Project Title Goes Here

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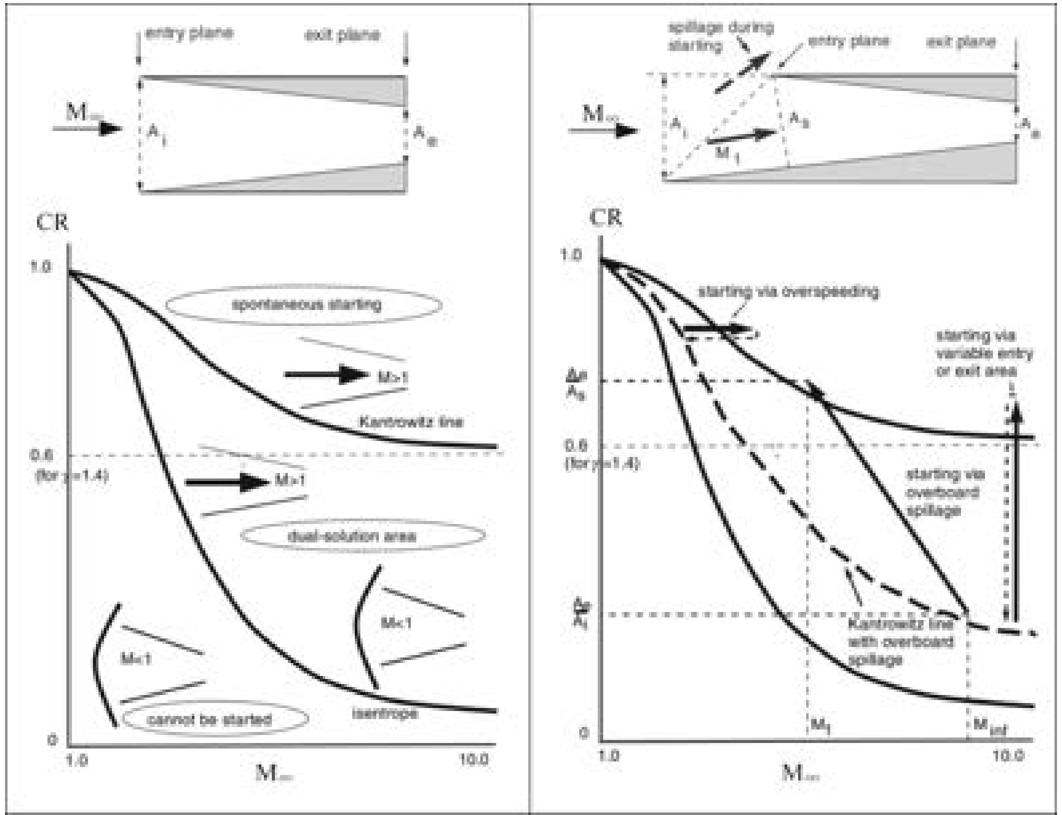
Background

- The original goal of this project was to develop an innovative flow management approach that utilizes the kantrowitz limit to expand the operating range of a hypersonic inlet
- The kantrowitz limit is a conservative estimate for measuring the startability of a hypersonic inlet

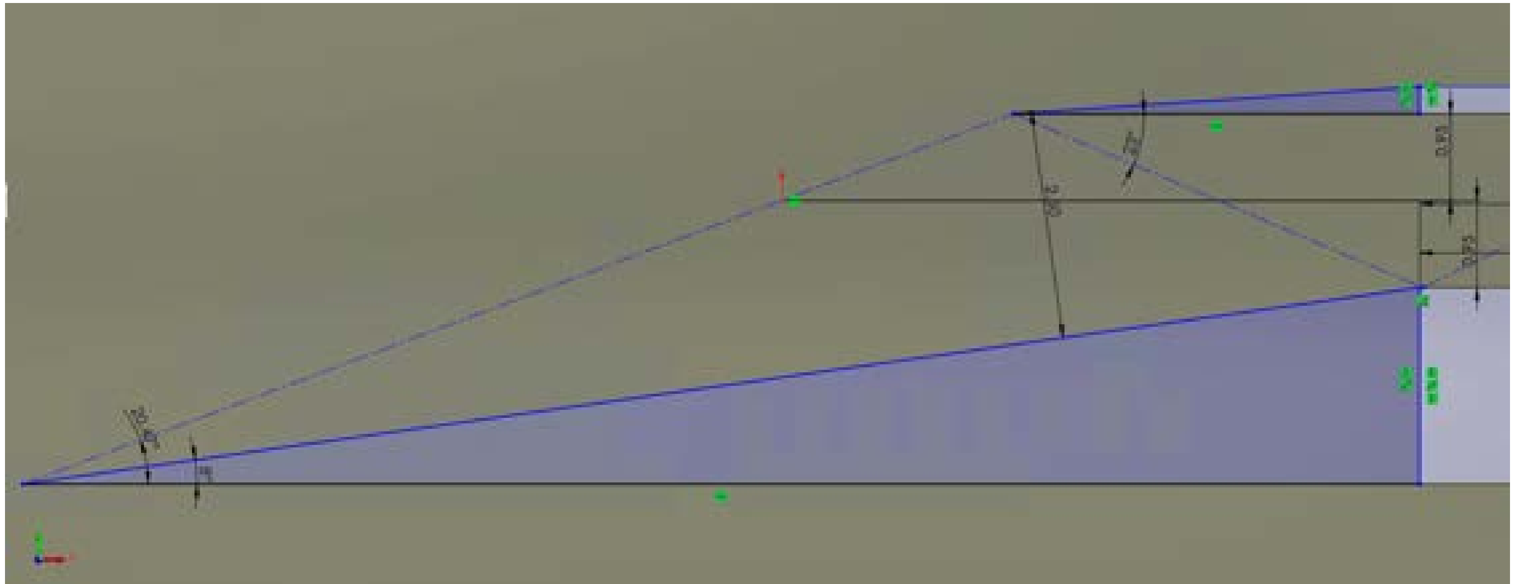


a) start boundary of fully enclosed internal contraction inlet

b) starting via overspeeding, overboard spillage, and variable geometry

Inlet Design

- Our original design was based on what could be physically tested at UC, therefore we went with a square Mach 4 inlet that begins to unstart at Mach 2
- Then fluidic injection would be added to the inlet to restart the inlet at Mach 2
- The desired contraction ratio for a guaranteed started Mach 4 inlet is about 0.67 and the current design is 0.76
- The angle of the compression ramp is 8° and the design goal was to have the shock from the cowl hit the throat to allow for a less complex flow within the isolator



Results: Contours

- The turbulent contours that are discussed are in the following order for all results: Baseline, 0.1in injector form the cowl lip with a pressure of 100 kPa, 0.1in injector form the cowl lip with a pressure of 200 kPa, 0.1in injector form the cowl lip with a pressure of 300 kPa, and variable geometry cowl moved down toward the compression ramp.
- These were investigated to determine the effects of different injection pressures on potentially starting the inlet at Mach 2.
- A rounded cowl tip was also investigated to allow for the injector to be closer to the cowl lip. This is shown in the results on slide 8 where unstart caused by increasing the mass flow rate was investigated.

Results: Contours

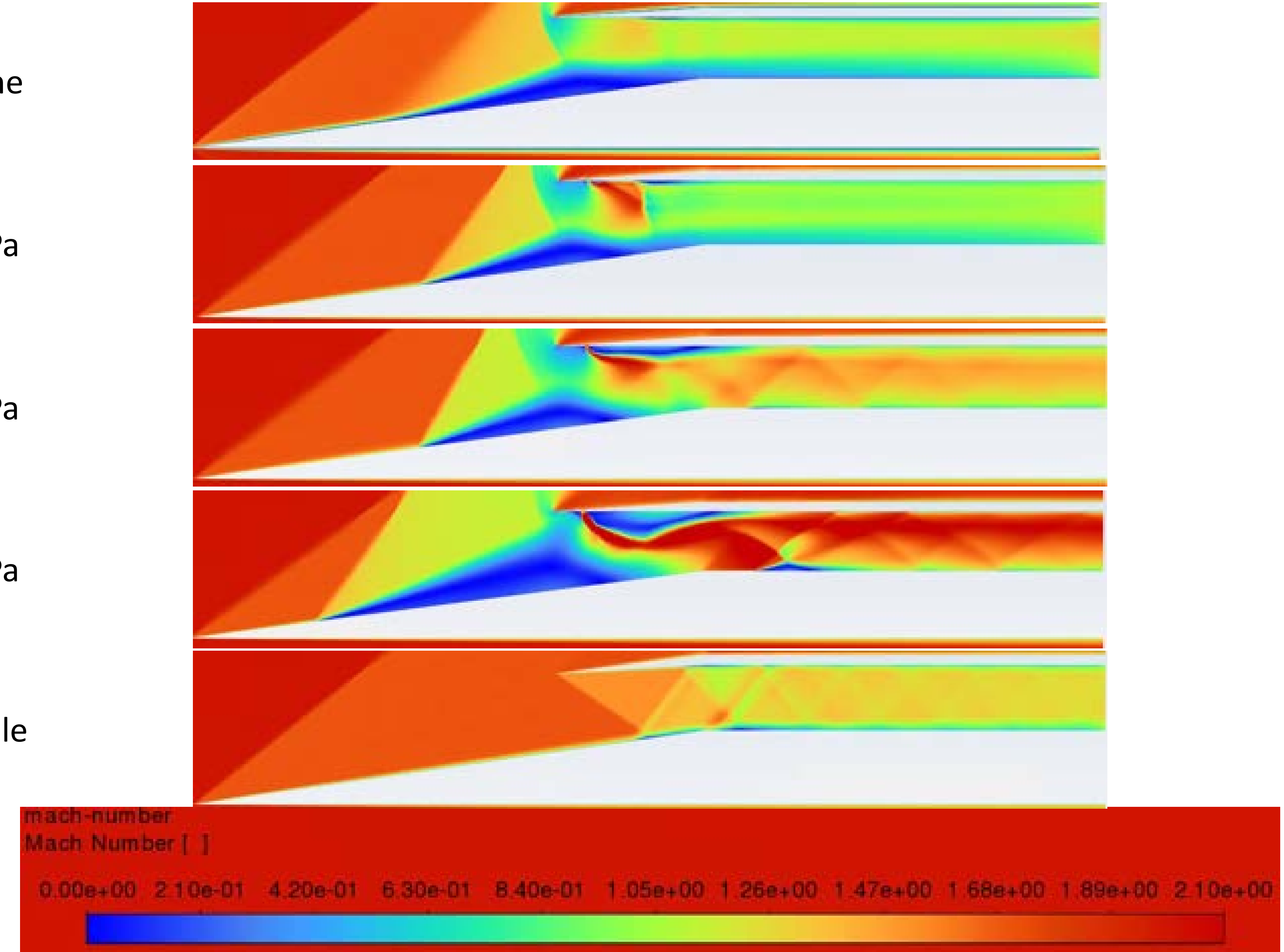
Baseline

100k Pa

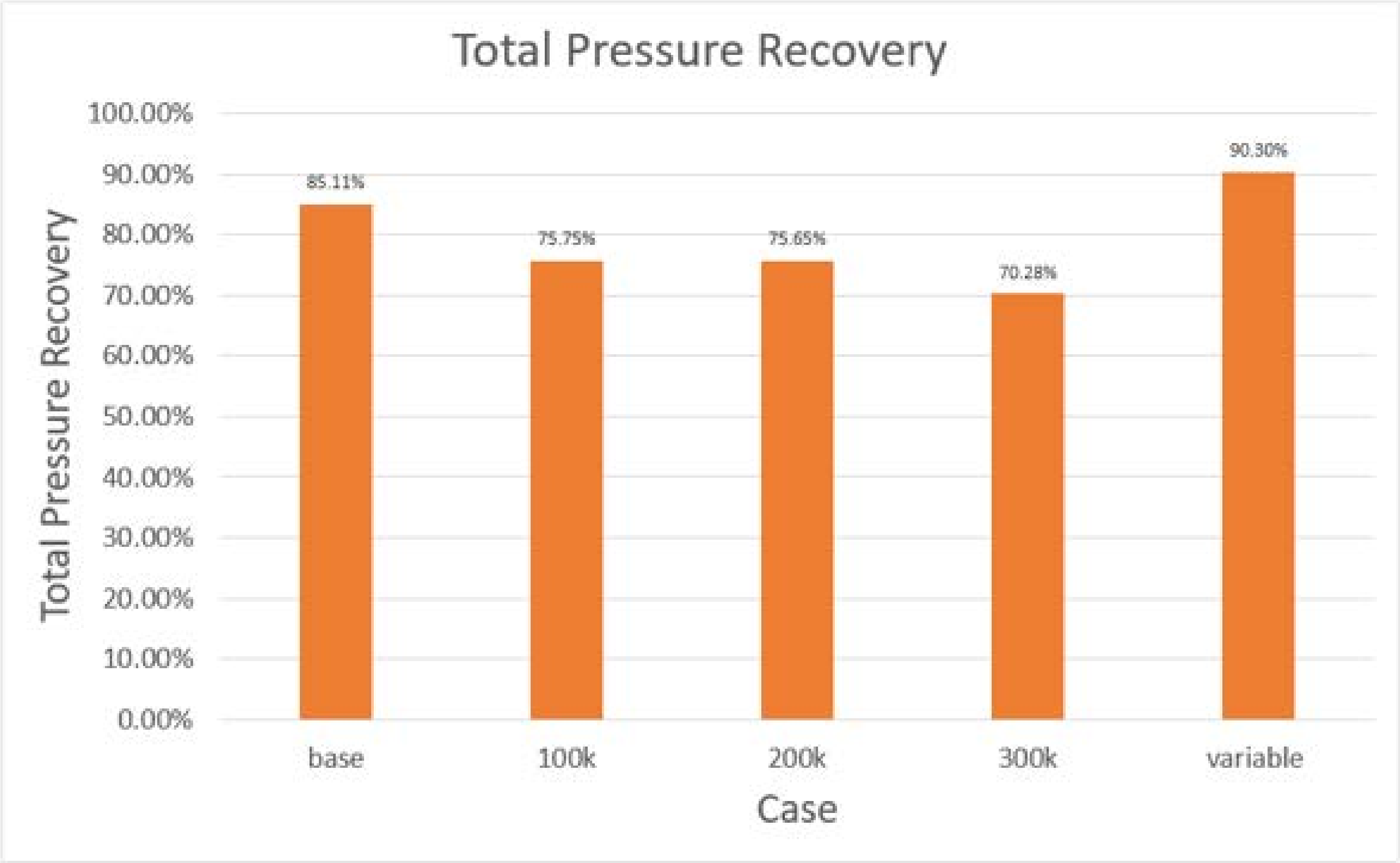
200k Pa

300k Pa

Variable

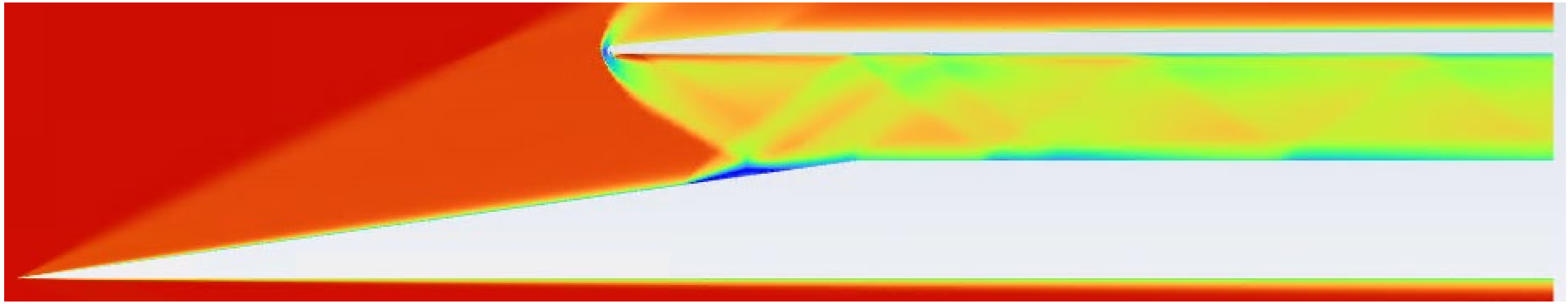


Results

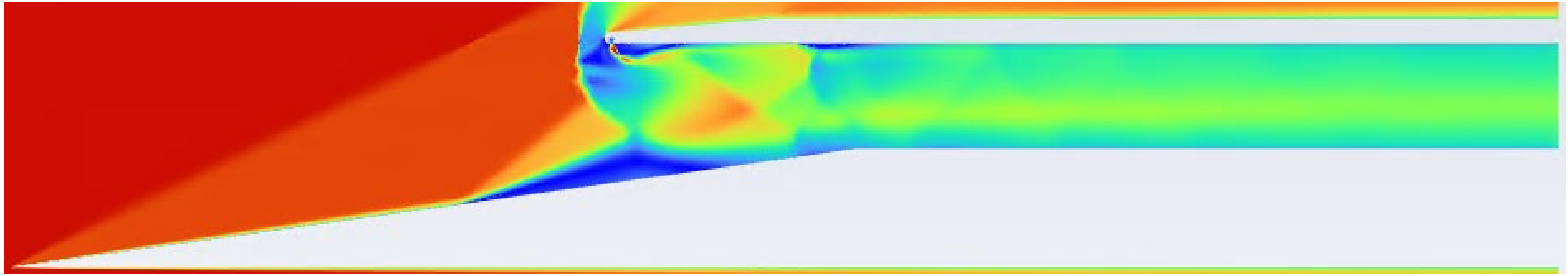


It appears that the addition of perpendicular injection from the cowl is not beneficial for total pressure recovery of the inlet. This is likely because the separation bubble forming along the bottom isn't really affected.

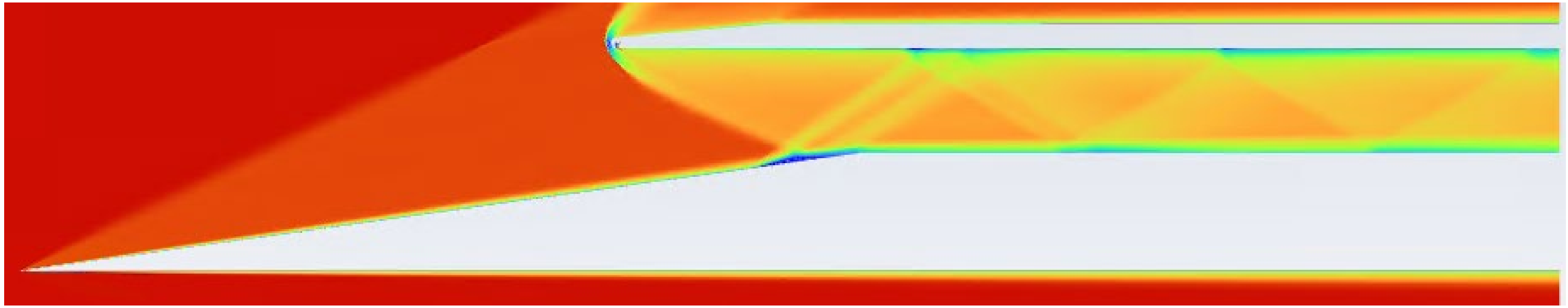
Mach 3 Mass Addition Simulations



BL Injection
Injector ~2.0 kg/s
Outlet ~17.9

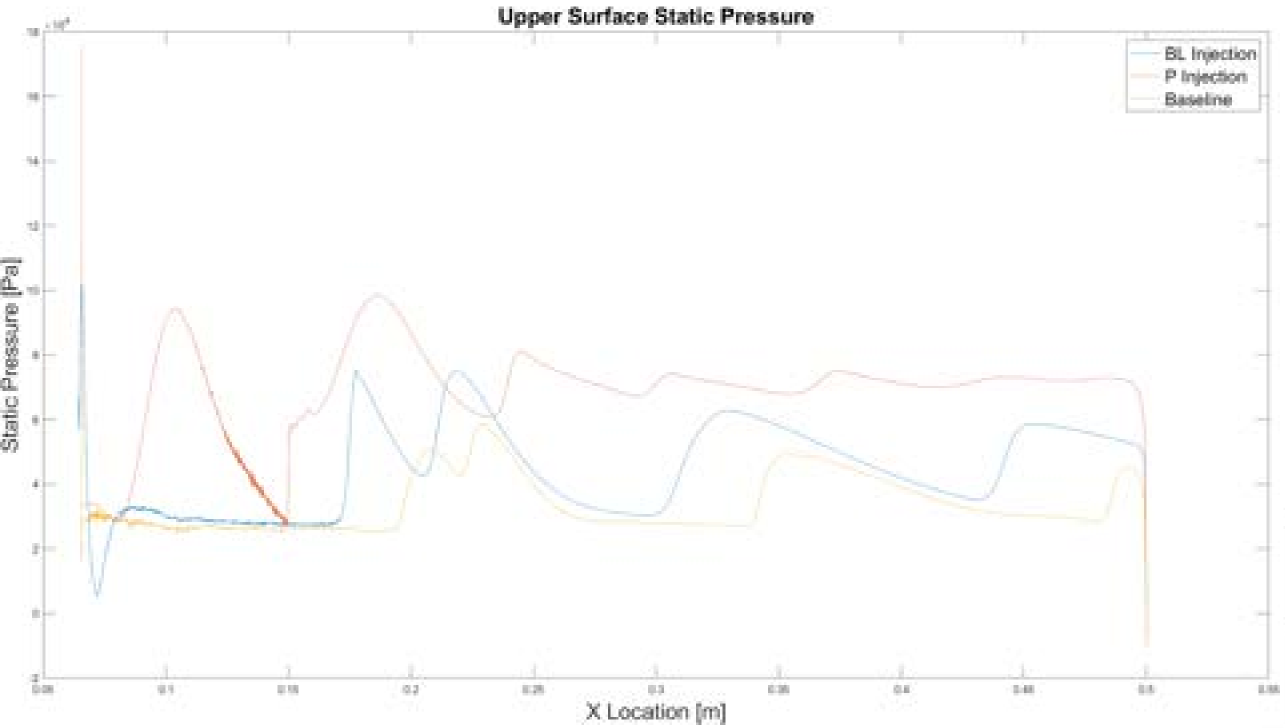


P Injection
Injector ~2.2 kg/s
Outlet ~14.1 kg/s

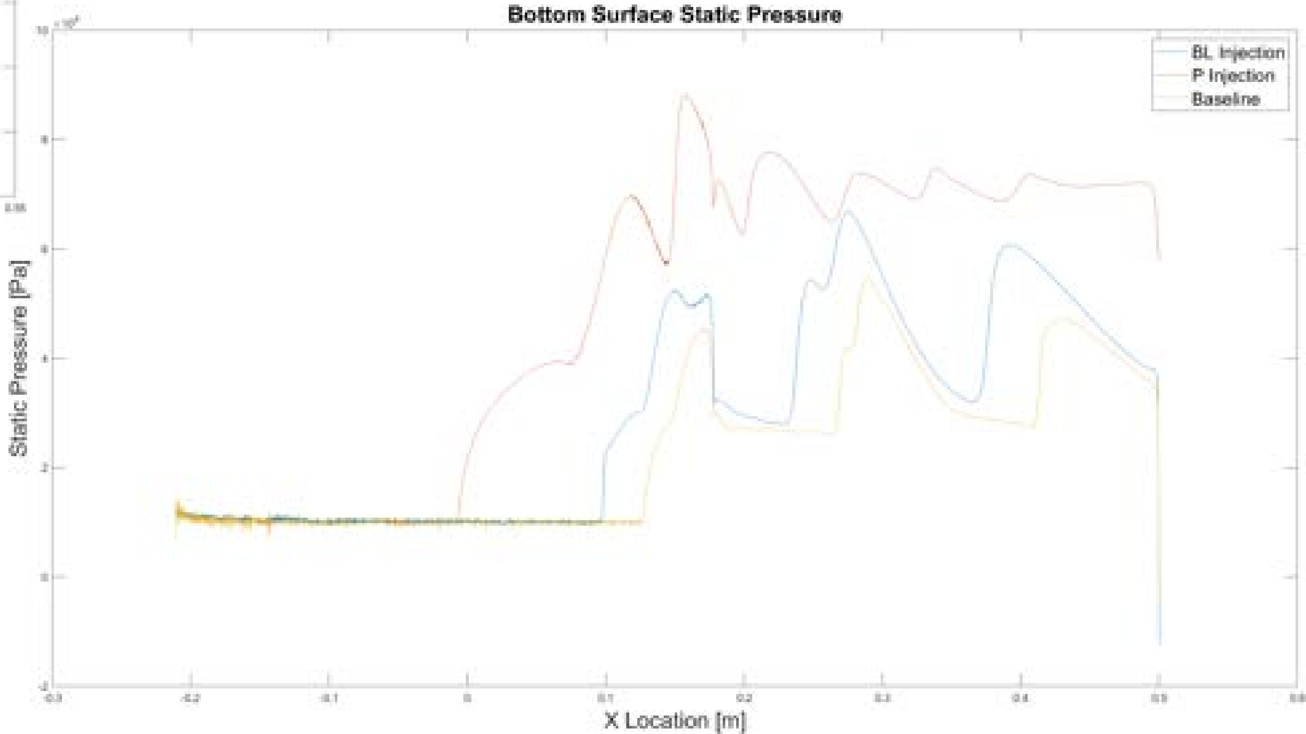


Baseline
Injector 0 kg/s
Outlet ~13.6 kg/s

Mach 3 Mass Addition Simulations



Average static pressures
BL Injection: 57,311.7 Pa
P Injection: 93,004.3 Pa
Baseline: 44,423.2 Pa

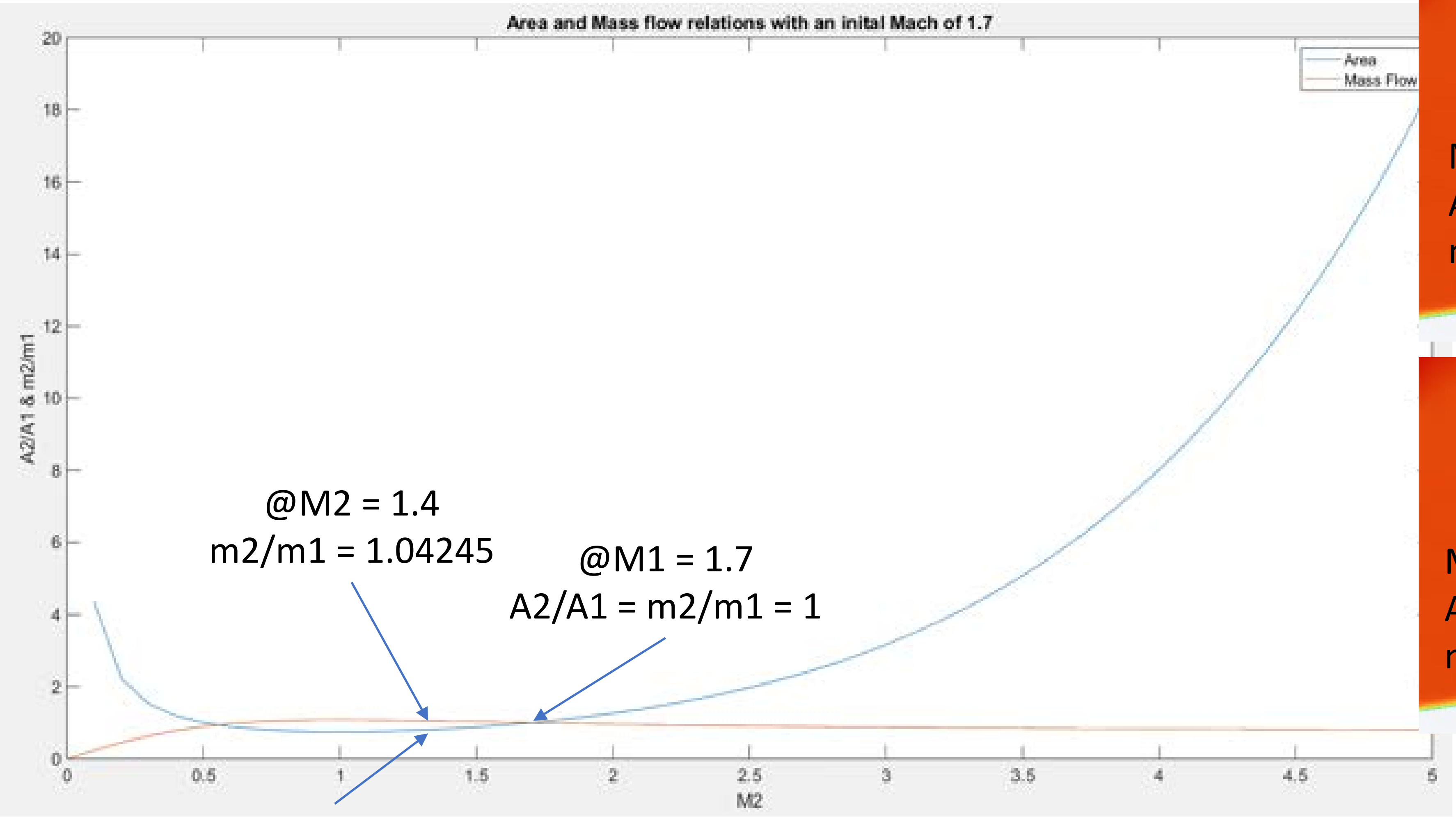


As can be seen perpendicular injection results in an increase in static pressure across the whole surface for both the top and bottom. Additionally, the first static pressure rise occurs earlier along both surfaces due to the separation regions that occur.

Area and Mass Flow Relation

- Using influence coefficients found in Shapiro's Compressible Fluid Flow textbook an equation can be derived that relates area ratio and mass flow rate ratio to Mach number for a hypersonic inlet.
- To show the effects of area and mass flow rate ratios on our inlet an equation was derived for both area and mass flow rate individually, using those equations it can be shown the effects of area change and mass flow rate change on an inlet.
- As shown on slide 10, an inlet at Mach 1.7 will decrease to Mach 1.4 if the mass flow rate ratio is increased by ~4.25% or if the area ratio is decreased by ~16.65%.

Area and Mass Flow Relation



@M2 = 1.4
A2/A1 = 0.833523