



**Kettering SnowDogs
Clean Diesel Technology**

Kettering UNIVERSITY 2018 Design Approach

1. Versatility

- Ski-Doo Tundra SE 137"
- Diesel cycle, high efficiency and torque

2. Modern, Clean Diesel Technology

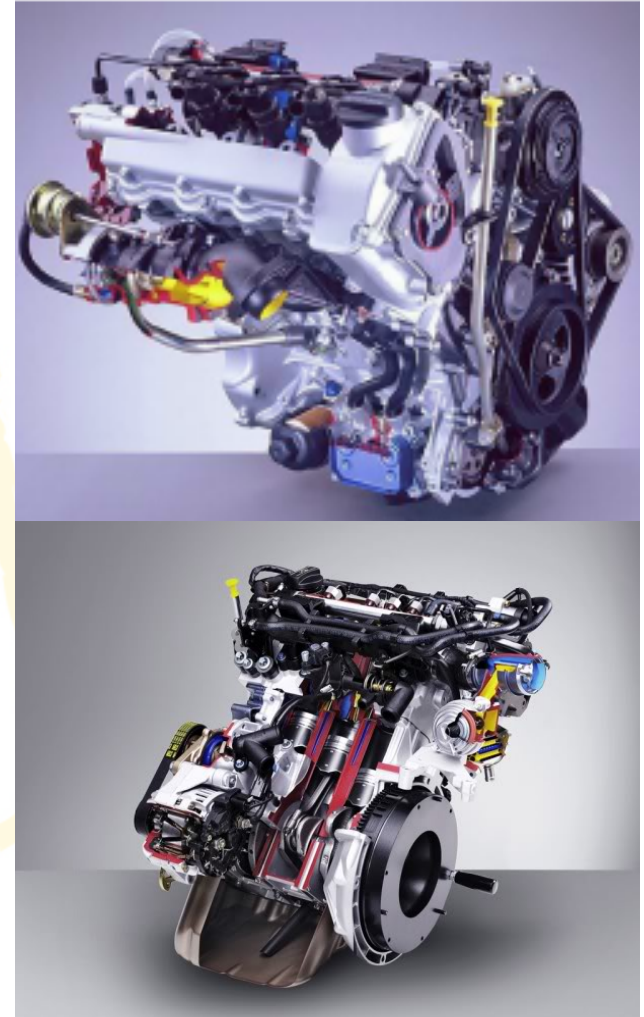
- Common Rail Direct Injection

3. Advanced Controls

- Full Authority Engine Management in Simulink

4. Emissions and Noise Controls

- DOC, DPF, SCR aftertreatment system

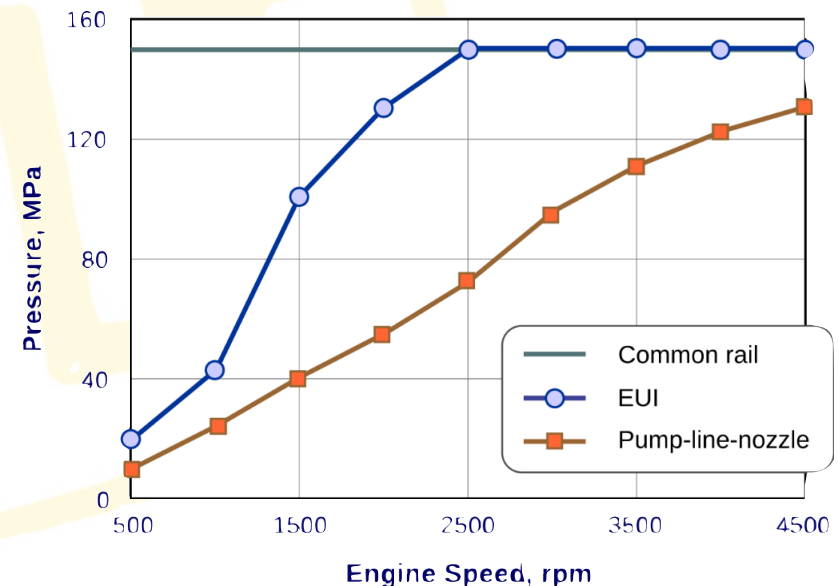
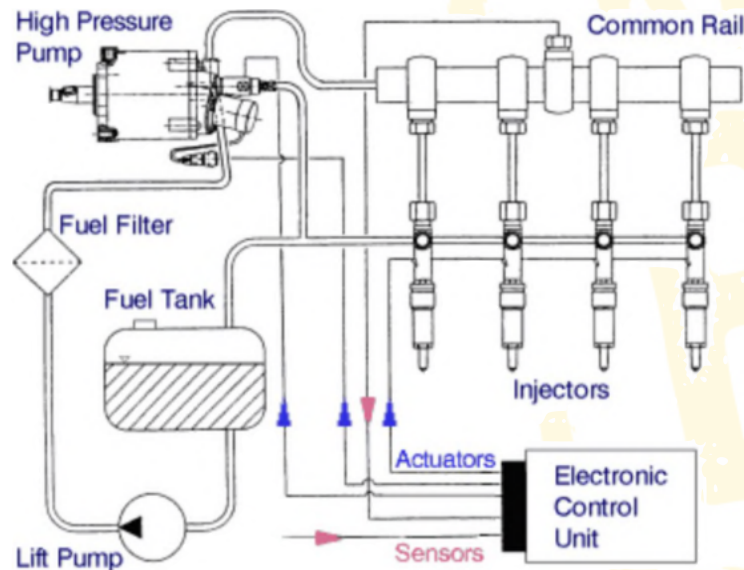


Mercedes-Benz OM660 Engine

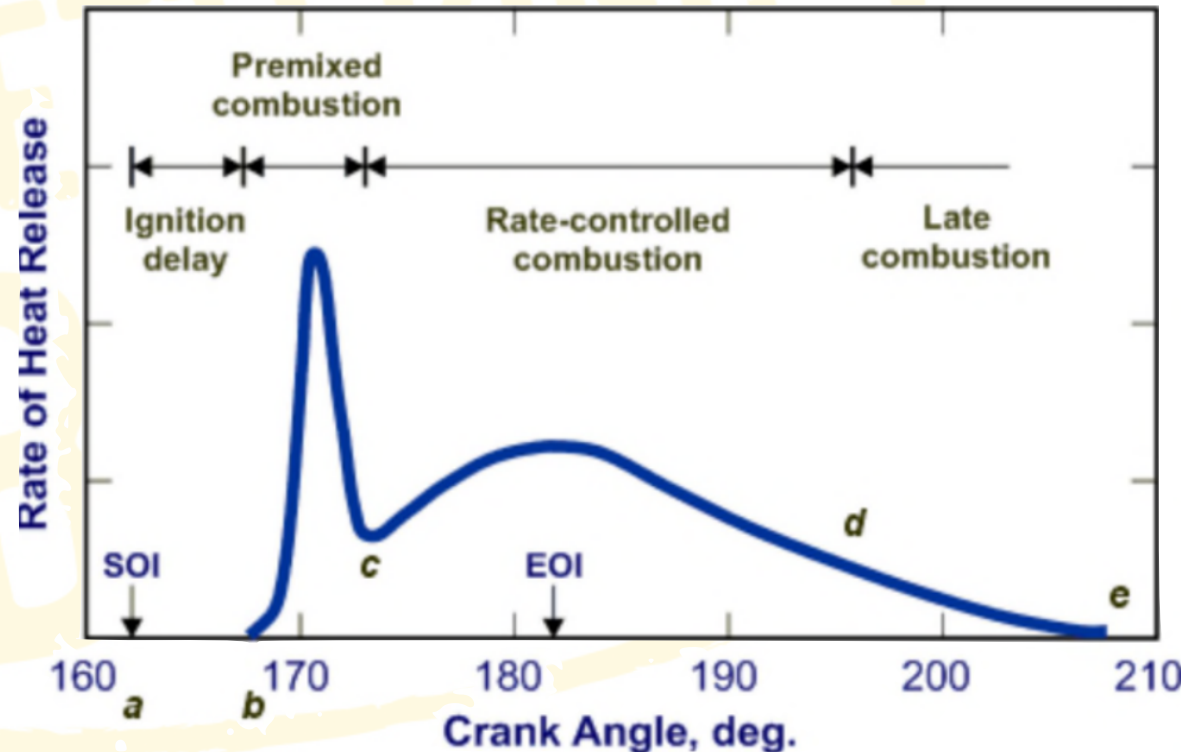
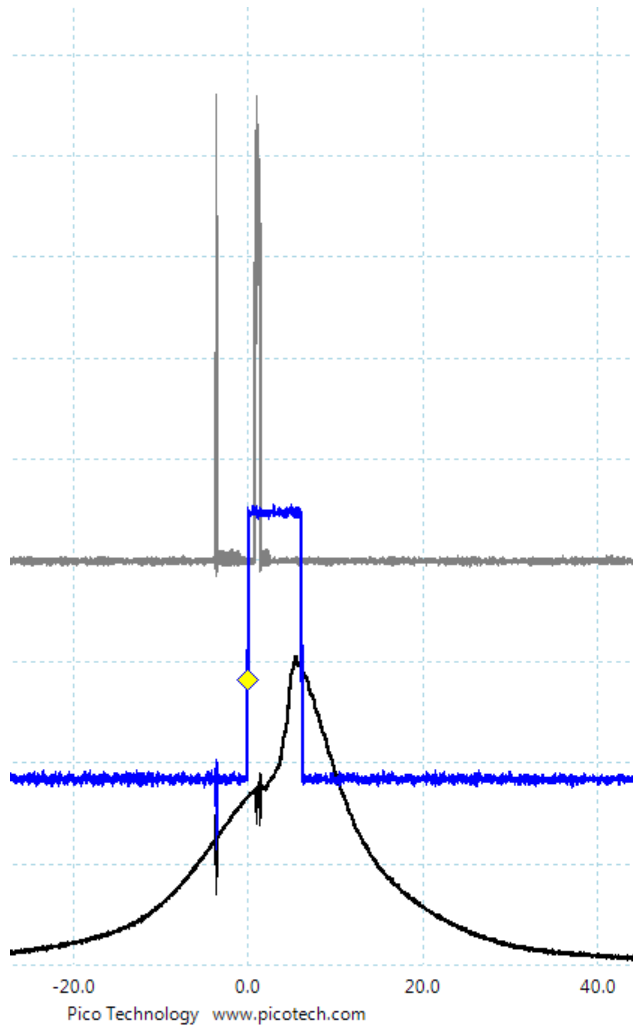
Model	OM660
Displaced volume	799cc
Stroke	79mm
Bore	65.5mm
Compression ratio	18.0:1
Number of cylinders	3 in-line
Dry weight	190lb.
Combustion chamber	Direct injected
Valvetrain	Chain-driven OHV
Rated Power	36kW @4000rpm
Rated Torque	95Nm @2400rpm
Fuel System	Common Rail
Maximum Fuel Pressure	1400 Bar
Fuel System Supplier	Bosch

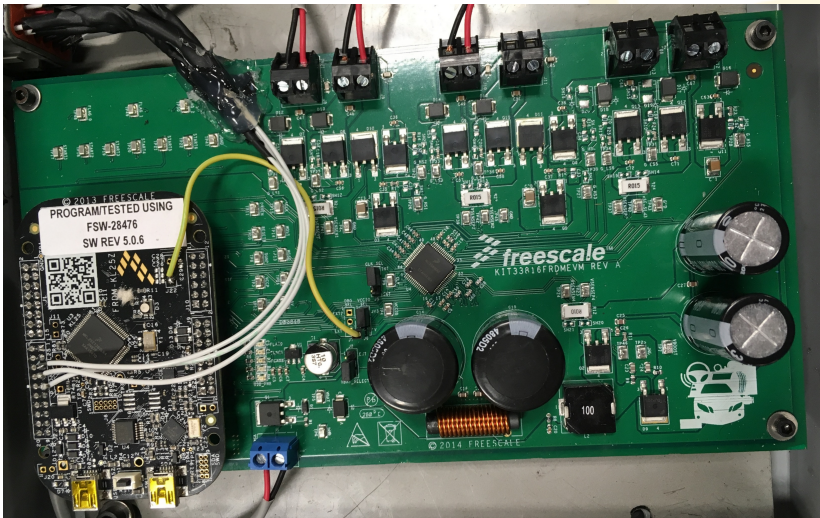
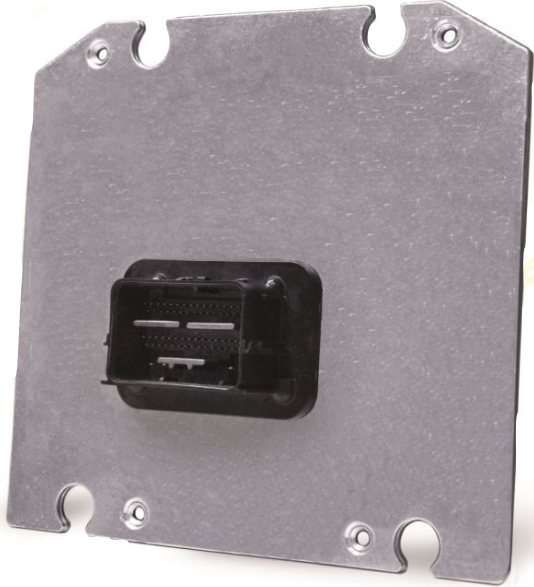


- Injectors may be individually controlled
- Full injection pressure is available at any RPM
- Software control of combustion characteristics

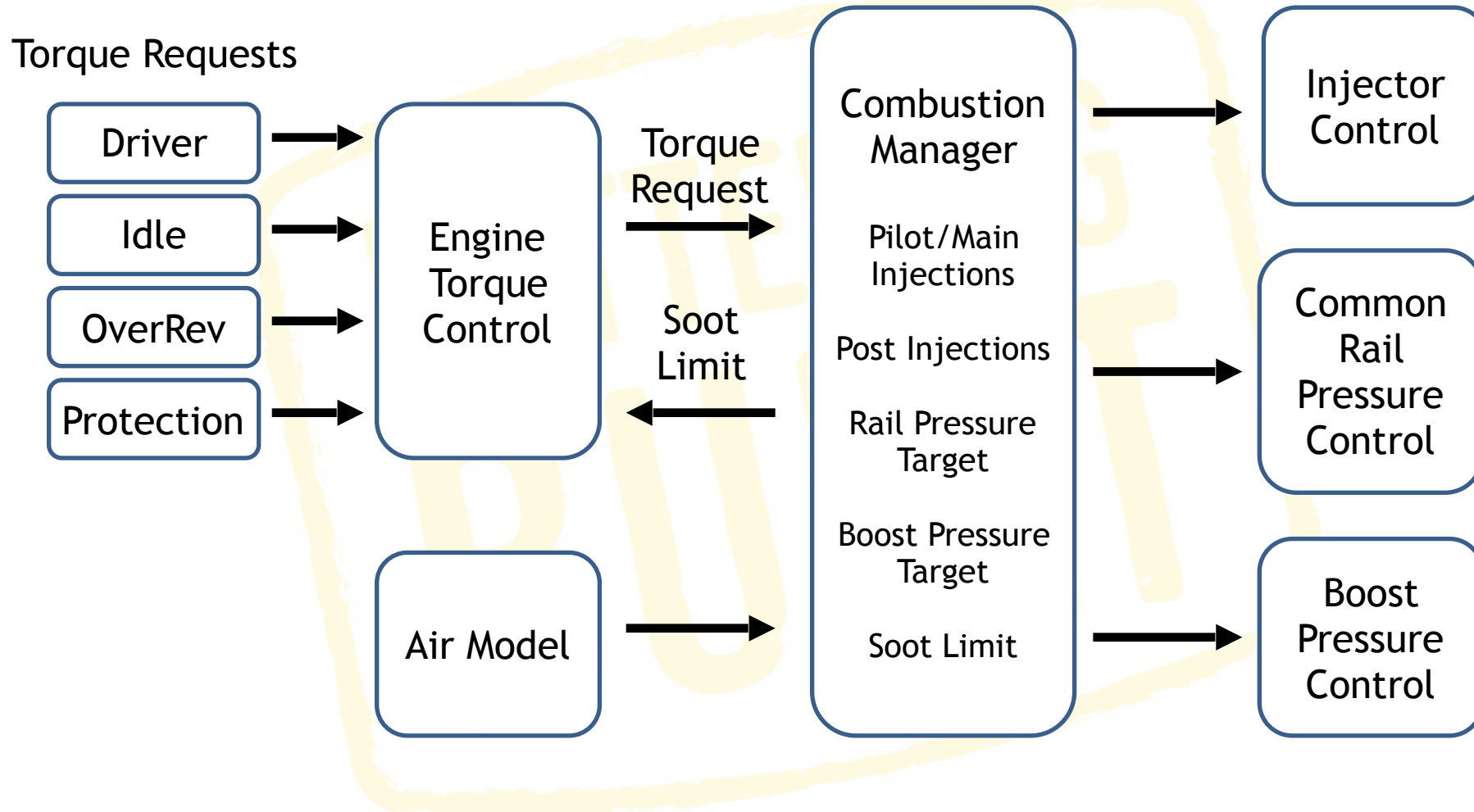


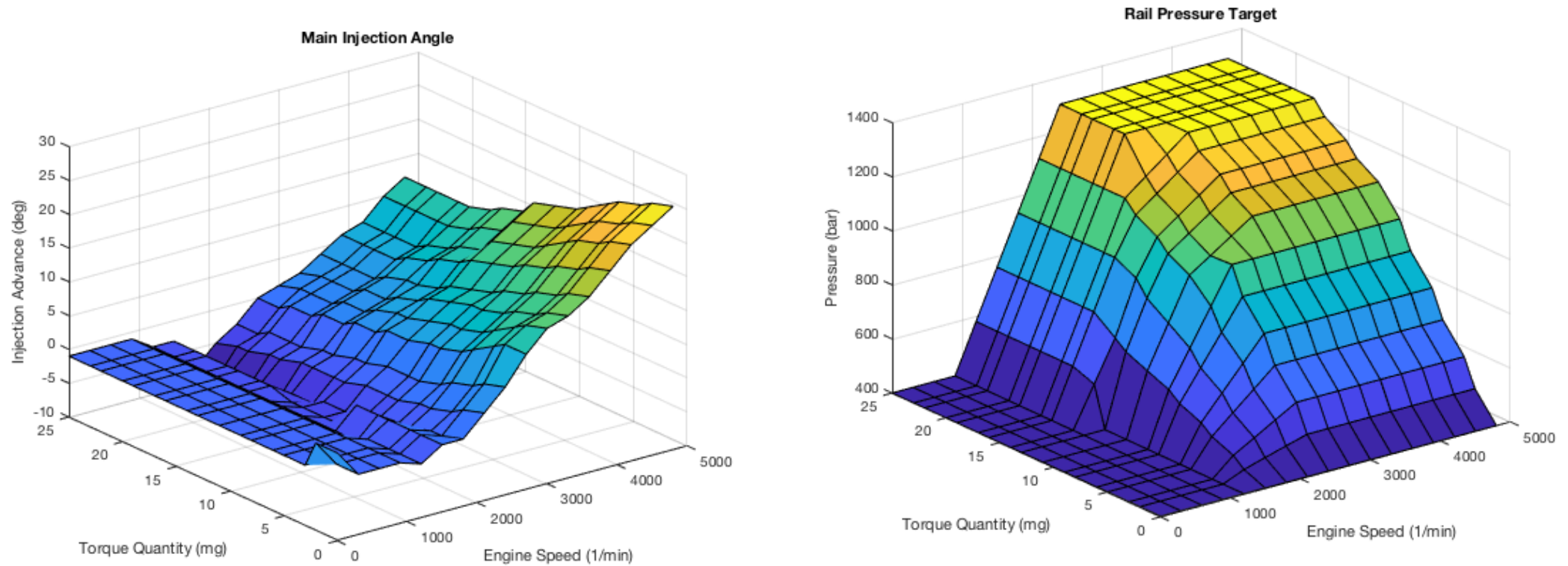
- Reduction of Diesel 'Clatter' through pilot injections
- Improvement in NOx vs Soot tradeoff



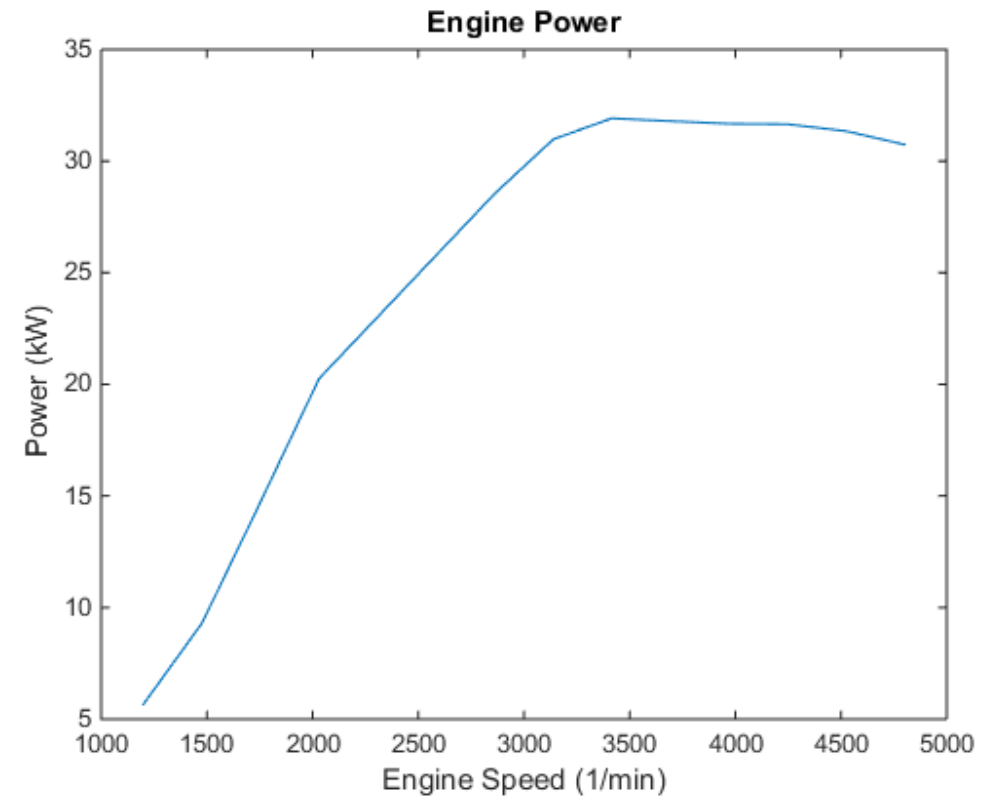
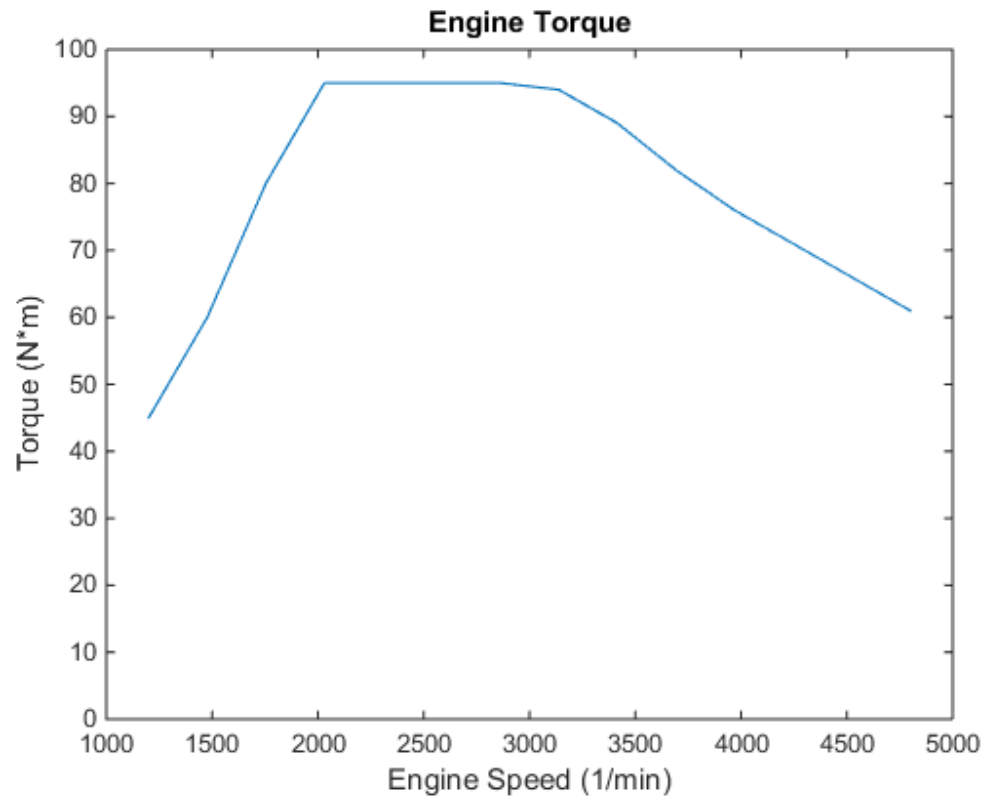


- **Student developed Common Rail control system**
- **Rapid prototype ECU hardware**
- **Custom DI injector driver**
- **Engine control algorithms developed in Simulink**
- **Torque based engine management**
- **Clean and Efficient focus**





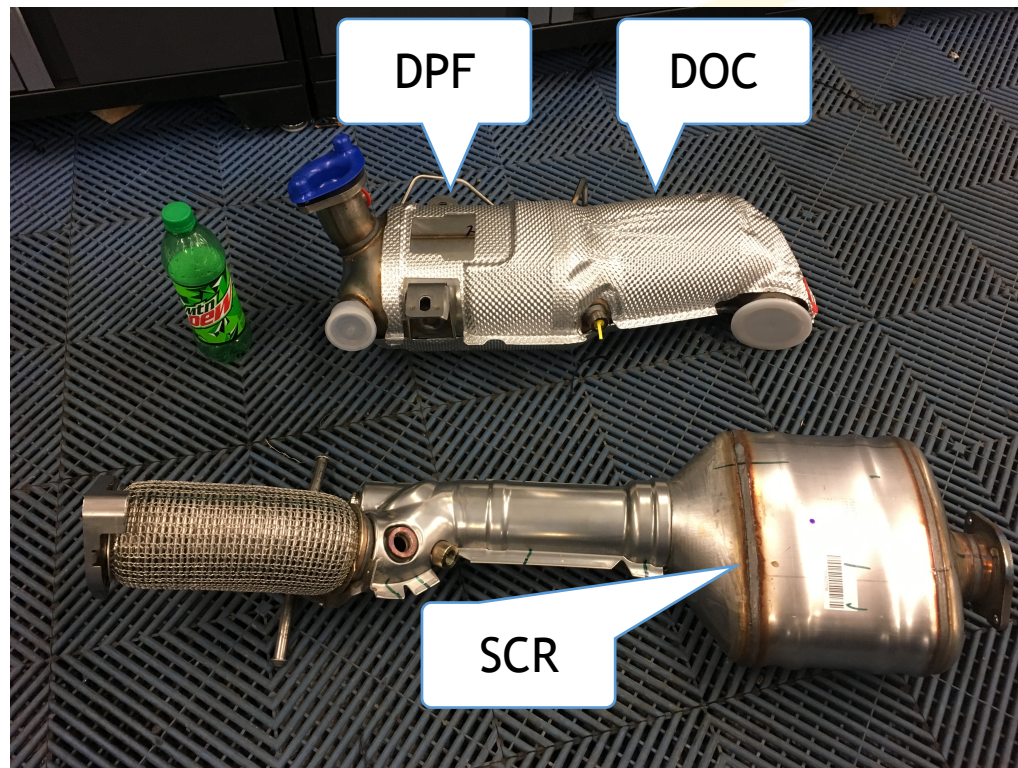
Dynamometer mapped for best BSFC and low soot



Matched OM660 Stock Curves

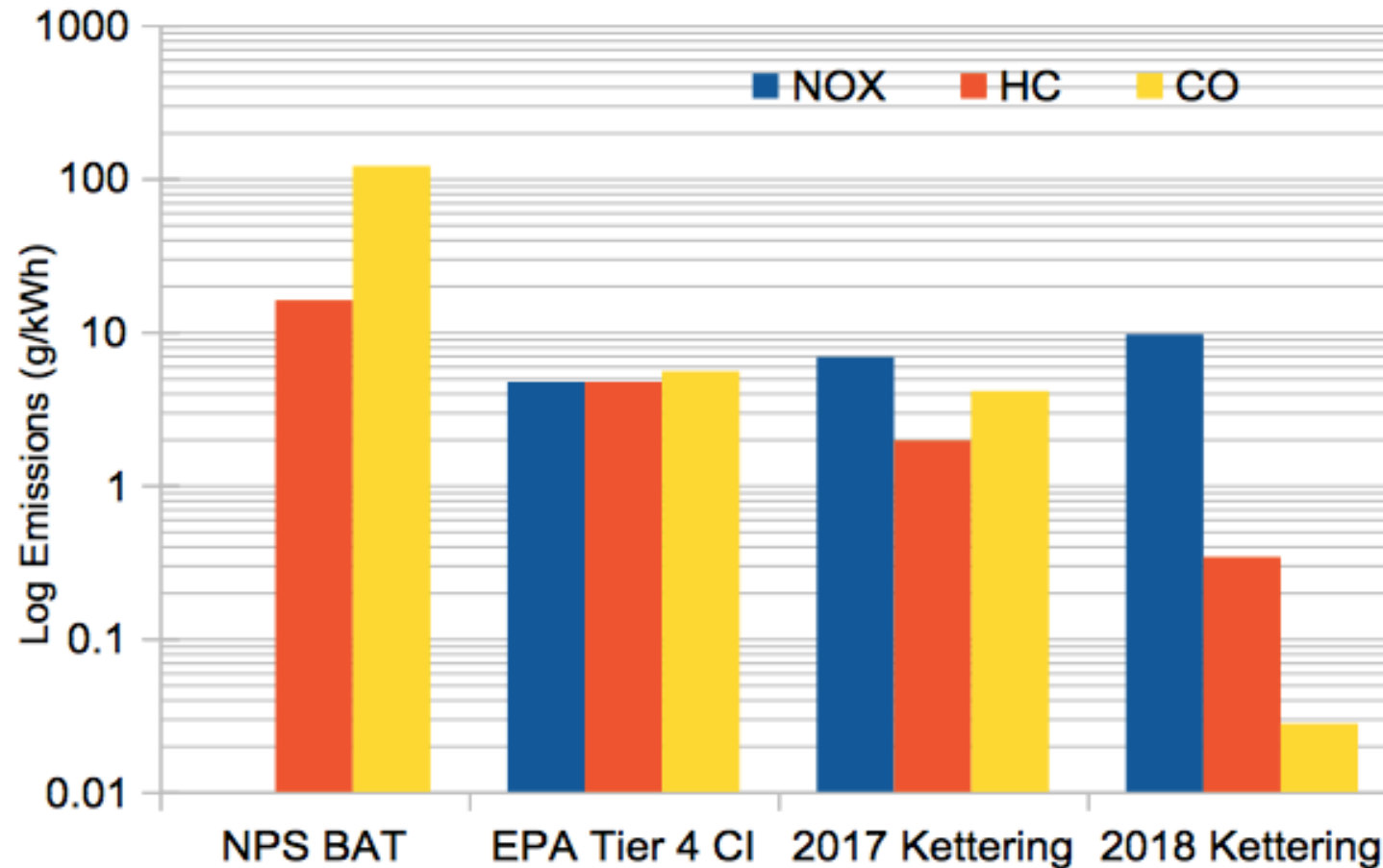
- **Three-pronged approach to emissions**
- **Diesel Oxidation Catalyst (DOC)**
 - **Oxidizes Hydrocarbons (HC) and Carbon Monoxide (CO) with excess oxygen**
- **Diesel Particulate Filter (DPF)**
 - **Traps soot particles until they can be cleanly oxidized**
- **Selective Catalytic Reduction (SCR)**
 - **Reduction reactions convert NO_x but consume reducing agent**
 - **Ammonia is ideal, but difficult to transport (hazardous)**
 - **Aqueous urea used, decomposes into ammonia at high temperature**

Kettering UNIVERSITY Aftertreatment



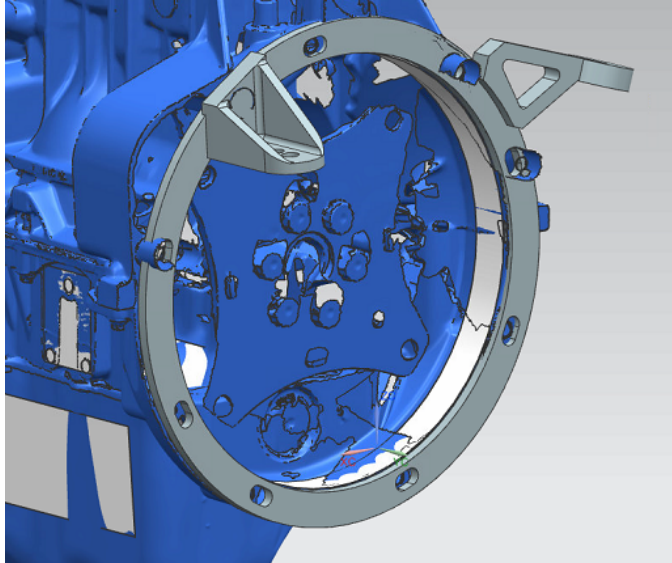
Emissions Results

Emissions Results
EPA 5-Mode Snowmobile Test



DOC Catalyst
>99% CO efficiency
84% HC efficiency

AVL Measured
0.03 g/kWh CO
11.1 g/kWh HC+NOX
0.21 mg/kWh soot



- Engine mounts designed in CAD
- Scanned engine model
- Four mount points
- Vibration isolation used

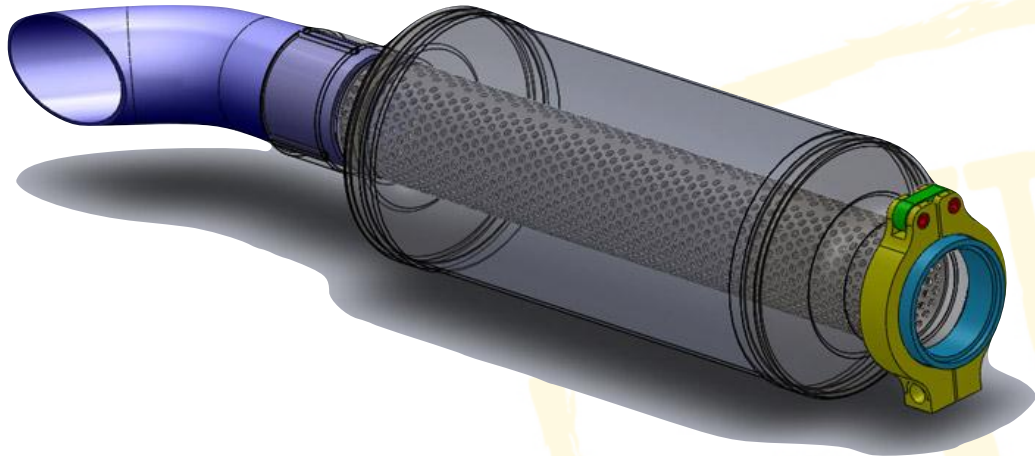


- Rotax E-DRIVE clutch system used
- Clutch mass increased (44%) to lower engagement speeds of primary clutch
- Engagement at 1200rpm

Kettering UNIVERSITY Noise

- **Focus on all sources of noise**
 - Engine intake and exhaust
 - Radiated engine noise
 - CVT/Chaincase/Driveline
 - Track
- **Attenuation strategy**
 - Dynamat Xtreme dampening of all chassis panels and bodywork, tunnel, and CVT cover
 - Dynamat Hoodliner absorptive foam on all bodywork surfaces
 - Short 137" track selected for minimal track noise





- **Exhaust noise attenuation**
 - **DOC, DPF, SCR catalysts act as restrictions on exhaust, reducing noise**
 - **Catalyst bricks insulated for heat and noise attenuation**
 - **Pilot injections**
- **Exhaust silencer**
 - **Flow-through absorptive design**

Kettering UNIVERSITY Questions?

