



**Kettering SnowDogs
Spark Ignited**

Kettering UNIVERSITY 2018 Design Approach

1. Versatility

- Ski-Doo MXZ Sport 600 ACE

2. Advanced Controls

- Full Authority Engine Management with Electronic Throttle

3. Emissions and Noise Controls

- Three-way catalytic muffler
- Switching O2 control

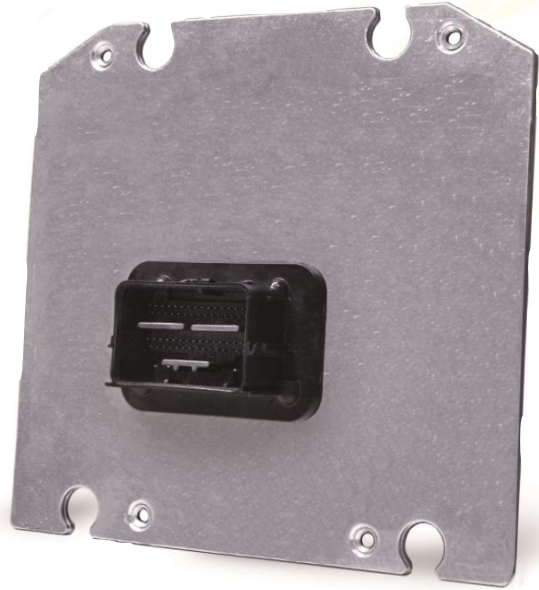
4. Simple, Reliable design



Rotax 600 ACE engine

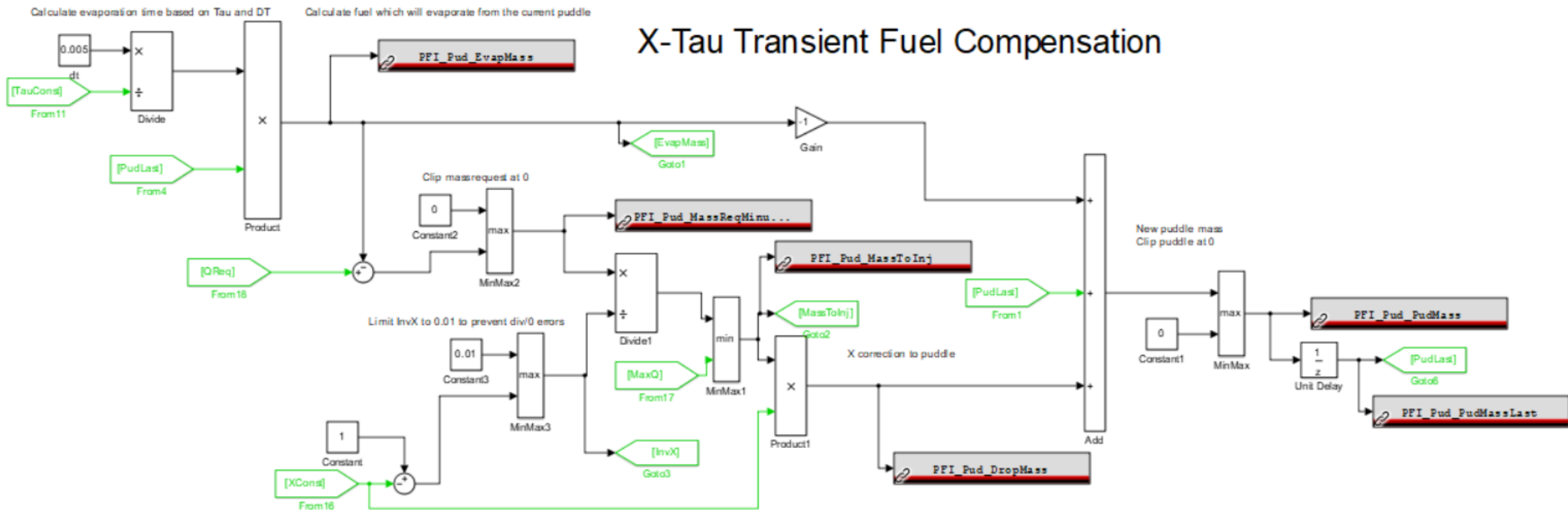
Model	600 ACE
Displaced volume	599cc
Compression ratio	12:1
Number of cylinders	2 in-line
Combustion chamber	Four-valve pent roof
Valvetrain	Chain-driven DOHC
Rated Power	42kW @ 7200rpm
Rated Torque	55Nm @ 6000rpm
Fuel System	Returnless Port Fuel Injection
Throttle Control System	Electronic
Engine Control Unit	Woodward MotoTron SECM70
Control Model	Student-Developed
Catalyst	1/0/1 600cpi 33 g/cu-ft loading

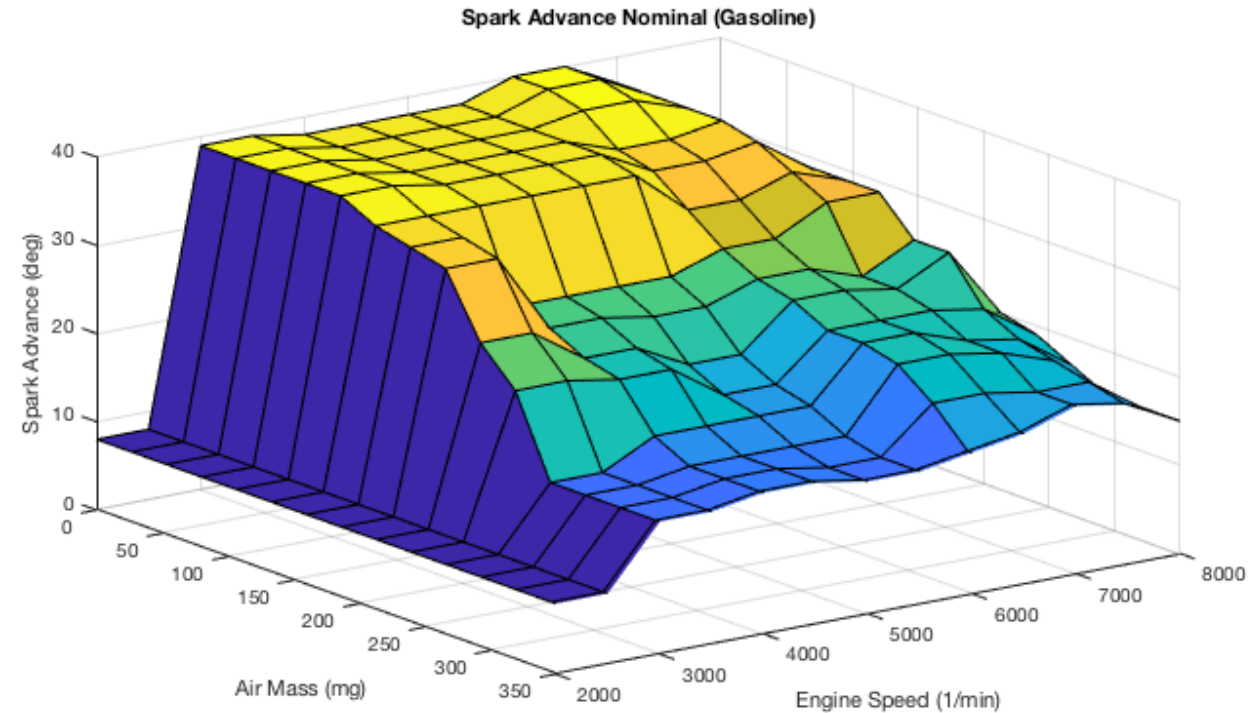
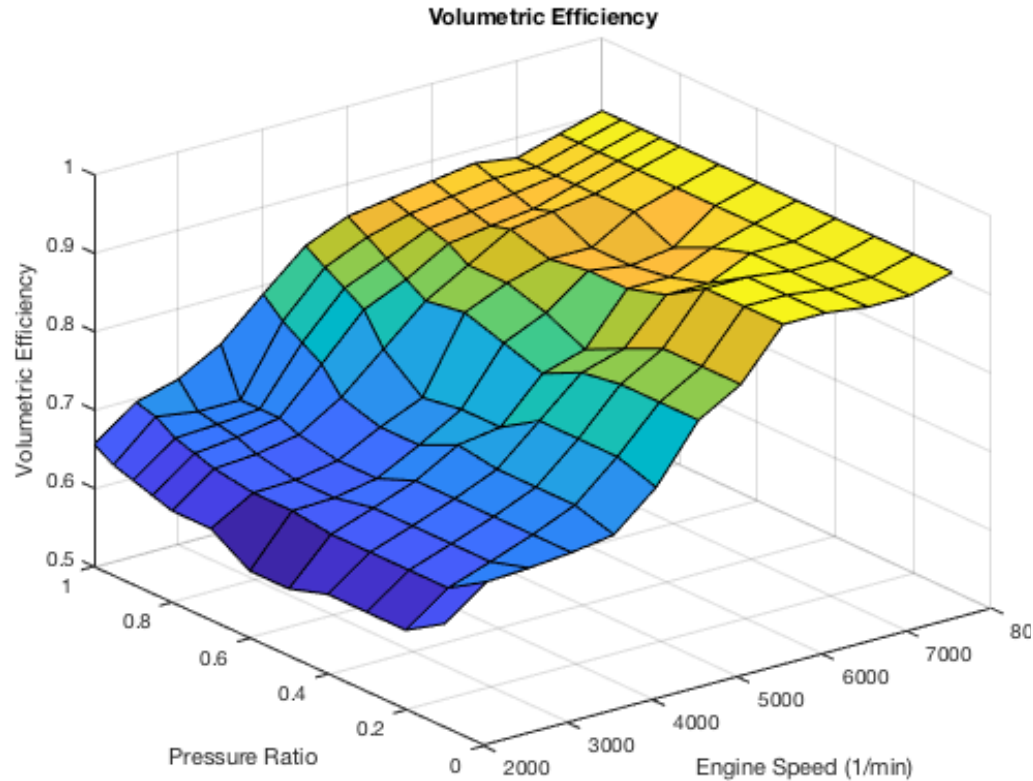




- **Student developed**
- **Rapid prototype ECU hardware**
- **Engine control algorithms developed in Simulink**
- **Full authority including throttle control**
- **Flexible fuel equipped**
- **Decel Fuel Cut**
- **Clean and Efficient focus**

- **Engine control algorithms are air mass based**
- **Air mass modeled from MAP**
- **Fuel mass calculated from air mass and fuel-air ratio target**

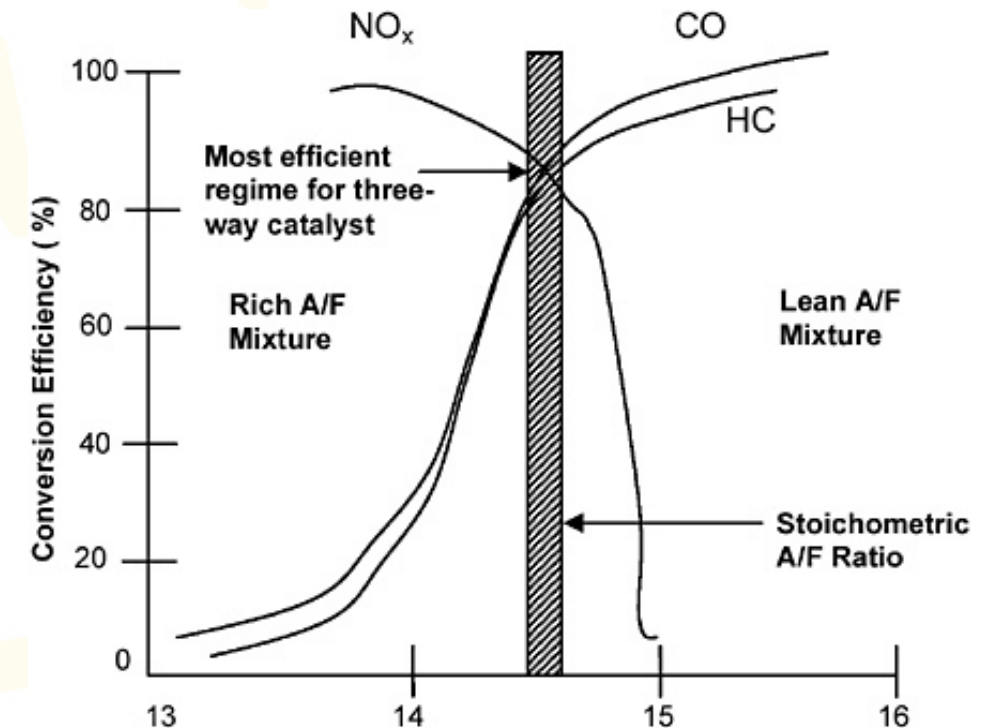




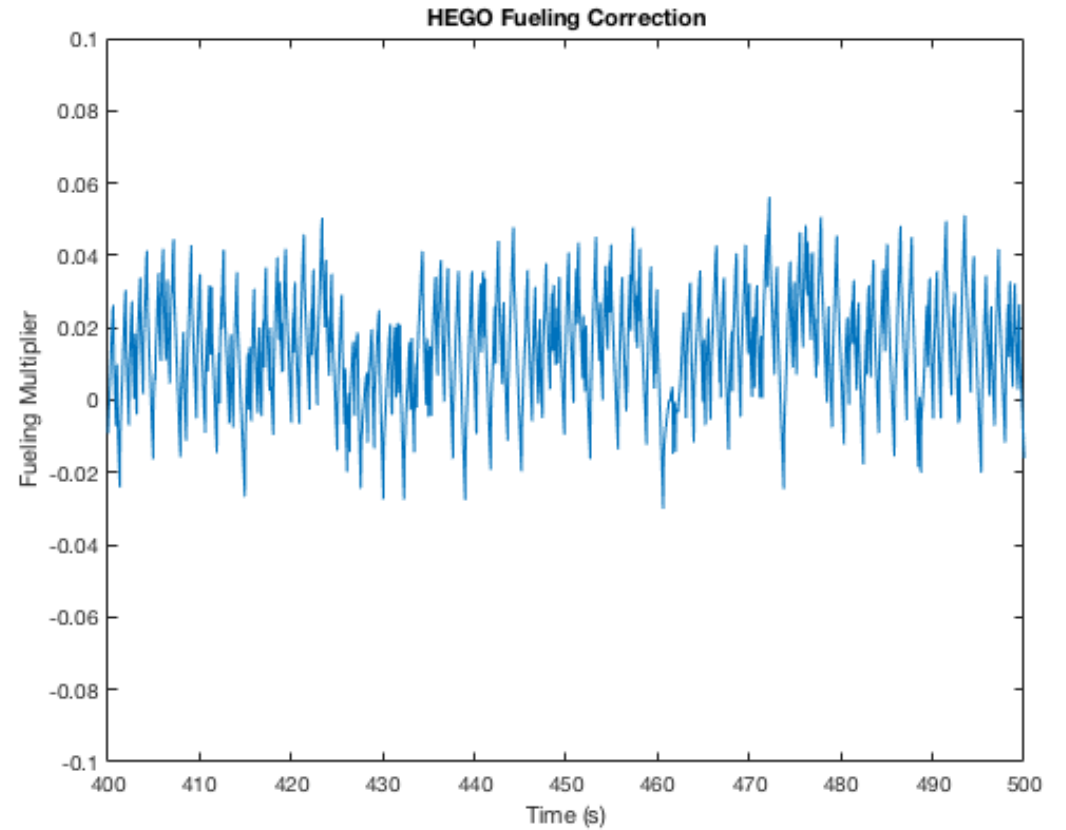
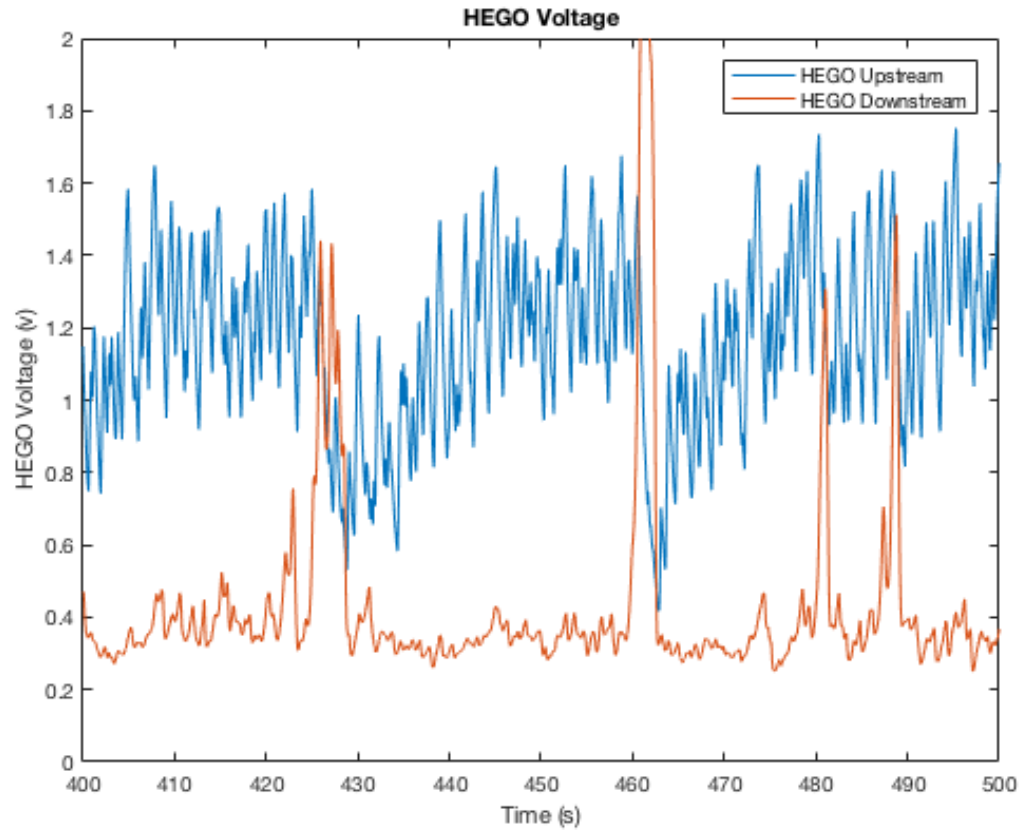
Dynamometer mapped for best BSFC - 260g/kWh best

Kettering UNIVERSITY Aftertreatment

- **Three-Way Catalyst**
 - Oxidizes HC and CO
 - Reduces NO_x
 - High conversion efficiency when oxygen is controlled
- **Switching oxygen sensor control**
 - 'Upstream' control of engine-out oxygen
 - 'Downstream' control of catalyst-out oxygen to moderate oxygen storage on brick
- **Engine must enrich at high load for catalyst protection**



Kettering UNIVERSITY Aftertreatment



EPA 5 mode E-Score: 189

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 120" track selected for minimal track noise





- **Exhaust silencer**
 - **Two-chamber muffler design**
 - **Low frequency resonator**
 - **High frequency fiberglass muffler**
- **Passive acoustic valve**
 - **Resistive tuning for low frequency attenuation at low mass flow**
 - **Valve opens at high load to reduce engine performance penalty**
- **Catalyst integrated into muffler**

Kettering UNIVERSITY Questions?

