Computational Fluid Dynamics Modeling of Projectile Aerodynamics

S&T Campaign: Computational Sciences
Computational Fluid Dynamics (CFD)

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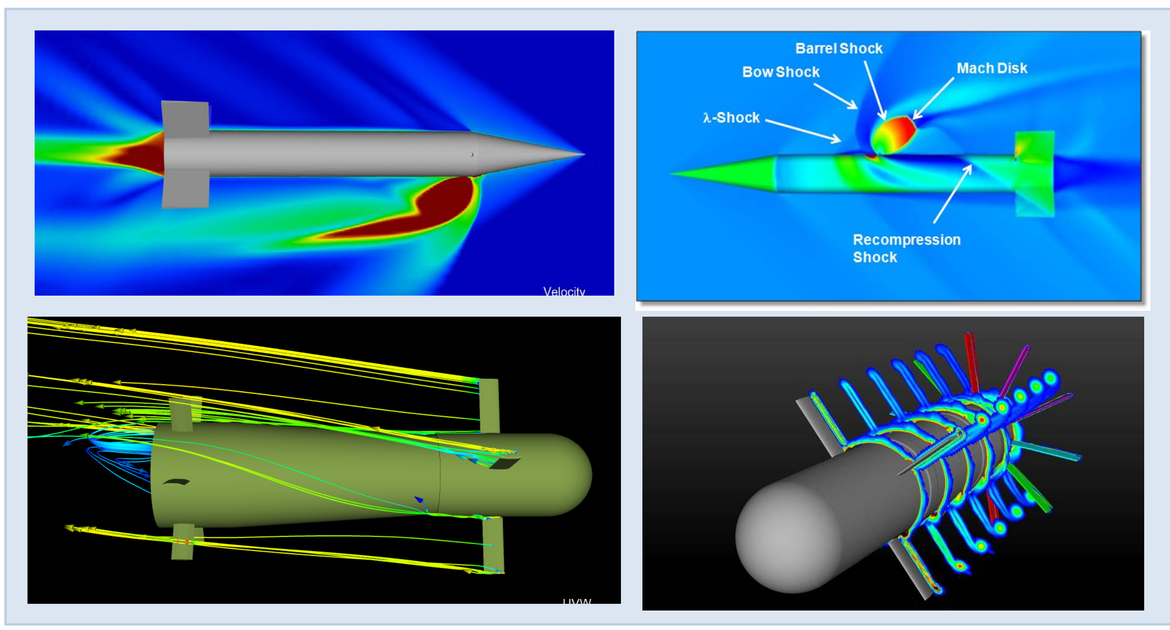
Research Objective

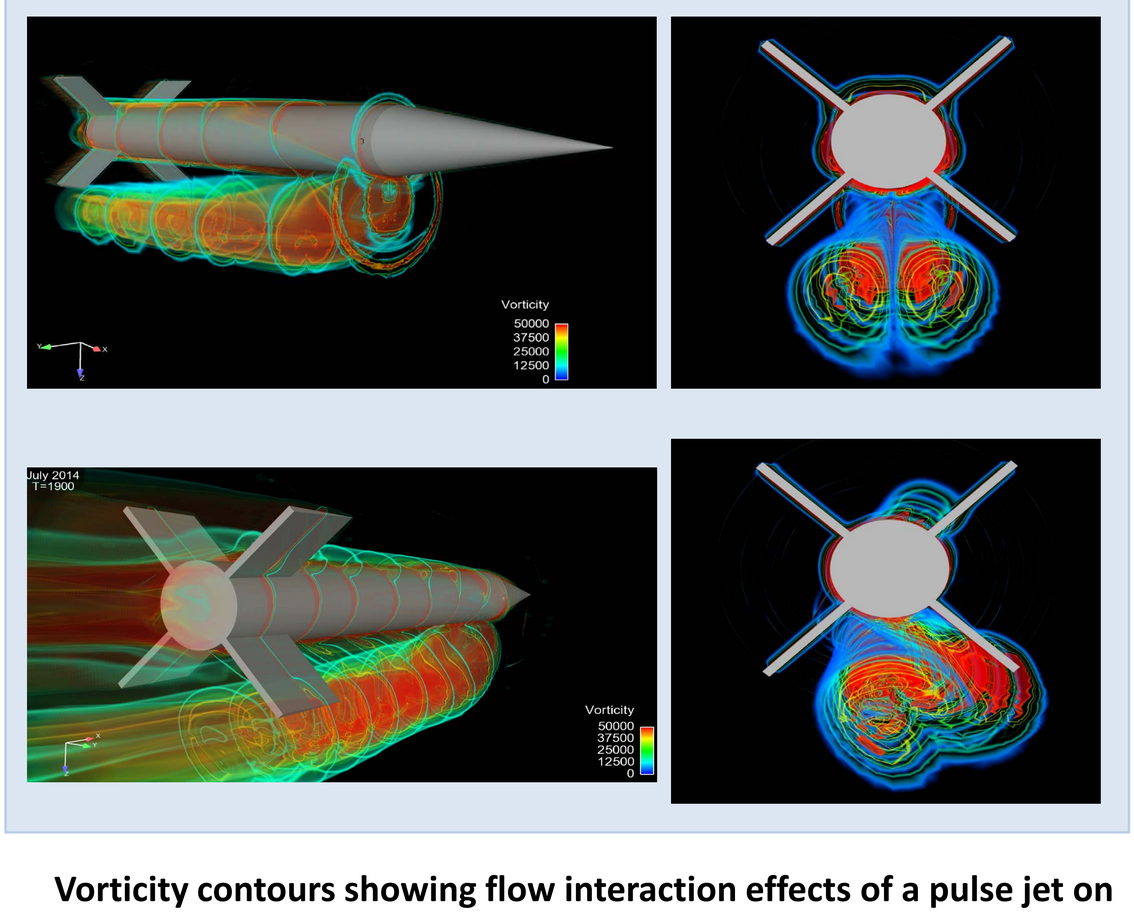
- **Develop and validate highest-fidelity CFD-based capabilities to predict non-linear aerodynamic and flight dynamic behaviors of complex guided munitions.**
- **Gain understanding of fundamental vortex flows and shock-boundary layer interactions.**



Fundamental Jet and Canard Flow Interactions

Challenges

- **Fundamental understanding and control of flow interaction effects**
- **Time-dependent motion of flight body and components**
- **Lack of validation data for coupled method**
- **Efficient methods**



Vorticity contours showing flow interaction effects of a pulse jet on the afterbody fins during jet-control maneuvers

ARL Facilities and Capabilities Available to Support Collaborative Research

- **Advanced virtual wind tunnel and virtual fly-out techniques to understand aerodynamic behavior**
- **State-of-art fully coupled CFD/RBD/FCS capability**
- **Aerodynamic facilities to support flight experiments of munitions**
- **Complementary computational and experimental resources for understanding flight dynamics**
- **Expertise in computational aerodynamic design and analysis**
- **DOD Defense Supercomputing Resource Center (DSRC)**

Selected Publications

•Sahu, J., "Time-Accurate Numerical Prediction of Free-Flight Aerodynamics of a Finned Projectile," AIAA Journal of Spacecraft and Rockets, Vol. 45, No 5, pp 946-954, 2008.
•Sahu, J., Fresconi, F., Heavey, K.R., "Control Performance, Aerodynamic Modeling and Validation of Coupled Simulation Techniques for Guided Projectile Roll Dynamics", AIAA Paper No. 2014-2191, AIAA Aviation Forum, Atlanta, GA, 16-20 June 2014.
•Silton, S., "Navier-Stokes Computations for a Spinning Projectile from Subsonic to Supersonic Speeds," Journal of Spacecraft and Rockets, Vol. 42, No 2, pp 223-231, 2005.
•DeSpirito, J., "Transient Lateral Jet Interaction Effects on a Generic Fin-Stabilized Projectile," AIAA Paper No. 2012-2907, 30th AIAA Applied Aerodynamics Conference, New Orleans, LA, June 2012.
•Bhagwandin, V., and Sahu, J., "Numerical Prediction of Pitch Damping Derivatives for a Finned Projectile at Angles of Attack," AIAA-2012-691, 50th AIAA Aerospace Sciences Meeting, Nashville, TN, Jan 2012.
•Sahu, J. and Heavey, K.R., "Parallel CFD Computations of Projectile Aerodynamics with a Flow Control Mechanism", *Computers and Fluids*, May 2013.

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- **Static and dynamic wind tunnel testing for validation data**
- **Experimental flight tests for validation of coupled method**
- **Rapid, accurate prediction of maneuvering flight physics and experimental validation**
- **Higher order turbulence modeling/numerical schemes**
- **Multidisciplinary design and optimization**
- **Control mechanisms for high maneuverability of flight bodies across omnisonic speeds to include, but not limited to plasma flow control, morphing bodies and exploitation of interaction effects**

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