Aerodynamics Branch

MICRO-ADAPTIVE FLOW CONTROL AND NON-LINEAR AERODYNAMICS

(COMBUSTION GAS GENERATORS)

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TECHNOLOGY TO WIN

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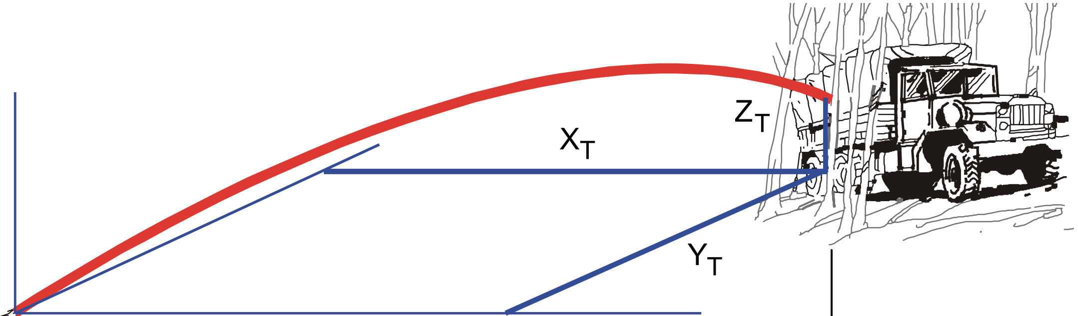
Weapons & Materials Research Directorate

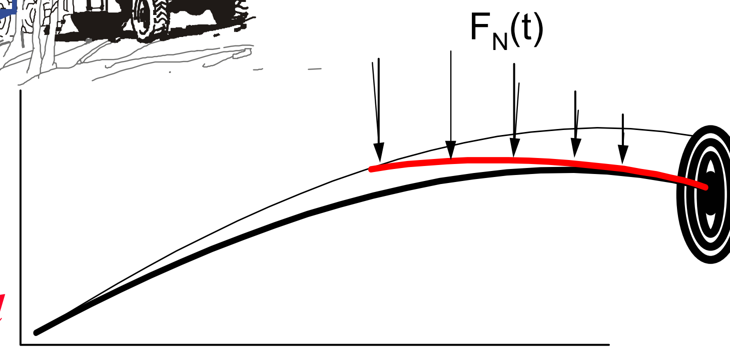
ARL

AMERICA'S ARSENAL FOR THE BRAVE

Aerodynamics with Flow Control

GAS COMBUSTOR JETS





Demonstrate Adequate Aerodynamic Steering Forces using Flow Control

***Objective:* Provide fundamental understanding of the flow phenomena associated with synthetic jet micro-adaptive flow control (MAFC) and assess its effectiveness to provide adequate aerodynamic forces to divert or guide a small caliber projectile to its target**

Pacing Technologies:

- Combustor gas generators
- High Performance Computing
- Advanced Visualization
- Unsteady Aerodynamics

Warfighter Payoffs:

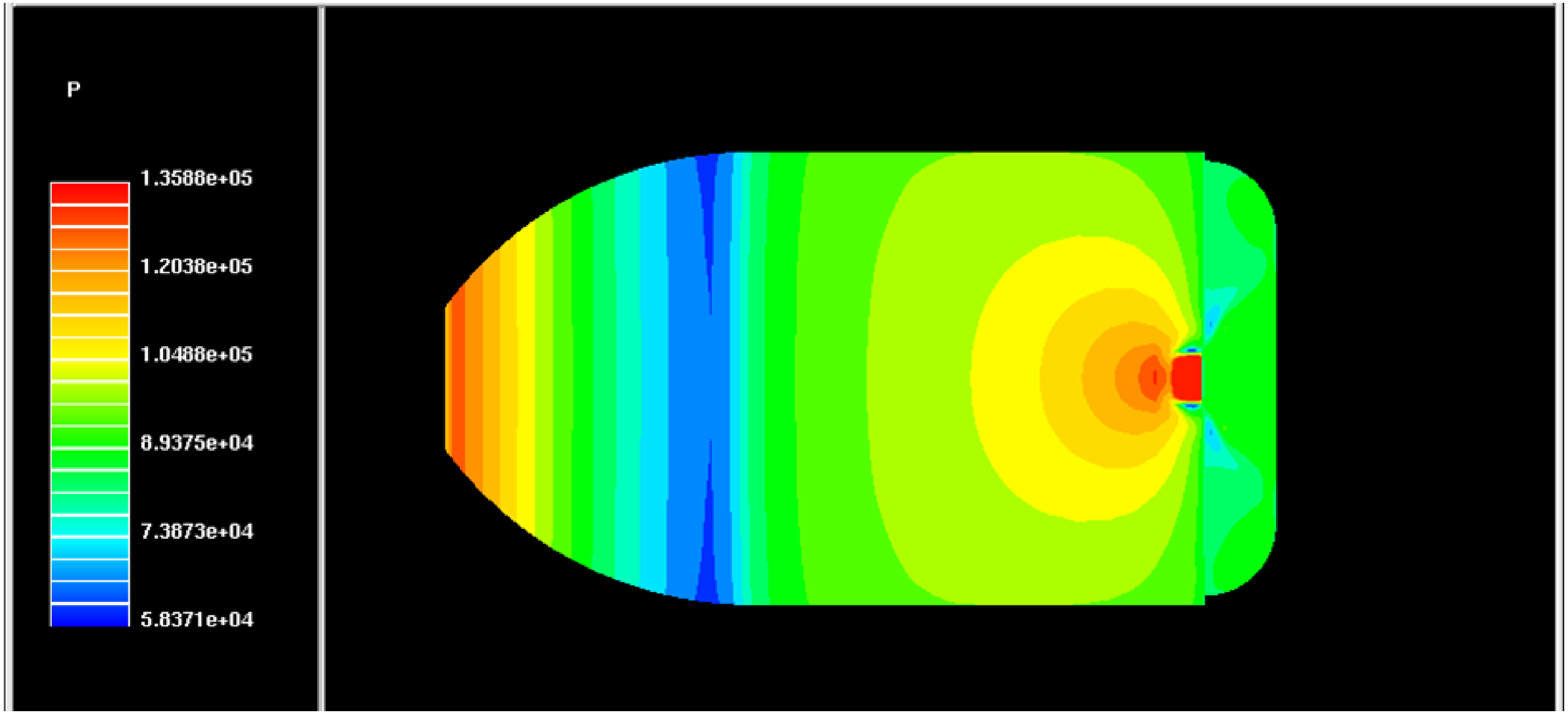
- Improved lift control
- Precision-guided munitions
- Increase lethality

High Fidelity Computational Tool for Improved Performance of Army Munitions

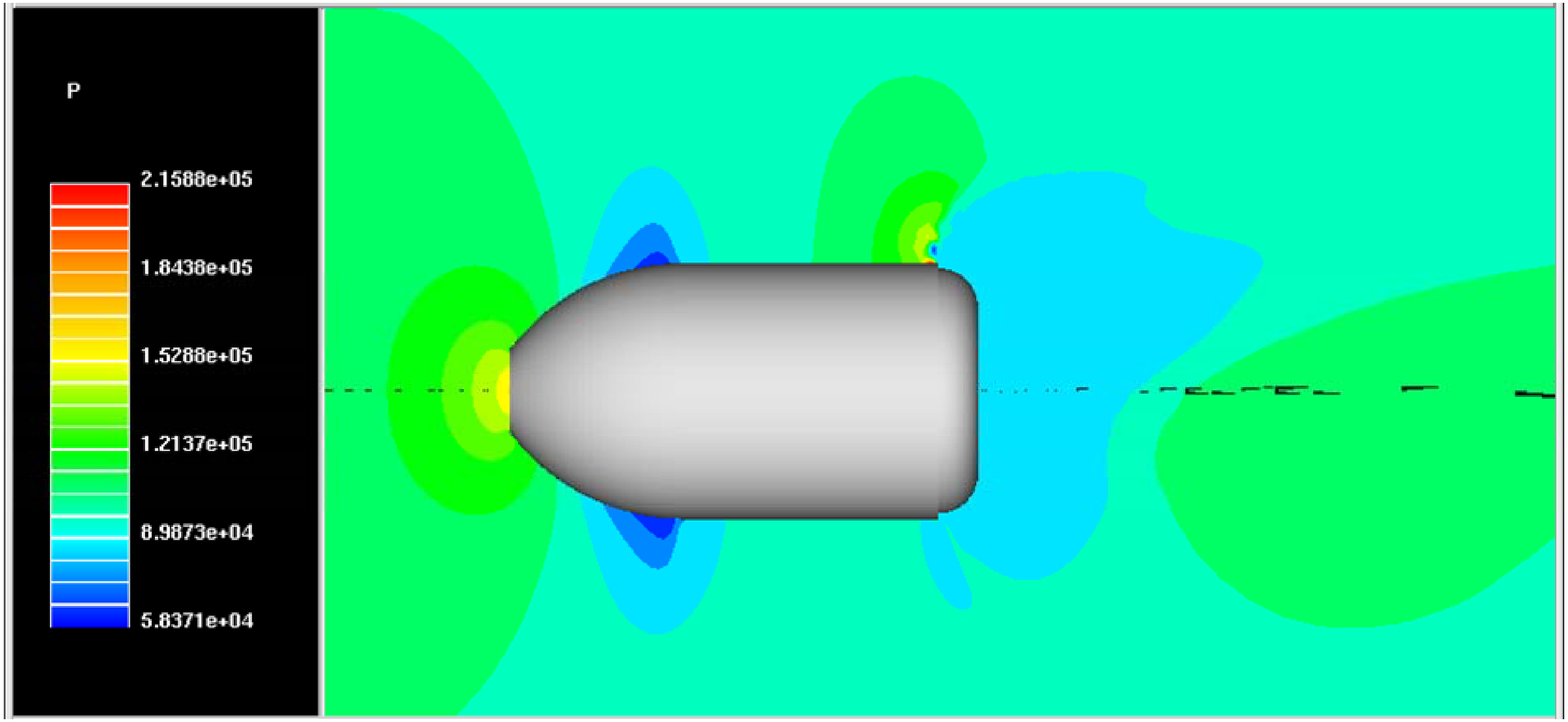
COMBUSTOR JET CFD

- 3-D Navier-Stokes computational technique
- Steady jet CFD
- Unsteady (time-accurate) jet CFD
- Fast convergence to steady state
- Fast computation of unsteady flows
- Dual time-stepping
- Special jet boundary conditions for unsteady CFD
- Validation of both non-spinning and spinning cases

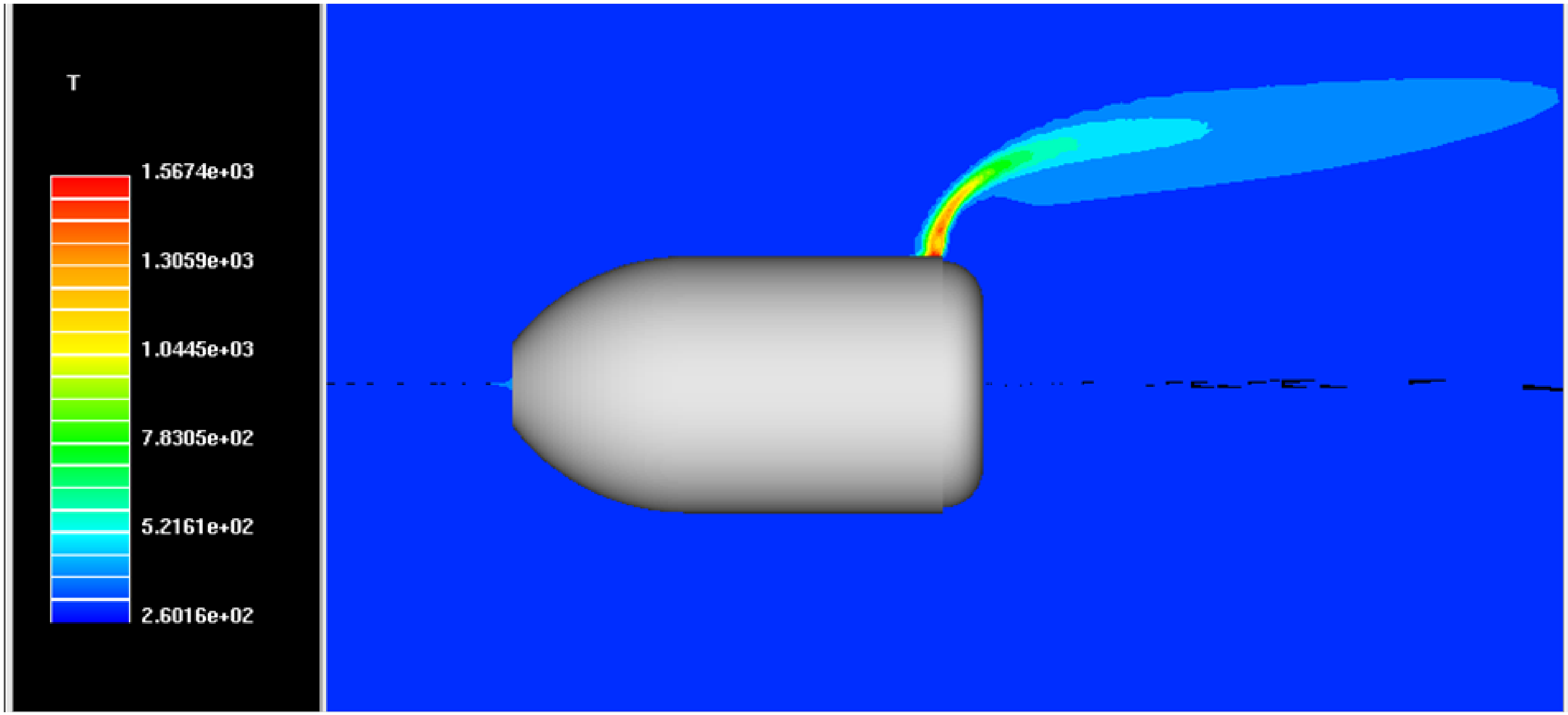
SURFACE PRESSURE CONTOURS



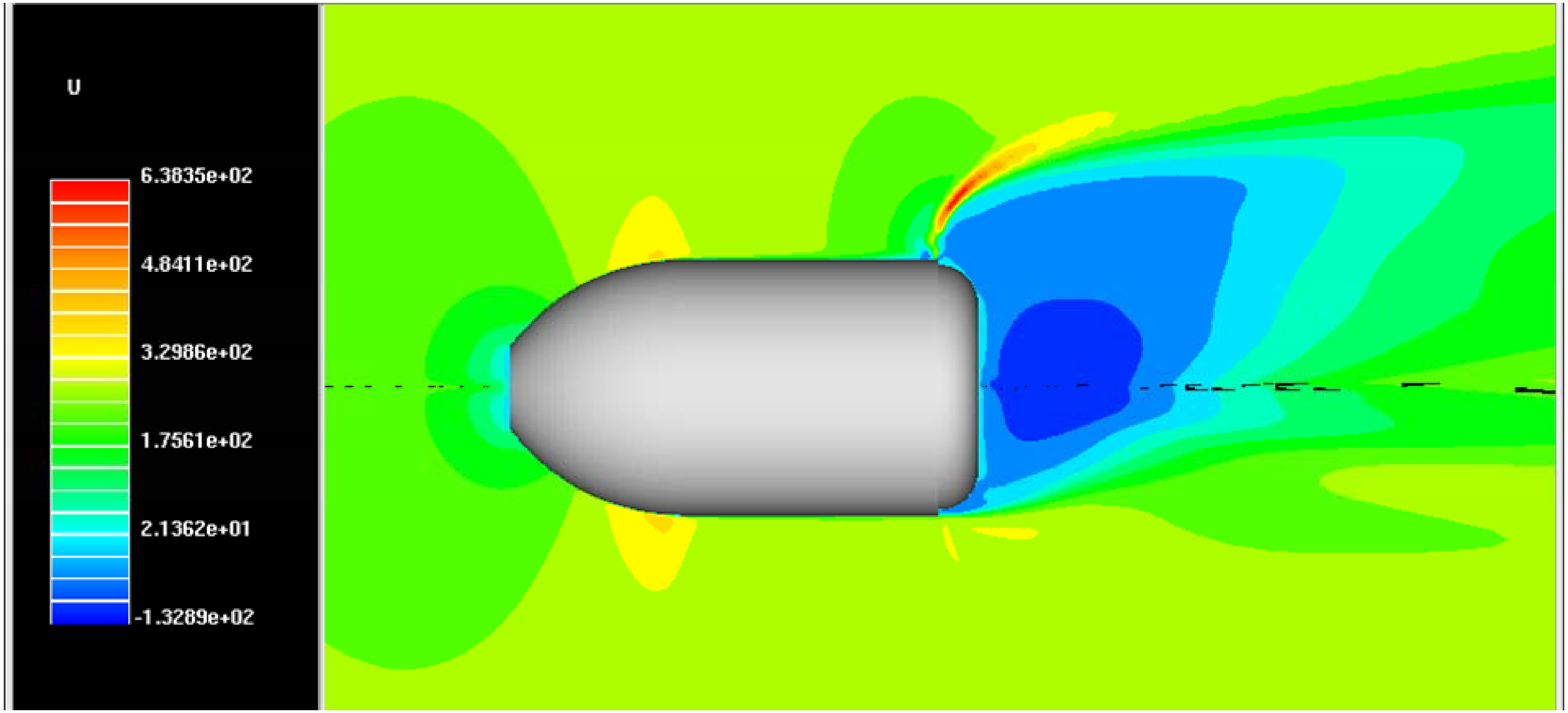
PRESSURE CONTOURS



TEMPERATURE CONTOURS

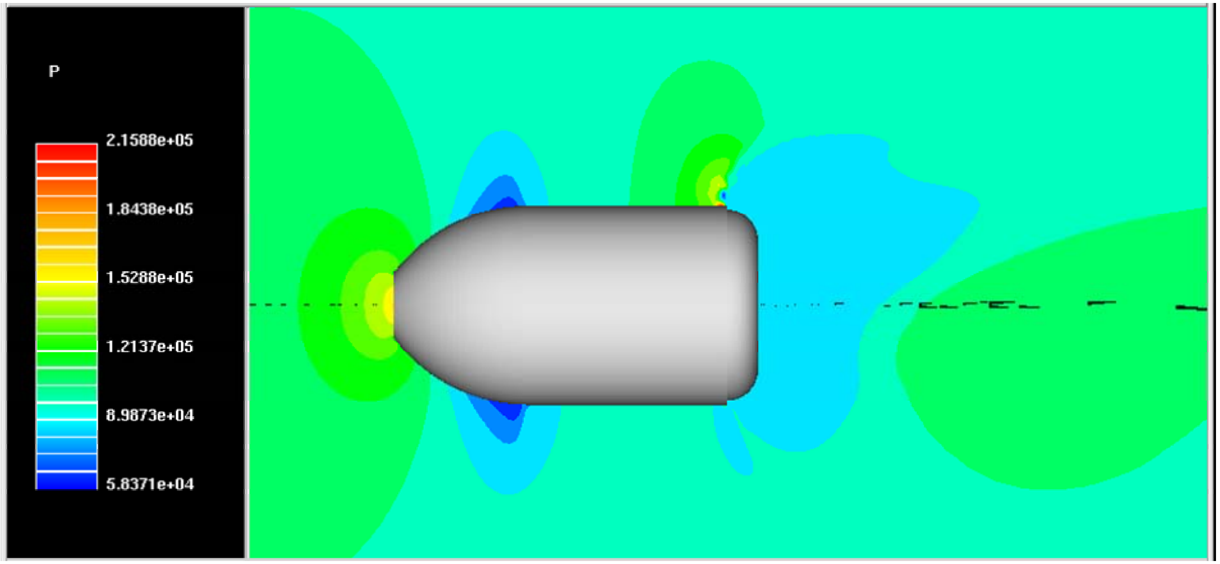


U-Velocity Contours

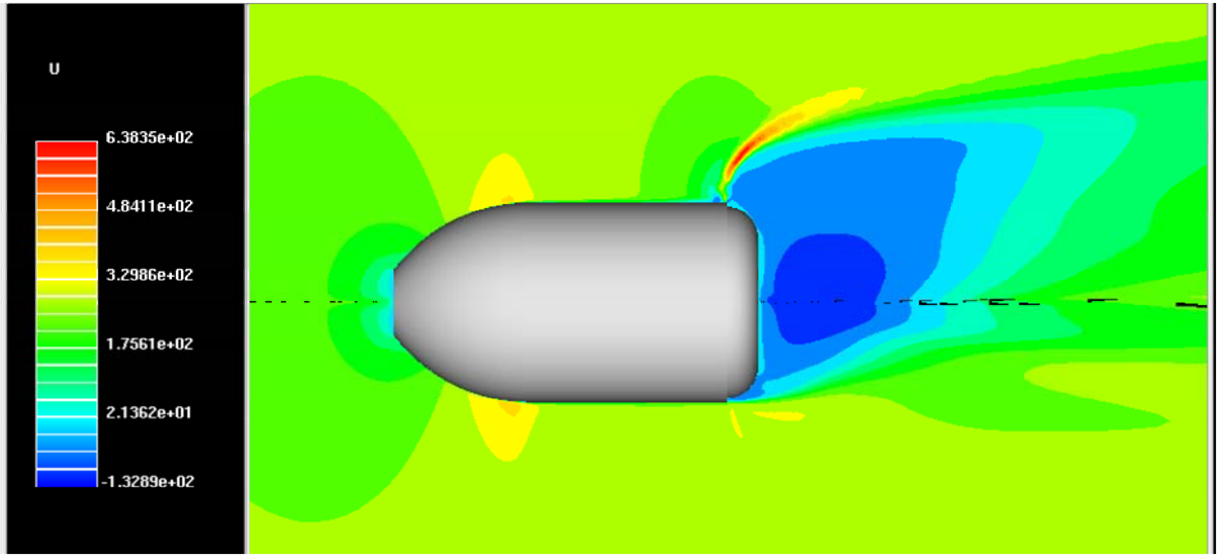


STEADY JET CFD

$M = 0.8, \alpha = 0°, P_0 = 5$ atm, $T_0 = 2000$ K



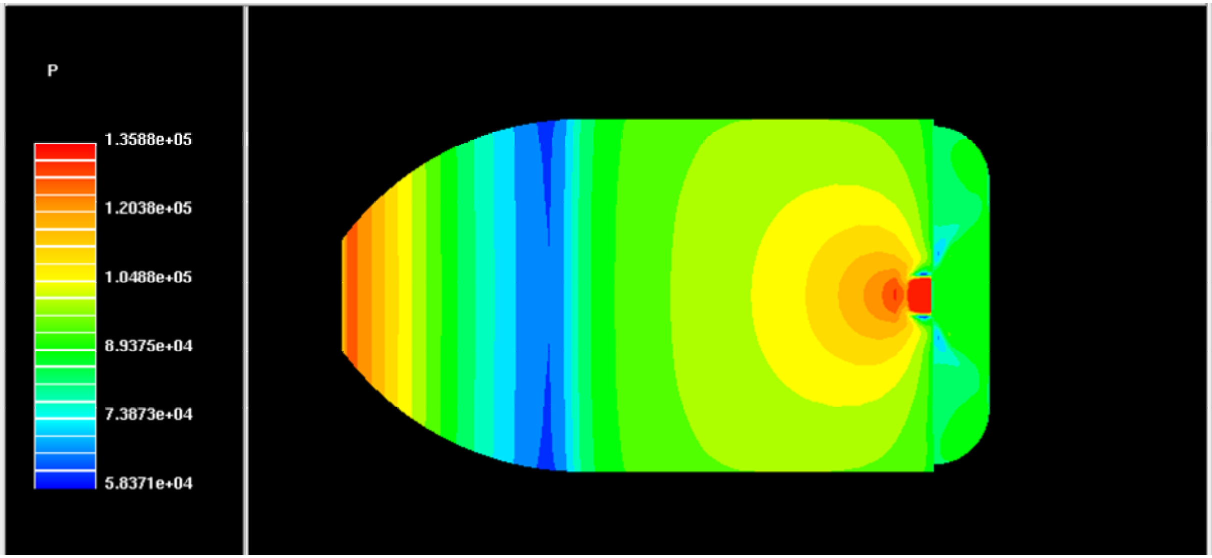
Pressure Contours



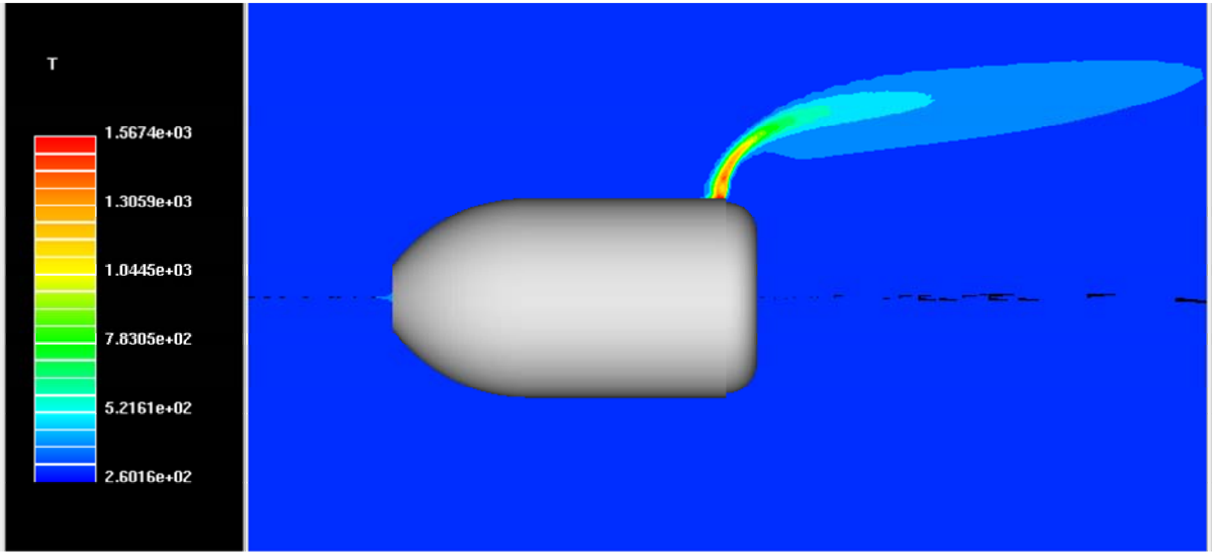
Velocity Contours

STEADY JET CFD

$M = 0.8$, $\alpha = 0°$, $P_0 = 5$ atm, $T_0 = 2000$ K



Surface Pressure Contours



Temperature Contours

STEADY JET CFD

$M = 0.8$, $\alpha = 0°$, $P_0 = 5$ atm, $T_0 = 2000$ K

Body jet-on, Fy = -9.1 N

Body jet-off, Fy = 0.0

Jet Force, $F_{jet} = -3.8$ N

Amplification Factor = $(F_{jet} + F_{ji}) / F_{jet}$

or, AF = (-3.8 + (-9.1 – 0.0)) / (-3.8) = 3.3

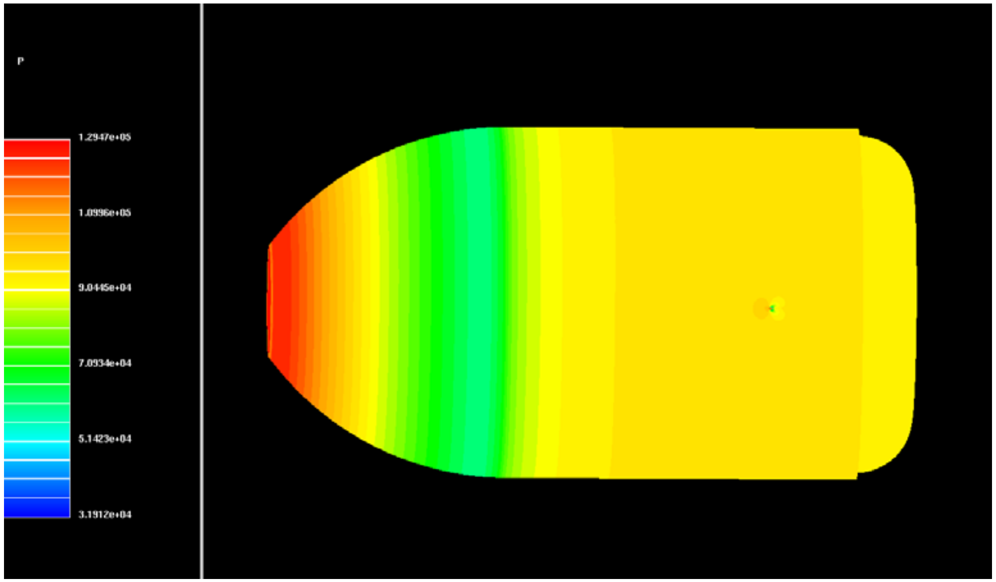
COMBUSTION JET CFD

Jet Size = 0.6 mm axial,
0.3 mm circumferential

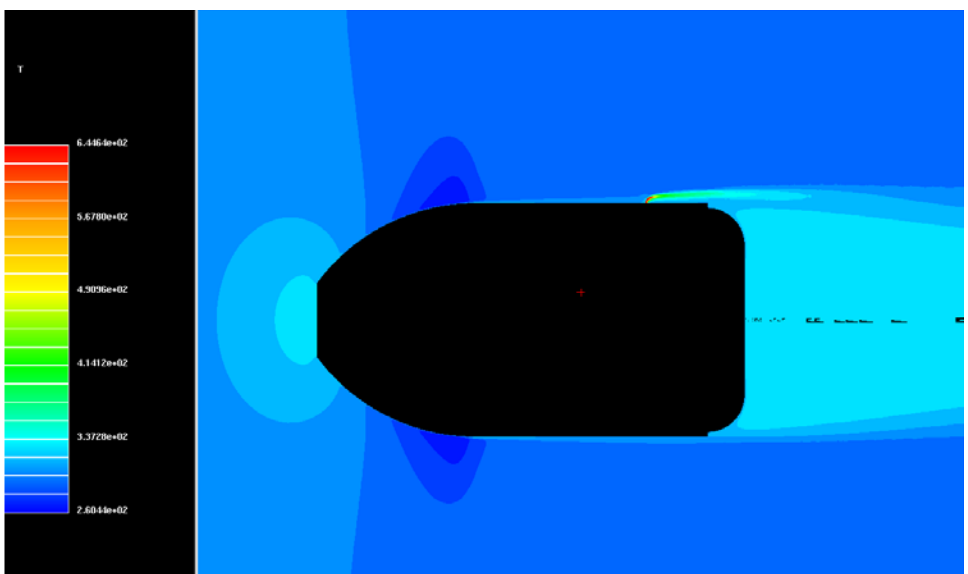
Jet location = 31 mm ahead of the step

STEADY JET CFD

M = 0.8, α = 0°, P_0 = 5 atm, T_0 = 2000 K



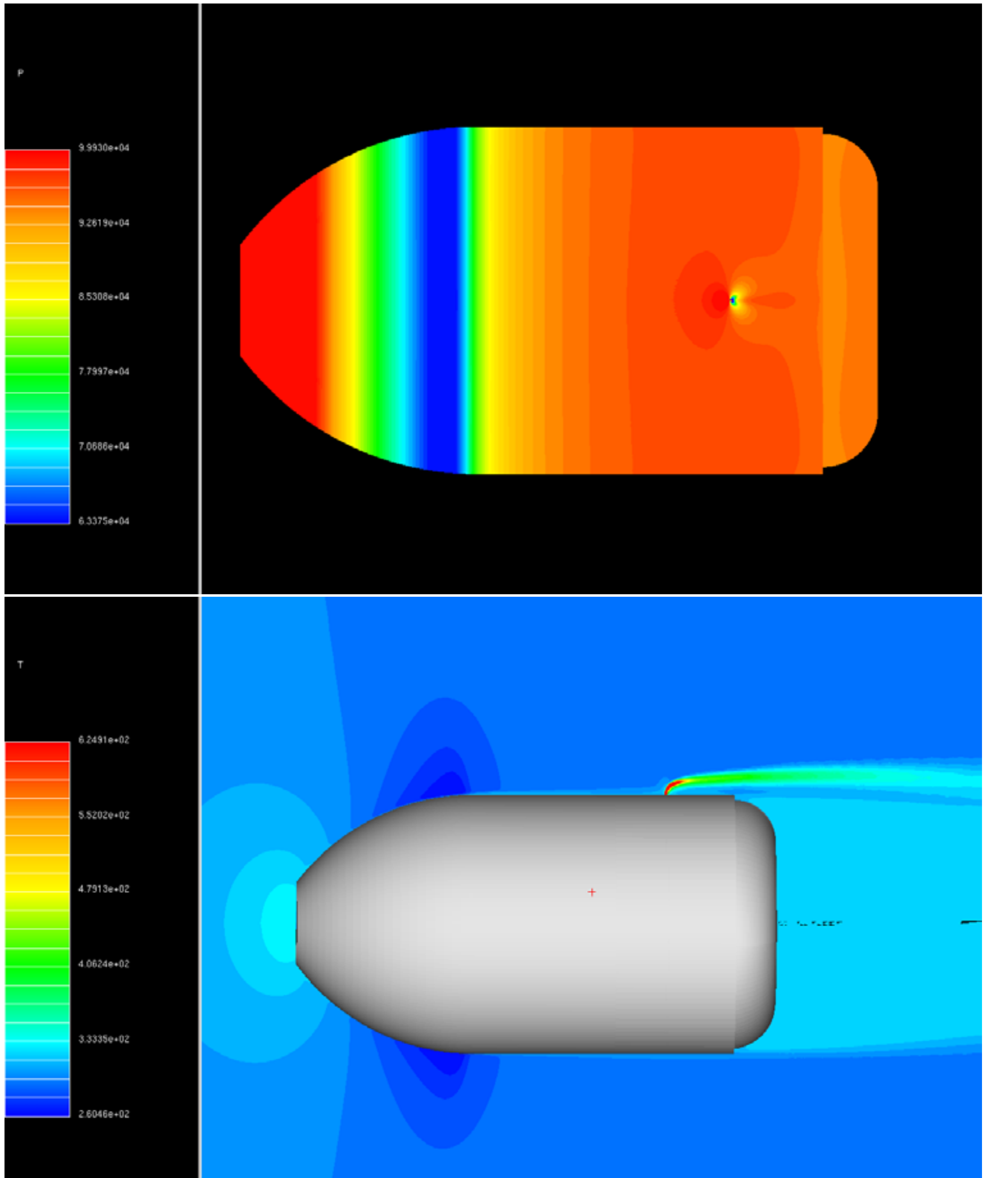
Pressure Contours



Temperature Contours

STEADY JET CFD

M = 0.8, α = 0°, P_0 = 20 atm, T_0 = 4000 K



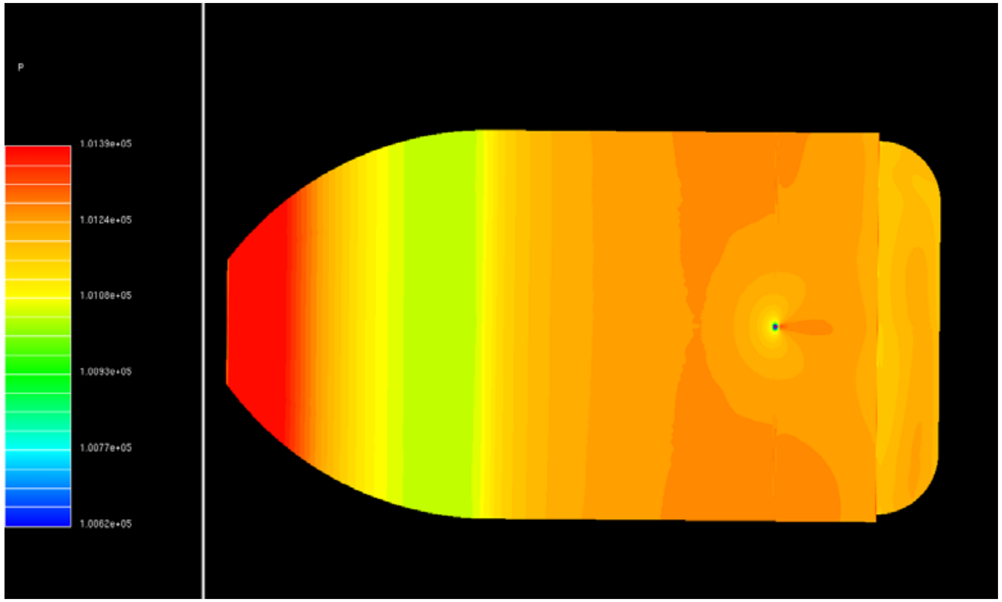
Pressure Contours

Temperature Contours

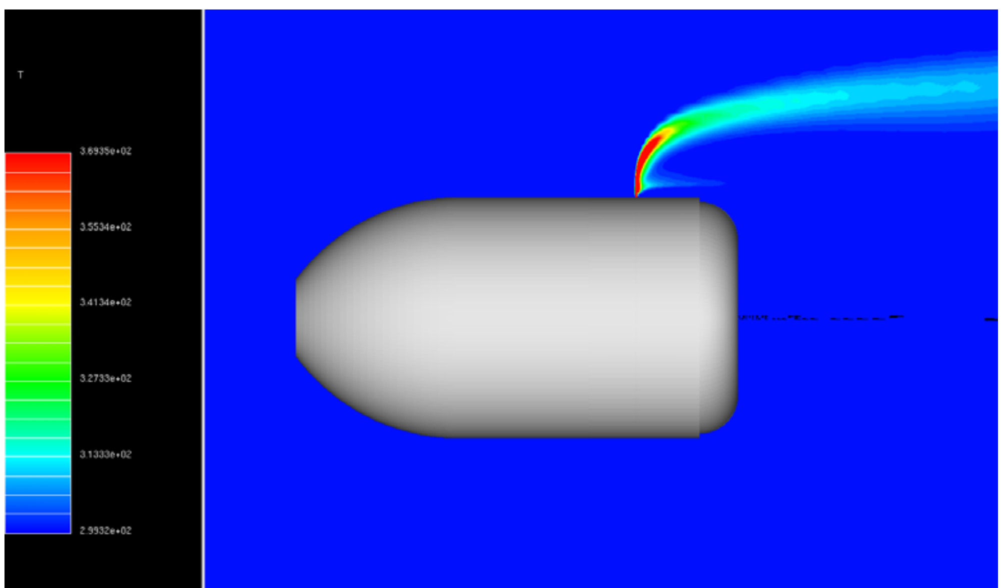
COMBUSTION JET CFD
80mm

STEADY JET CFD

$U = 30$ m/s, $\alpha = 0°$, $P_0 = 5$ atm, $T_0 = 2000$ K



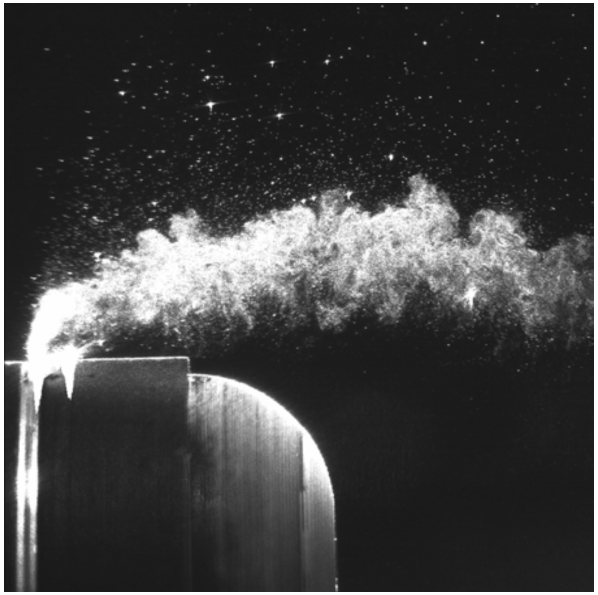
Pressure Contours



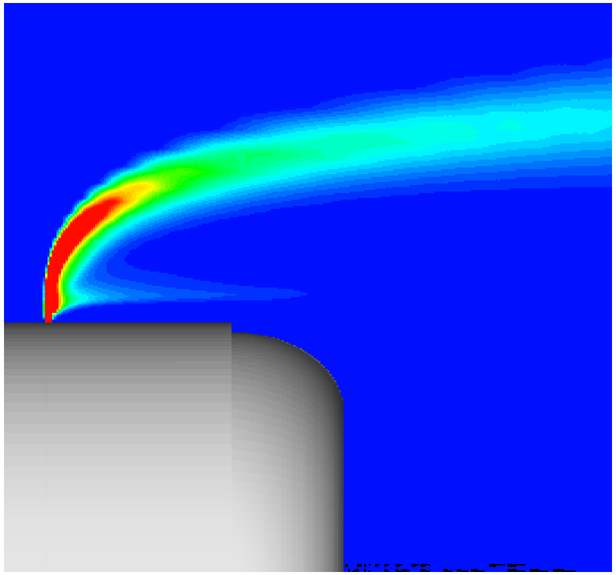
Temperature Contours

STEADY JET CFD

U = 30 m/s, $\alpha = 0°$, $P_0 = 5$ atm, $T_0 = 2000$ K



Experiment



CFD

STEADY JET CFD

$U = 30$ m/s, $\alpha = 0°$, $P_0 = 5$ atm, $T_0 = 2000$ K

Body jet-on, Fy = 0.06 N

Body jet-off, Fy = 0.0

Jet Force, $F_{jet} = -0.08$N

Amplification Factor = $(F_{jet} + F_{ji}) / F_{jet}$

or, AF = (-0.08 + (0.06 – 0.0)) / (-0.08) = 0.25