

# ANALYSIS OF HYPERSONIC FLOW OVER AIRCRAFT PRESSURE SENSORS

## BACKGROUND INFORMATION

- Flying at hypersonic speeds puts intense pressure on aircraft sensors, making extreme environment analysis via Computational Fluid Dynamics (CFD) critical for aerospace safety.
- Understanding how air behaves at these high velocities helps engineers design more resilient measurement tools.
- This project investigates whether a pressure-based sensor can be accurately modeled as a 2D wedge to establish a reliable baseline.

## METHODS

- Generated multiple 2D wedge models by varying the bluntness and width of the wedge tip.
- Meshed the geometries to ensure accurate boundary layer resolution before testing.
- Executed hypersonic airflow simulations on these models to gather aerodynamic data.
- Analyzed the resulting flow data to determine shockwave standoff distance and surface pressures.
- Implemented a validated computational workflow to minimize user error and ensure consistent testing conditions.

## RESULTS

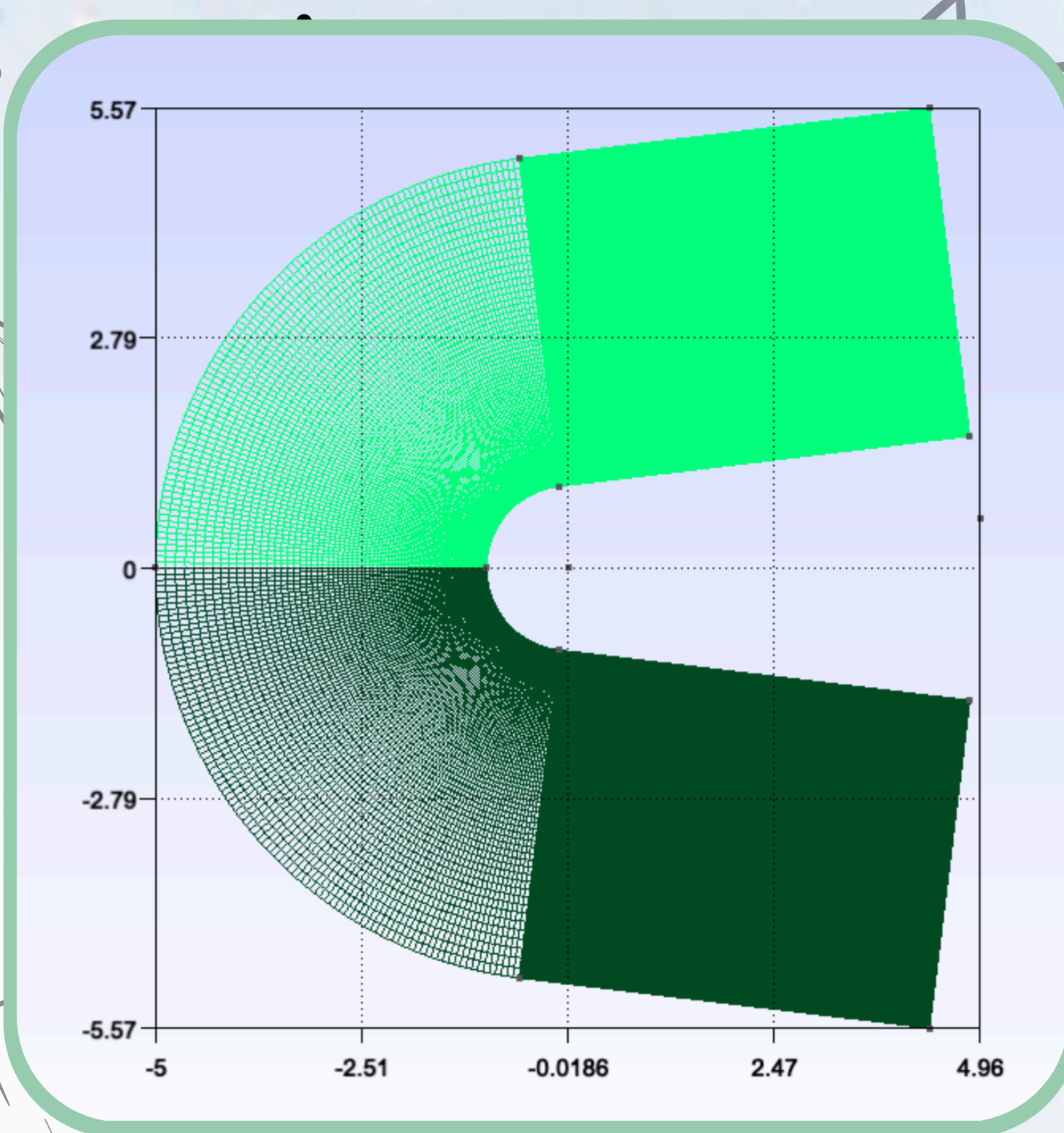
- Preliminary simulations show that varying the bluntness and width of the sensor tip significantly alters the shockwave standoff distance.
- Finalizing these parameters is expected to yield a robust computational baseline for future pressure-based sensor evaluations.
- Research remains ongoing to iteratively refine the 2D wedge geometry to better analyze the extreme hypersonic flow conditions.

## DISCUSSION

- Conducting this 2D simulation serves as a crucial stepping stone before running complex 3D simulations that capture the sensor's full geometry.
- Validating the sensor as a 2D wedge provides a simplified, highly accurate baseline for future measurements.
- Ultimately, this computational baseline can be referenced later to verify results when testing the actual physical models.

## REFERENCES

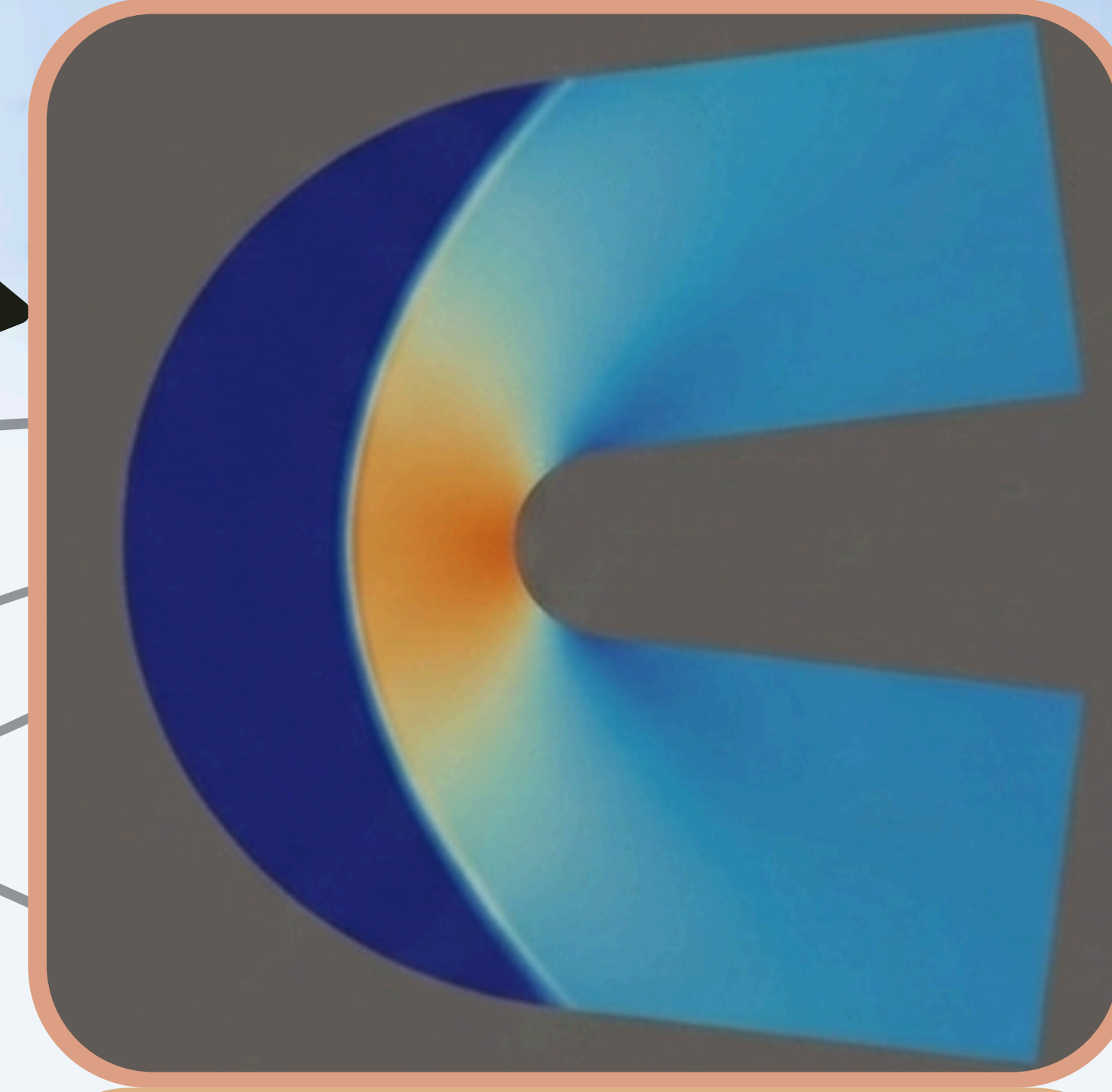
- SU2 Code Documentation: Economon, T. D., et al. (2016). SU2: An open-source suite for multiphysics simulation and design. AIAA Journal.
- Meshing Standards: Geuzaine, C., & Remacle, J.-F. (2009). Gmsh: A 3-D finite element mesh generator with built-in pre- and post-processing facilities. International Journal for Numerical Methods in Engineering.
- CFD Fundamentals: Miller, S. A. E. (2020). Introduction to Computational Fluid Dynamics - Preliminaries - 3 - Code Overview and SU2/Paraview.
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GMSH mesh dividing space into quadrilaterals for analysis

Inner_Iter	Time(sec)	rms[Rho]	rms[RhoE]	Cl	CD
1501	4.4570e-01	-1.417855	4.431740	-0.000131	0.077468
1502	4.4575e-01	-1.378641	4.419087	-0.000081	0.077467
1503	4.4581e-01	-1.375510	4.464040	-0.000079	0.077461
1504	4.4586e-01	-1.320432	4.470234	-0.000065	0.077462
1505	4.4590e-01	-1.279446	4.508999	-0.000051	0.077460
1506	4.4594e-01	-1.240021	4.584003	-0.000070	0.077458
1507	4.4598e-01	-1.204082	4.691549	0.000015	0.077451
1508	4.4601e-01	-1.011300	4.740957	-0.000012	0.077445
1509	4.4606e-01	-0.776157	4.887982	0.000049	0.077443
1510	4.4611e-01	-0.693761	5.054530	-0.000164	0.077419
1511	4.4615e-01	-0.726905	4.961296	-0.000353	0.077384
1512	4.4619e-01	-0.494869	5.176855	-0.000541	0.077368
1513	4.4625e-01	-0.422237	5.246421	-0.000742	0.077346
1514	4.4629e-01	-0.671274	5.032734	-0.000739	0.077359
1515	4.4634e-01	0.022717	5.611660	-0.001013	0.077312
1516	4.4637e-01	-0.078929	5.592766	-0.001334	0.077306
1517	4.4639e-01	-0.356863	5.251294	-0.001055	0.077315
1518	4.4640e-01	-0.394271	5.171775	-0.001090	0.077317
1519	4.4640e-01	-0.524944	5.061125	-0.001156	0.077300
1520	4.4641e-01	-0.654437	4.953960	-0.001227	0.077293
1521	4.4640e-01	-0.789929	4.839183	-0.001111	0.077303
1522	4.4640e-01	-0.983126	4.755247	-0.000753	0.077366
1523	4.4634e-01	-1.123272	4.567482	-0.000528	0.077433
1524	4.4617e-01	-1.275763	4.426317	-0.000605	0.077431
1525	4.4621e-01	-1.642132	4.156826	-0.000549	0.077449
1526	4.4625e-01	-1.832850	3.885949	-0.000621	0.077451
1527	4.4622e-01	-1.979427	3.778924	-0.000616	0.077456
1528	4.4627e-01	-2.079599	3.590240	-0.000612	0.077458
1529	4.4631e-01	-1.786707	3.961496	-0.000564	0.077456
1530	4.4630e-01	-1.583161	4.239116	-0.000741	0.077441
1531	4.4634e-01	-1.368000	4.608501	-0.000801	0.077441

SU2 graph showing numerical error dropping as the solution stabilizes



ParaView map of air speed showing a hypersonic shockwave.