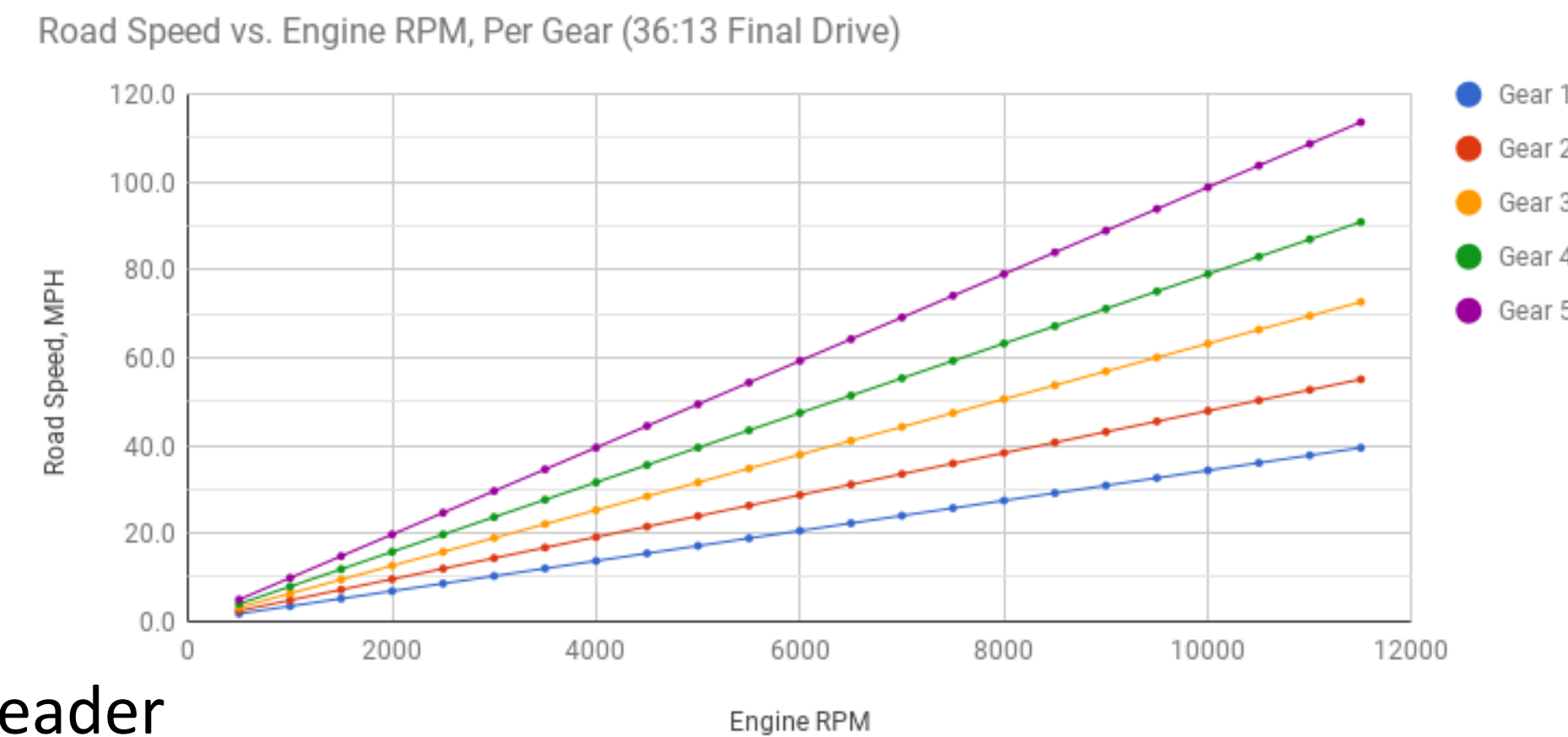


## Engine

### 2015 Yamaha WR450F

- 1 Cylinder, 449 cc
- Durable, Compact, & Lightweight
- Stock Piston and Camshafts
- Integrated 5 Speed Transmission
- YFZ450R Slipper Clutch
  - Smooths Downshifts
  - Reduces Engine Braking When Off Throttle
- FMF Q4 Exhaust Silencer w/ Stock Header



## Drivetrain

### Chain Drive

- 520 Chain Standard – Easy to Find Parts
  - YFZ450R Rear Sprocket
  - WR450F Drive Sprocket
- Drexler Limited Slip Differential & Half-Shafts

		ATV Front Differential		Taylor Formula SAE Differential		Drexler Formula SAE Differential	
Criterion	Weight	Score	Total	Score	Total	Score	Total
Cost	5	9	45	4	20	2	10
Adjustability	8	2	16	5	40	10	80
Weight	7	4	28	8	56	8	56
Simplicity	8	1	8	5	40	8	64
Lead time	3	8	24	6	18	8	24
Total			121		172		234

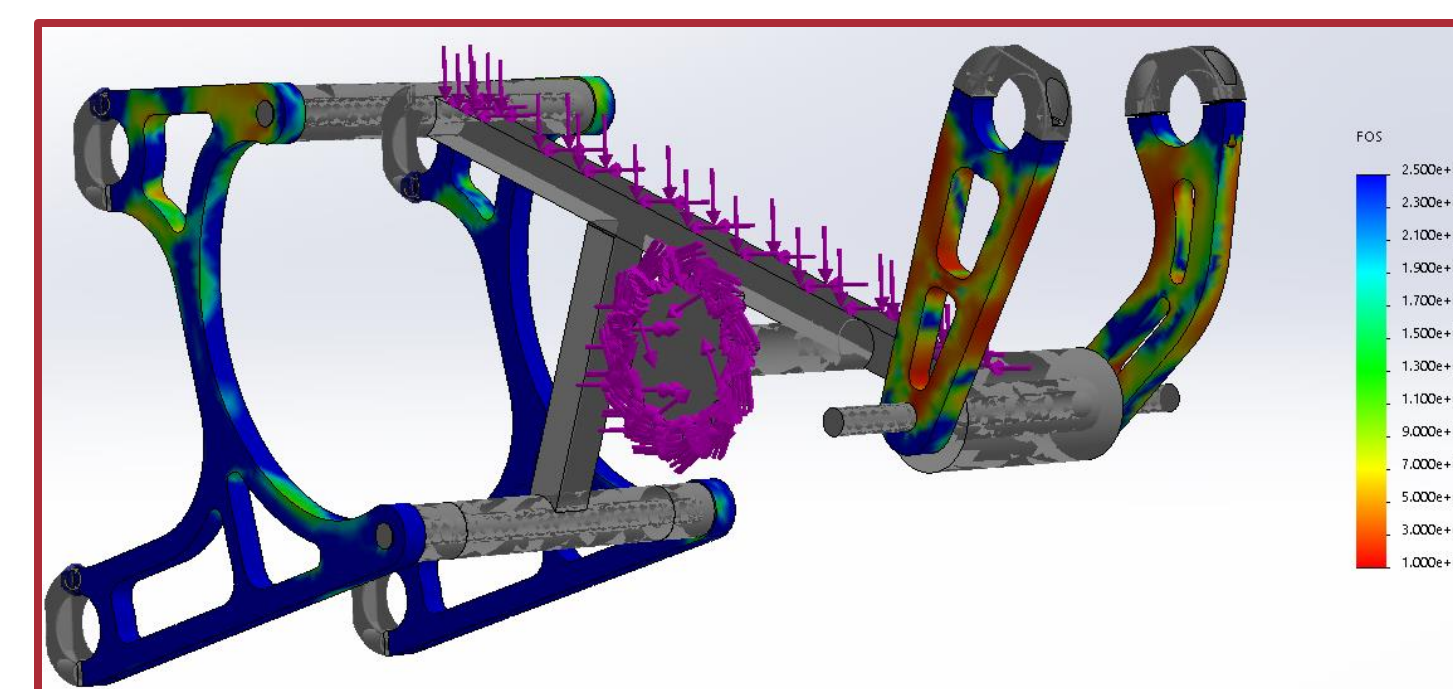
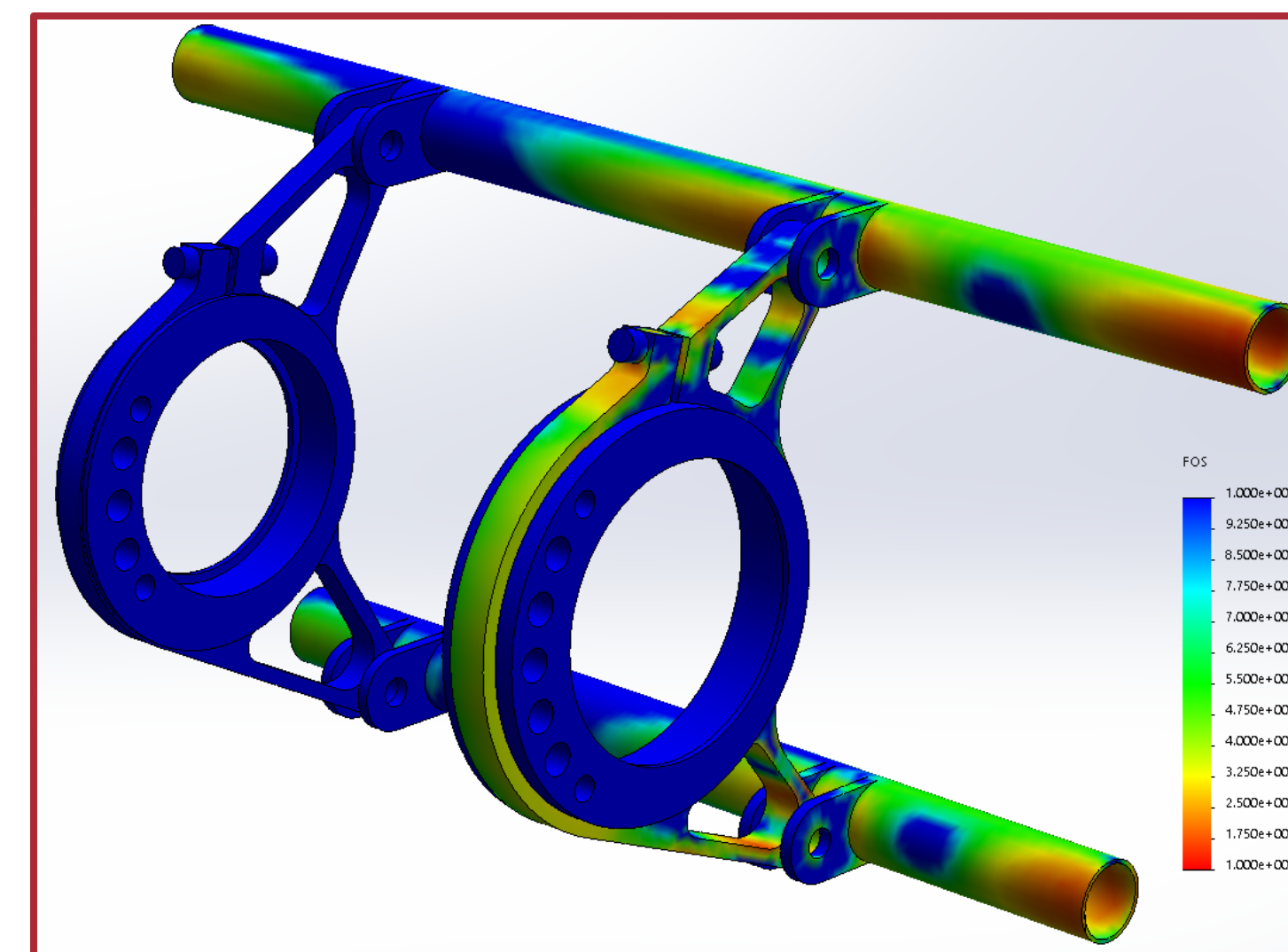
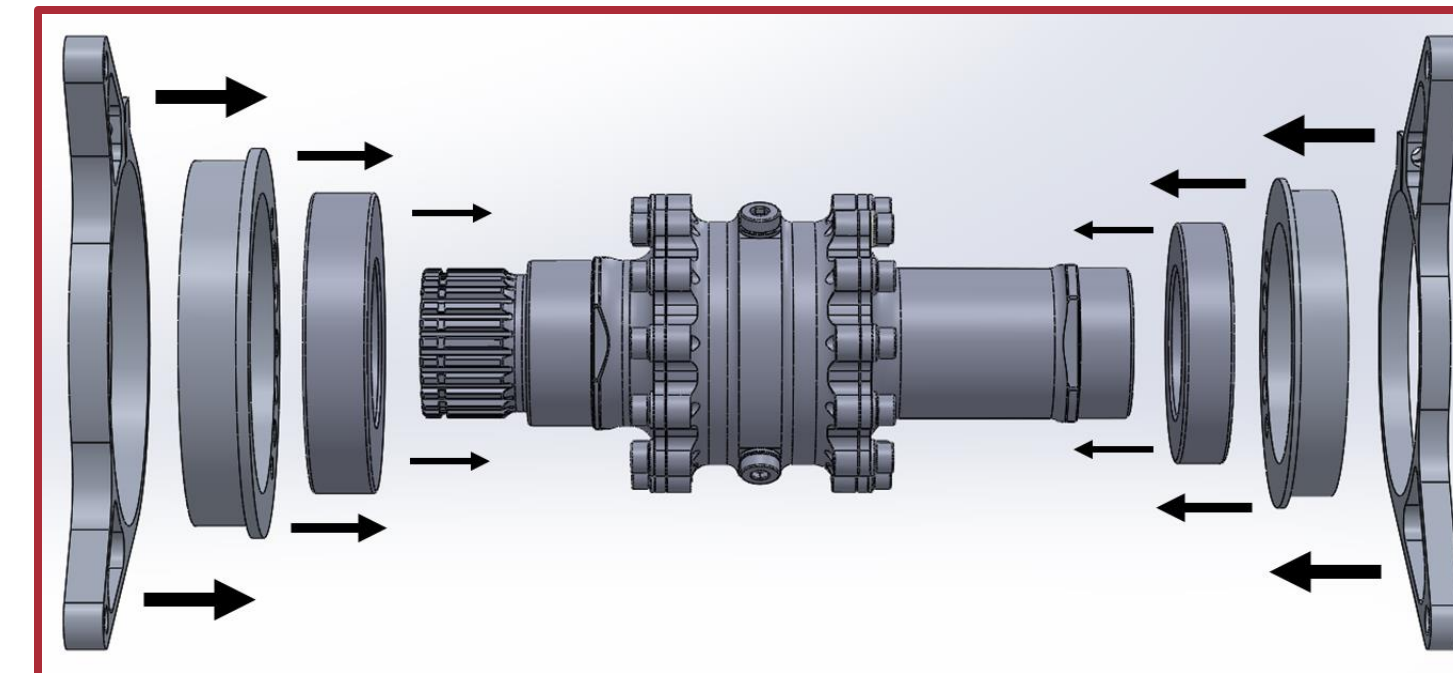
- 36:13 Final Drive – Versatility
  - 65 mph in 3<sup>rd</sup>, 4<sup>th</sup>, or 5<sup>th</sup> Gear
  - Fewer Gear Shifts Required

### Differential Mounts

- Eccentric Cam Chain Tensioning – 1 Link Range
  - Replaces Solid Mounts w/ Idler Pulley
  - Durability Improved, Weight Reduced
- Asymmetric Mounts Save Weight & Space
- Frame Tabs Simplify Install vs. Shaft Collars
- Horizontal Sandwich Assembly – Stable
- FoS  $\approx$  2 for Engine Lockup – SolidWorks FEA

### Engine Mounts

- Simple Manufacturing Process
  - Water Jet 2D Profile, Only Drilling & Threading After
- Position Based on 3D Scan of Engine
- FoS  $\approx$  2 – SolidWorks FEA



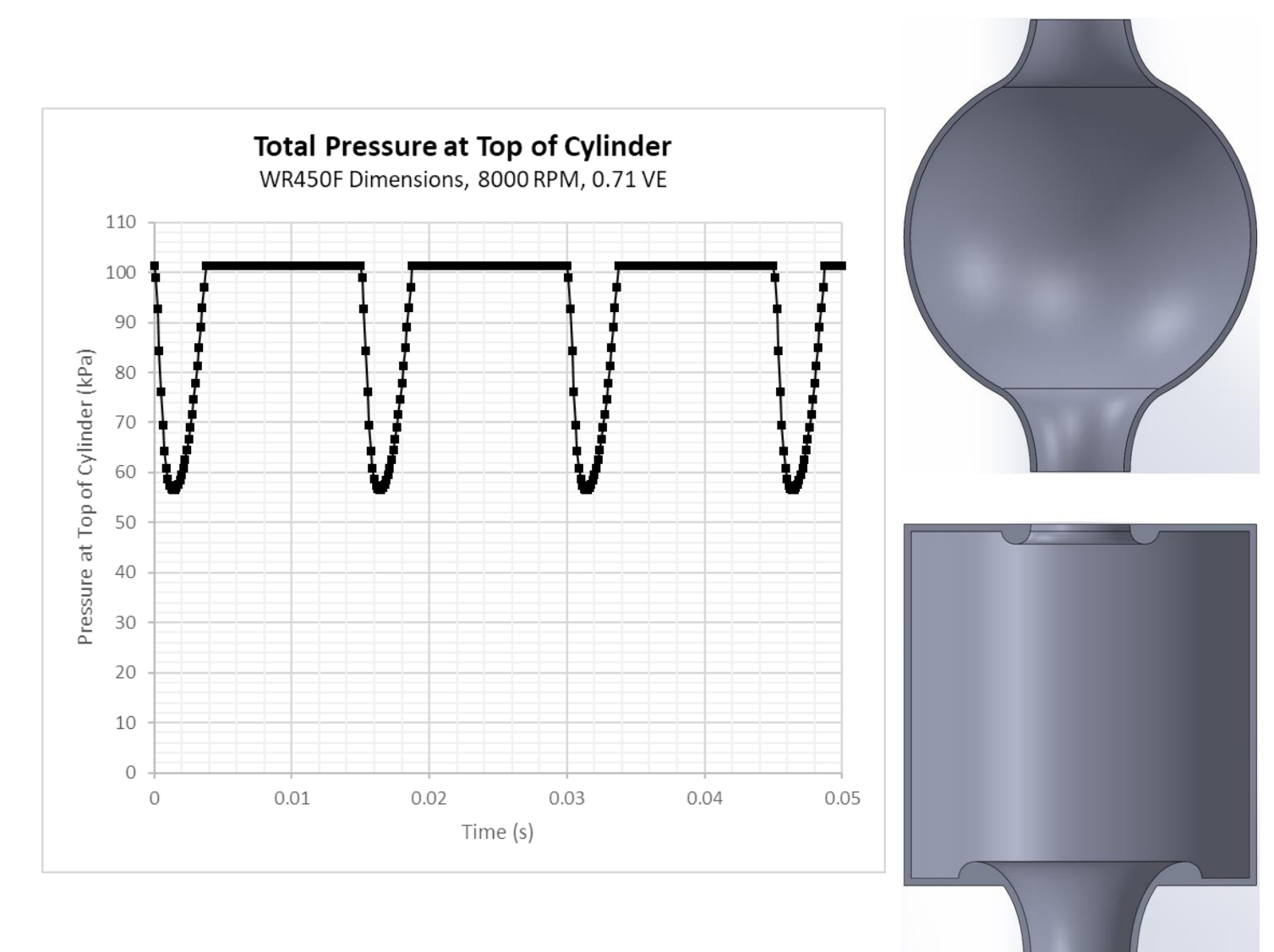
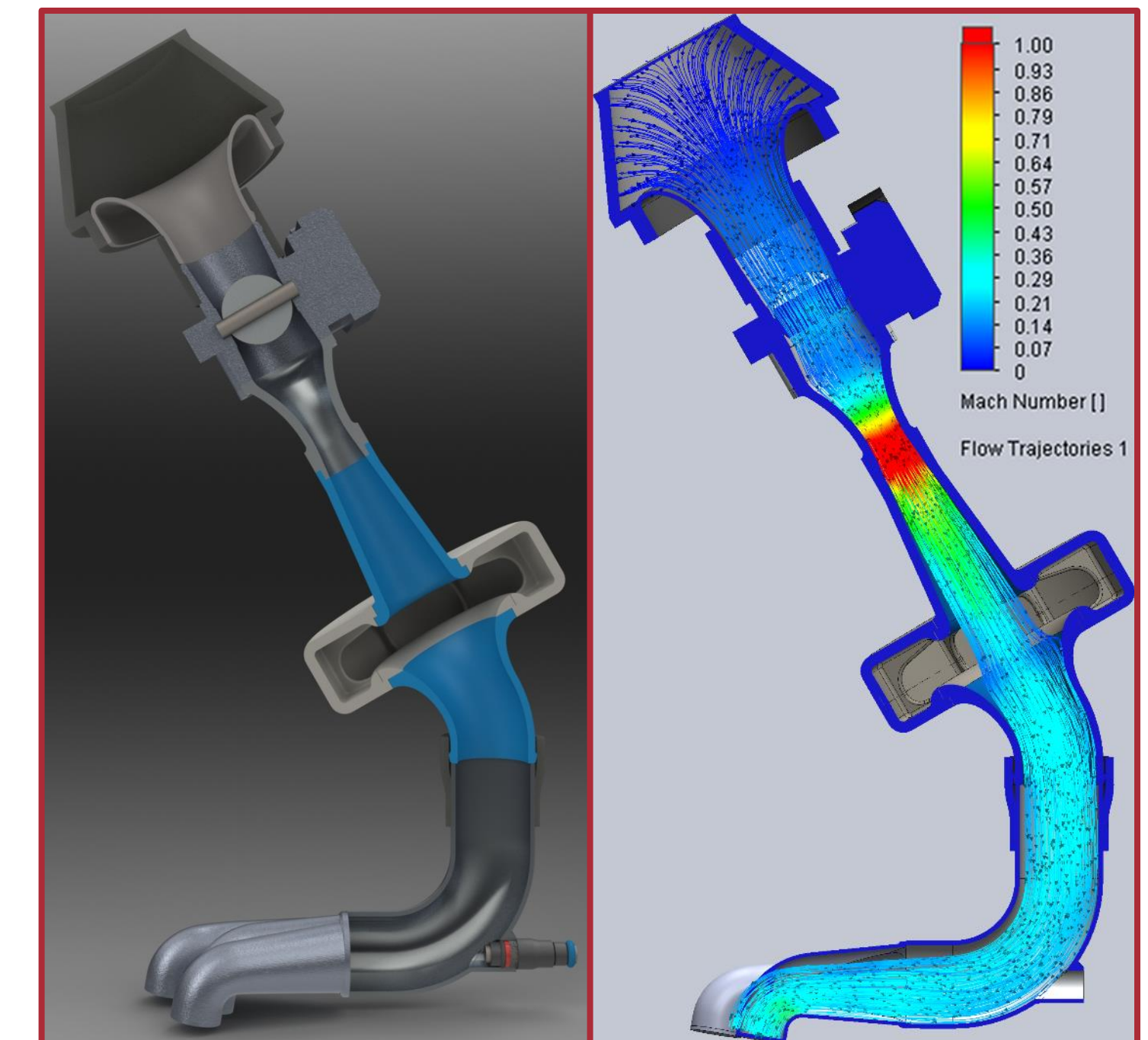
## Air Intake

### Research on Bellmouth & Restrictor Profiles

- Bellmouth – Elliptical Profile
  - 3.5% Higher Discharge Coefficient than simple radius
  - “Best Bell” – G. P. Blair & W. M. Cahoon
- Restrictor – “De-Laval” Profile
  - Radius Inlet 16° Half-Angle, Conical Outlet 4° Half-Angle
  - Smaller Pressure Drop than “Bell” or “Venturi” Profiles
  - “Space Advantage Provided by De-Laval Nozzle and Bell Nozzle over Venturi” – O. N. Deshpande & N. L. Narappanawar

### Developed Simulation Method to Test Designs

- Excel Sheet to Calculate Cylinder Pressure
  - Takes RPM, VE Guess & Cylinder/Valve Specs
  - Thermo. Equations & Cam Profiles – Many Assumptions
  - Outputs Cylinder Pressure vs. Time
- SolidWorks Flow Simulation to Find VE
  - Air Filter as Static Pressure Boundary
  - Intake Valve Plane as Time-Dependent Boundary
  - Outputs Volumetric Flow Rate Data at Intake Valves
  - Numerically Integrate for Volumetric Efficiency
- Calibrate with 2016 Car Info
  - 2016 Intake Plenum Model
  - VE Table from Engine Tuning
  - Calibration Variable in Excel Sheet
- Iteration with Plenum Shape & Volume
  - Cylindrical & Spherical from 1-10x Displacement
  - Cylindrical Better than Spherical, 1x Best and 10x Worst
  - Prototype Used for Initial Tuning, Modified for Final



### Final Design & Materials

- Plenum Volume = Engine Displacement
  - Bellmouth at Air Filter – Smoother Inlet Flow
  - 40mm Throttle – Slower, Less Turbulent Flow at Blade
  - Bellmouth at Runner – Reduce Effect of Resonance
  - Runner Shape/Length Set by Packaging in Frame
- 3D Printed PLA Plenum Body & Bellmouth
  - Light Weight + Simple to Manufacture
  - Epoxy Coating Improves Durability
  - Even 10% Infill is Strong Enough
  - Ribs Added to Improve Stiffness of Plenum
- Aluminum Restrictor & Runner
  - Durable and Dimensionally Stable
  - Simpler Shapes, Harsher Applications

