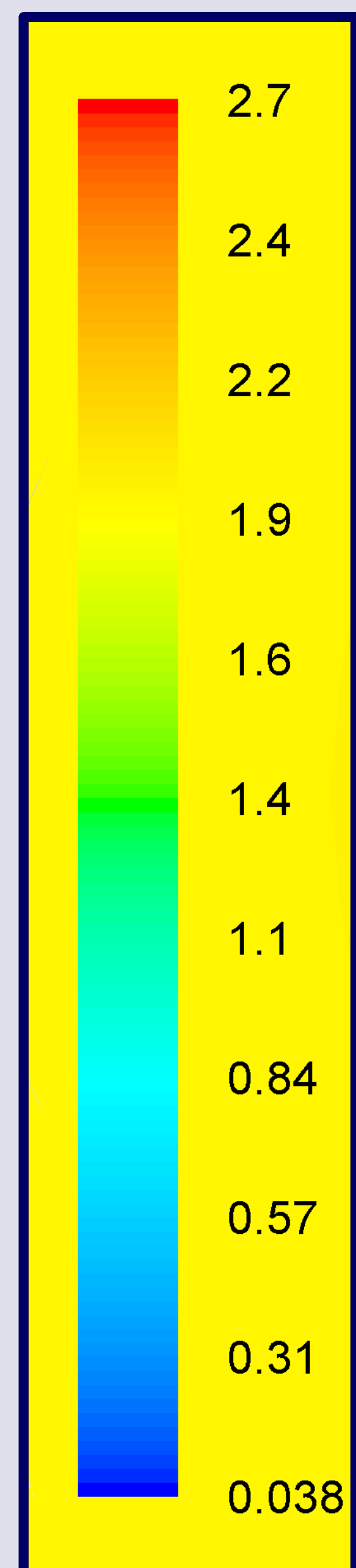
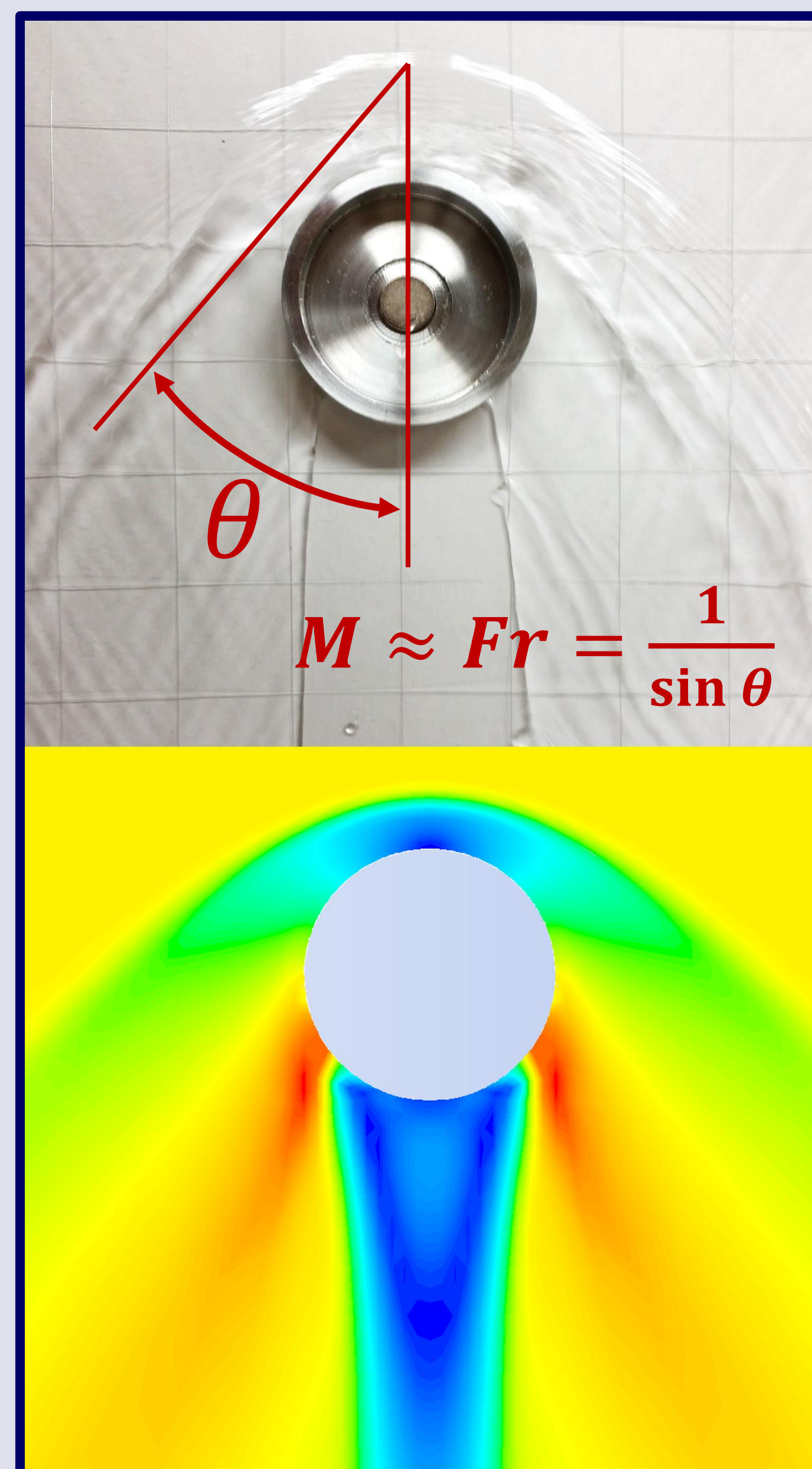


Methods of Testing

We designed and built a water table where cross-sectional models could be tested. The resulting hydraulic jumps generated in thin, laminar flows are analogous to shock behavior.



Contours of
Mach No.

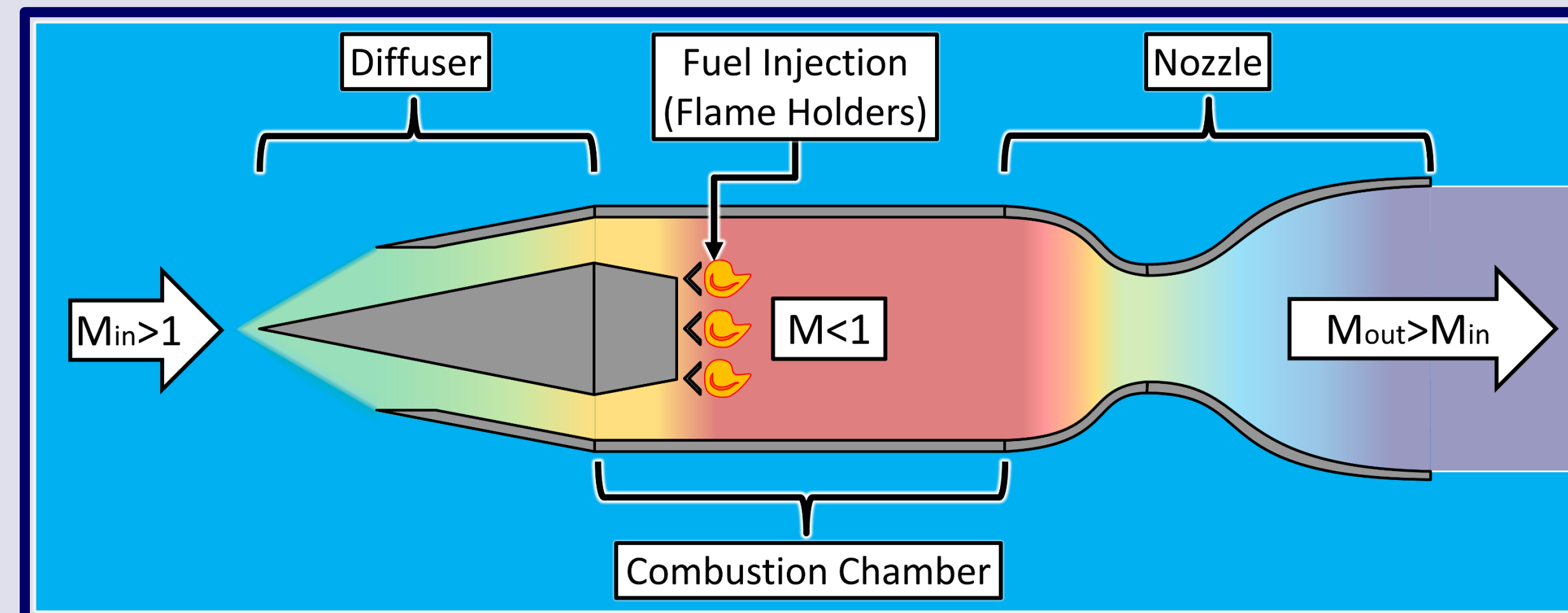


Cylinder
2D Cross Flow

$$M \approx Fr = \frac{1}{\sin \theta}$$

Problem

To reach a ramjet's operating speed, a separate propulsion motor is required for acceleration. Integrating a solid-fuel rocket into the ramjet design removes the need for a staged booster. This hybridization reduces the overall weight and cost of the ramjet system.



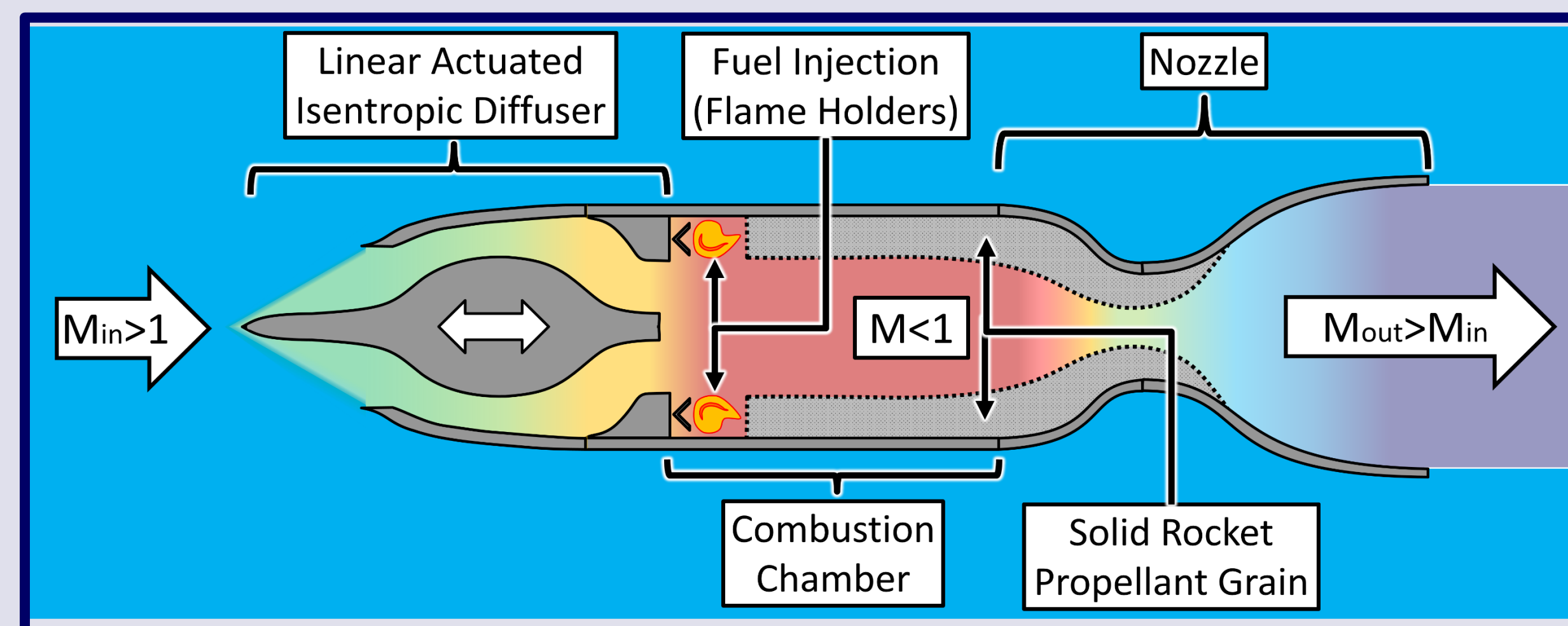
Project Goal

Using a moveable nose cone, develop mechanisms of the IRR to:

- Unify ramjet and solid rocket combustion chambers
- Ensure smooth transition from solid rocket to ramjet operation at approximately Mach 3
- Optimize inlet for variable intake conditions

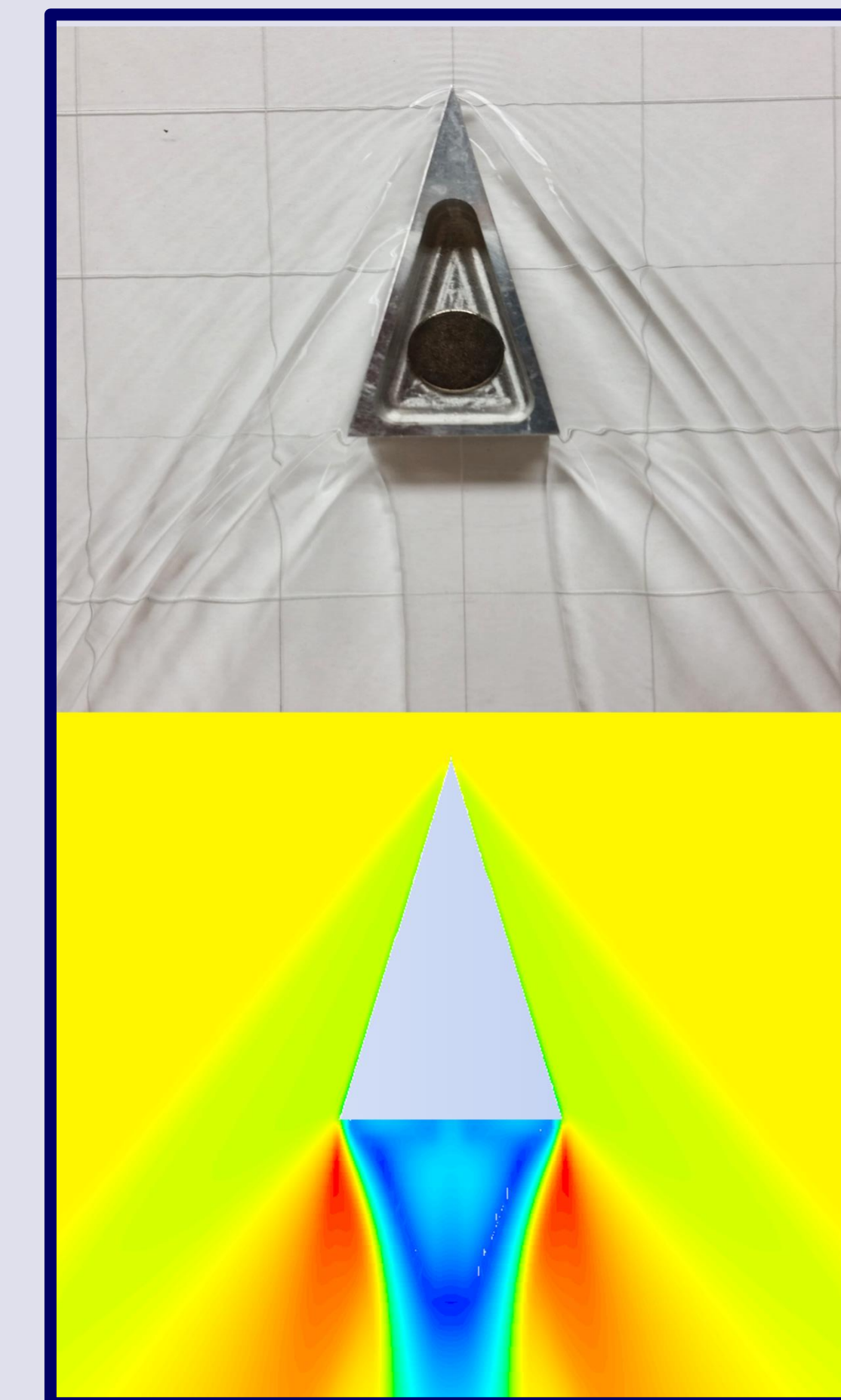
Solution Concept

- Linearly actuated nose cone shuts off air flow and optimizes shock behavior for pressure recovery
- Nose cone shaped for isentropic compression
- Propellant grain cast in ramjet combustion chamber to unify flow



Simulation & Validation

Comparison between Water Table experimentation and Computational Fluid Dynamic (CFD) simulation shows similar flow characteristics. Testing is done equating Froude and Mach numbers at 2:



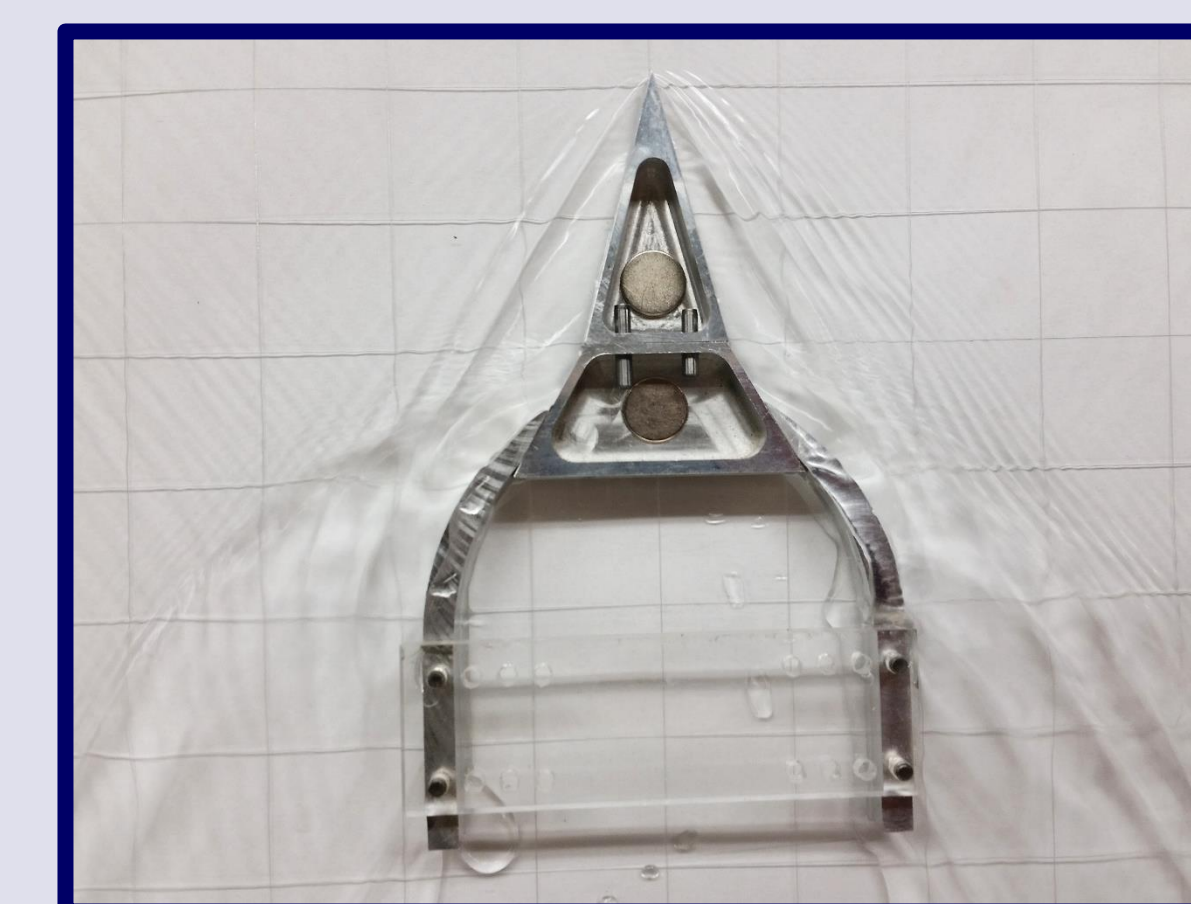
Standard Wedge
15° Turning Angle



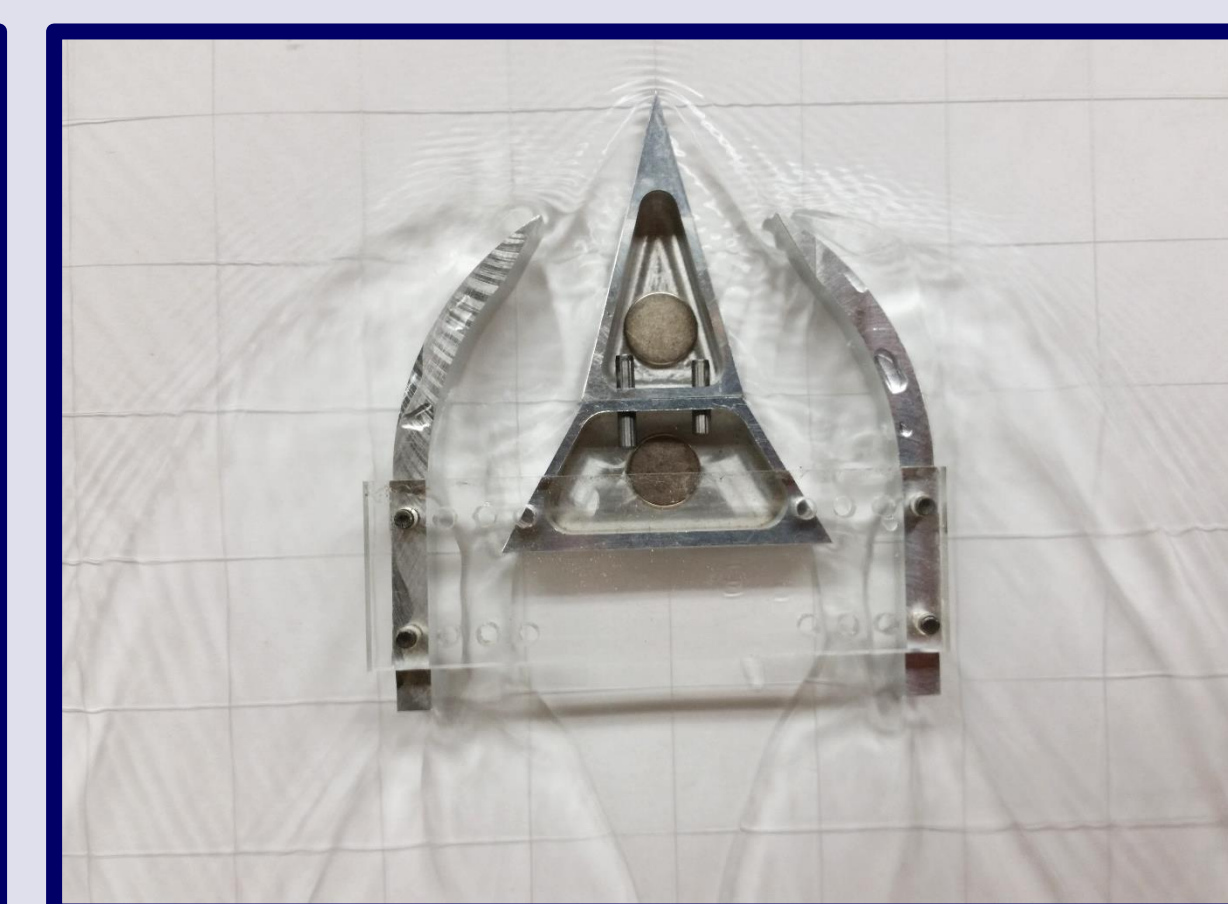
Stepped Wedge
15°-15° Turning Angle

Expected Performance

More complex internal flow geometries have been modeled with the water table. For the future developing CFD simulations of internal flow will help to refine design features.



Sealed Cowling for Solid Rocket Phase



Retracted Nose Cone for Ramjet Phase