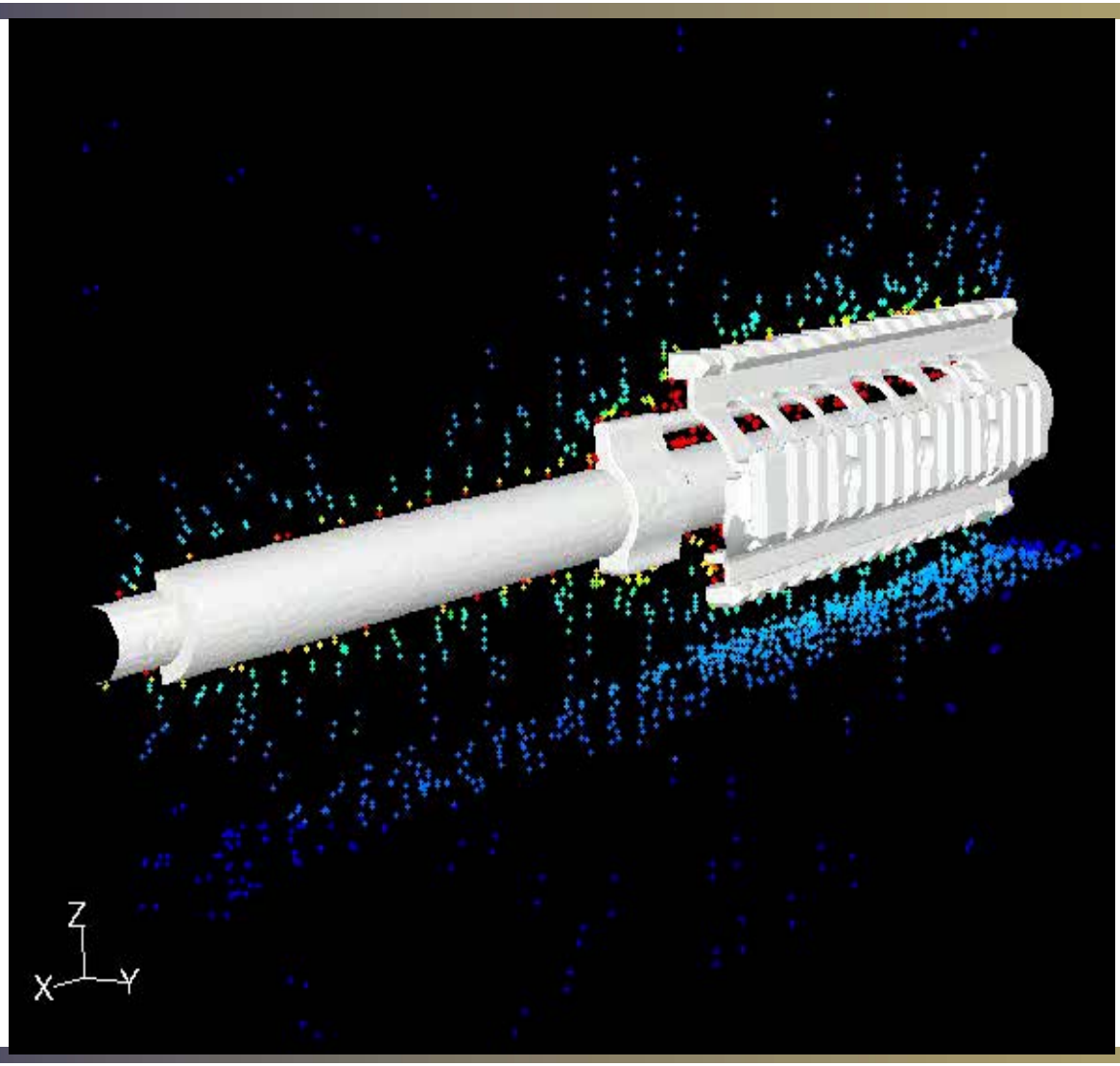


External Flow CFD Simulation

- Based on ARDEC Muzzle CFD model, muzzle blast can be ignored

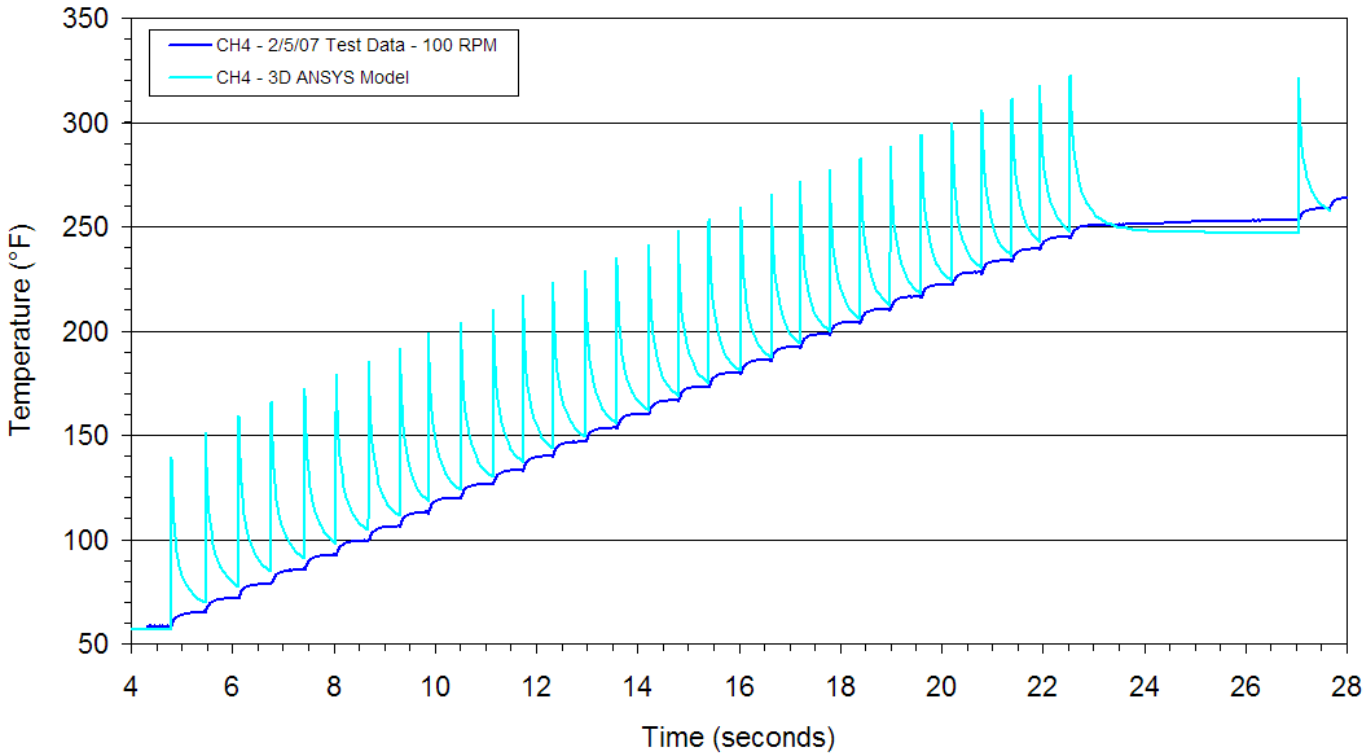


External Flow CFD Simulation



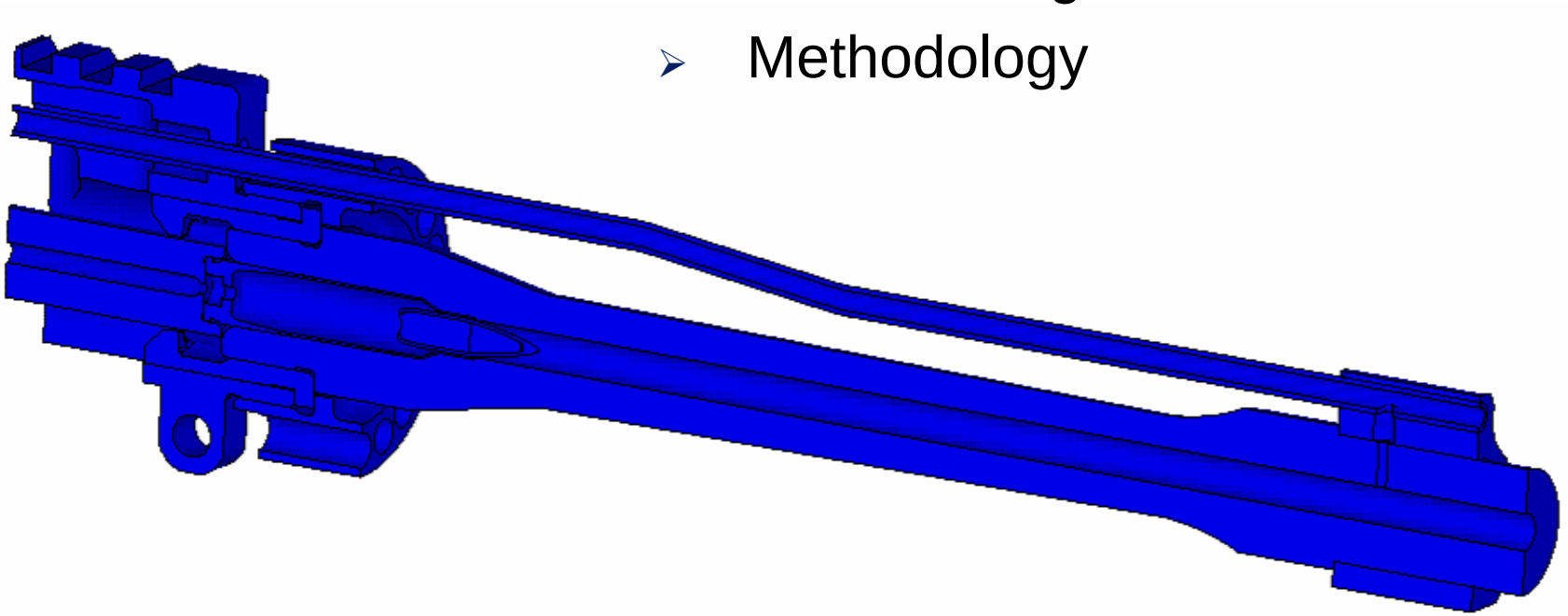
Current Thermal Model Results

- Model agrees with test data extremely well



Current Thermal Model Results

- Study completion in July 2008
  - 3D modeling
  - Methodology



SINGLE ROUND ANIMATION

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