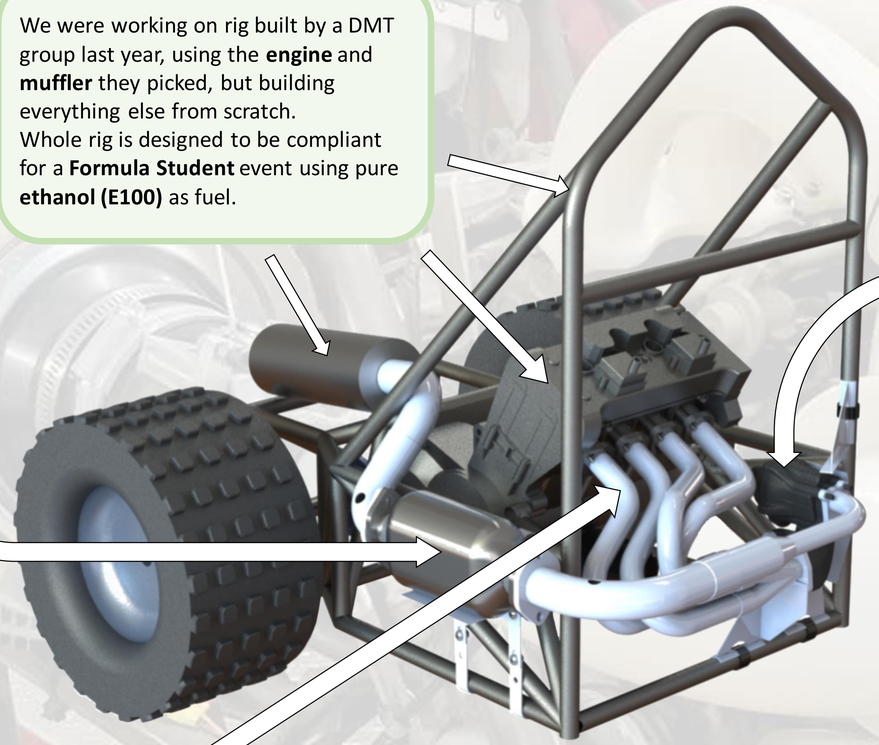
4A – Engine Intake
4B – Exhaust System
4C – Sensors & Control

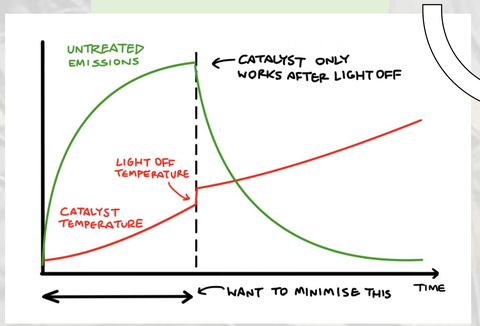
Bio-Fuel Engine: Exhaust System

We were working on rig built by a DMT group last year, using the **engine** and **muffler** they picked, but building everything else from scratch.
Whole rig is designed to be compliant for a **Formula Student** event using pure **ethanol (E100)** as fuel.

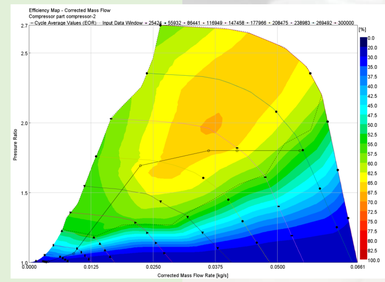


Catalyst

Simple enough to find catalyst valid for ethanol – more common in Brazil
Issue: **Cold Start** – before catalyst has reached certain '**light-off**' temperature after ignition, **untreated emissions still released** to air.
Testing planned to determine feasibility of close-coupling or electrically heating catalyst.

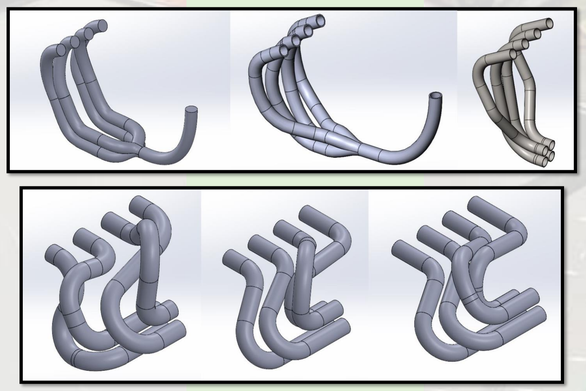


Turbocharger



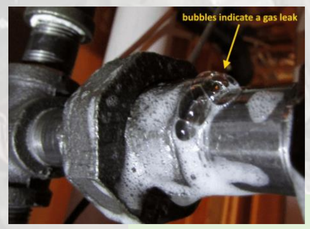
→ A **turbocharger** was included to modify torque and power curves to have the torque available at low engine speeds.
→ **Compressor and turbine maps** for 5 turbochargers were tabulated on GT Power. **Garrett's GT06** minimises turbo lag while providing sufficient boost, with **85 Nm of peak torque**.
→ With an **operating region** between 1500 and 6000 RPM, surge and choke are avoided. A **bypass valve** can allow future teams to run it beyond this speed.
→ **Rate of Pressure Increase** (ROPI) can be an issue for naturally aspirated engines by design where forced induction is applied. GT Power has been used to simulate this, and solutions include **spark timing**, **forged pistons**, lower **compression ratio** with thicker copper gaskets.

Pipes



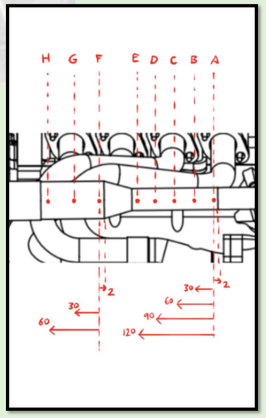
An initial design with piping routing through the bottom of the engine was developed.
However, due to both issues with ground clearance and pressure drops across the pipes, it was decided pipes would be routed through the side of the engine instead.

Testing

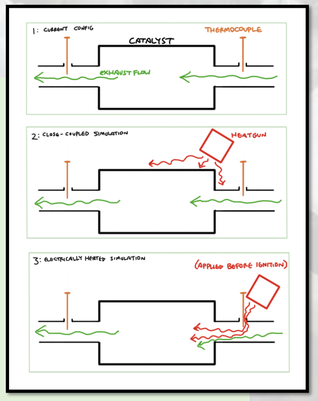


Soapy water gas leak test to assess joint manufacture quality.

Sound meter to assess compliance with Formula Student **rules**.

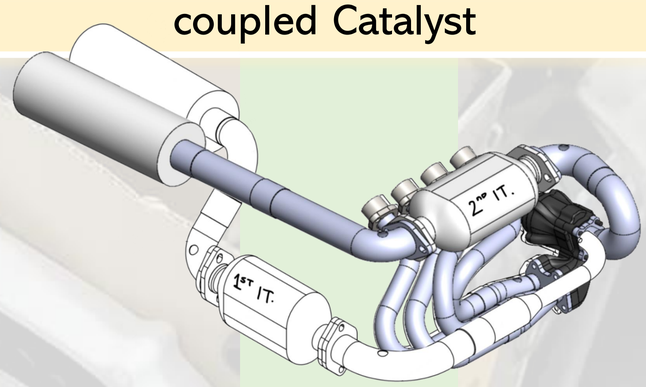


Impulse hammer test to find modal frequencies of least secure component.



Catalyst **thermocouple tests** to investigate **light off time** and reduction strategies.

Second Iteration: Close-coupled Catalyst



Catalyst moved **next to engine** for extra heat to reach light-off more quickly.
Questionable **pipe at front removed**: eliminates resonance concern and leaves **more space for driver seat**.
Less and simpler piping: money possibly saved for electrical heating mechanism.

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