ACARP
Wall-Flow DPF Project

Overview for 21st ETH Conference

June 2017
## Project Milestones – Completed C25073

<table>
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<tr>
<th>Phase 1</th>
<th>Project Activity</th>
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<tr>
<td>Part 1 - Onsite Duty Cycle Analysis and development of custom test cycles</td>
<td>✔️</td>
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<tr>
<td>Part 2 - Engine Setup/Baseline and Correlation to Real World</td>
<td>✔️</td>
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<tr>
<td>Part 3a - Hot System DOC+Filter</td>
<td>✔️</td>
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<table>
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<th>Phase 2</th>
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<tr>
<td>Part 3b - Preliminary (Aboveground) Site Trial (hot system)</td>
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<tr>
<td>Part 4 - P1 Design Engineering - Cold exo-surface DOC/Filter System</td>
<td>✔️</td>
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<tr>
<td>Part 5 - P1 Cold System PoC/Development</td>
<td>✔️</td>
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P1 is first level prototype; where proof-of-concept is demonstrated.
Australian Coal Industry Challenges

Underground coal mining has largely electrified many operations, but diesel engines are still used for multipurpose load-haul-dump (LHD) vehicles and man transporters.

Diesel engines operating in underground coal mining need to comply with additional flame and explosion protection measures due to the presence of elevated ambient methane and highly combustible coal dust.

The health of underground workers is at risk without appropriate exhaust emission controls for particulates and gaseous pollutants.

Compounding this situation, the low operational duty cycle of the diesel LHD engine results in a very low average EGT which works against the performance of conventional DPF solutions.
What is ACARP?

A$0.05 per tonne collected from all black coal produced in Australia

Access to R&D taxation rebates and generated research

Nominal ACR budget ~$18m/year; 100% industry funded

Fundamental research projects

Applied research projects

Commissioned projects

ACARP – Australian Coal Industry’s Research Program;
formerly Australian Coal Association Research Program
ACARP project C25073 was proposed by industry stakeholders seeking an exhaust aftertreatment solution that:

• Enhances worker health through improved underground air quality; and

• Reduces operational costs associated with currently implemented diesel particulate emissions systems.

2017 will see the industrialisation of the system for commercial trials.
Given explosion risks for product innovation in a working coal mine an alternate approach to development was adopted.

Characterisation of LHD operations in a working mine were used to develop a series of real world engine cycles for use during development.

Development was then undertaken off-line using a state-of-the-art engine test facility, with hardware transferred to the mine for confirmation testing of results.
Orbital’s Heavy Duty Engine Facility

- Exhaust Extraction
- Exhaust Flow by Horiba PTFM
- Data acquisition (temp and press)
- Gravimetric PM, Partial Dilution 4x Samples
- AC Dyno for Transients
- Water Brake Dyno for Steady State
- Precision Torque Flange
- Floating testing bed for vibration dampening
- Fire Suppression System
- Intake Air, with optional LFE
- Data acquisition (custom and high-speed)
- Onosokki Fuel Flow Meter
- Fuel Conditioning
- LNG Flow Meter
- Horiba gaseous emissions (next room)
- Intake intercooling (also underfloor)
- Underfloor coolant control
Developed Test Cycles

▲ Comparison of Regulatory and Fleet Based profile of LHD engine operation (Steady State engine testing points)

High resolution time based data was acquisitioned from a working machine, aligned with long-term fleet average data from a number of similar model machines and converted to both steady state and transient development cycles.

▼ Transient cycle representing a variety of LHD operations in underground coal mining composited into a single cycle
The coal industry has to date mostly used wet exhaust scrubbers and disposable filters to address tailpipe emission and temperature requirements.

The revised system uses a specially packaged wall-flow diesel particulate filter (DPF) with a platinum based pre-catalyst.

▲ Typical Load-Haul-Dump (LHD) vehicle used in underground coal operations

▲ Conventional wet scrubber and disposable filter system

▲ Proposed layout of the wall-flow filter system meeting underground coal regulations
The rapid development project delivered PM reductions in excess of 95% over both regulator and real world cycles with the selected DPF. Operation over continually repeated real world cycles showed that exhaust back pressure was stabilised confirming satisfactory regeneration was possible despite low exhaust gas temperatures.

▲ Comparison of Total PM results over different test cycles regulated and custom (steady state and transient)

▲ Comparison of DPF differential pressure and stabilisation over the industry developed transient test (10.5” system is lower/better)
Despite exhaust gas temperatures in excess of 600°C, external surface temperatures were measured to be controlled to less than 150°C through the use of an insulated DPF.

The industrialised system will use a combination of an insulated DPF and water-cooling.
## Next Project Milestones – C26070

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<th>Phase 1</th>
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<tr>
<td>Part 6a</td>
<td>Industrialisation Design - DPF, pipework and basic monitoring</td>
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<tr>
<td>Part 6b</td>
<td>On-Engine Validation and Durability Testing of P2* system</td>
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<tr>
<td>Part 6c</td>
<td>Field Trial of P2* system incl. Support and Monitoring System Software Refinement</td>
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<th>Phase 2</th>
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<tr>
<td>Part 7a</td>
<td>Emissions Certification Testing</td>
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<tr>
<td>Part 7b</td>
<td>Safety Certification Testing</td>
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System level P2 is second level prototype; which will have the form, function and performance of a production intent design but will not be made off production tooling/fixtures.
Contact Details

Website: www.orbitalcorp.com.au

Nick Coplin
ncoplin@orbitalcorp.com.au
+61-8-9441-2379
▲ CAD – Design Engineering
▲ CFD / FEA / Analysis
▲ Embedded Electronics
▲ Failure Analysis & Metrology
▲ Vehicle Fitout & Modification
▲ Prototyping and Supply
▲ Engine Test – 3hp to 800hp
▲ Alternative Fuels – NG, Bio
▲ Fuel System Testing