Transport for Greater Manchester

Clean Air for Schools Programme

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TfGM Yellow School Bus Fleet

- TfGM has a fleet of 93 Yellow School Buses.
- 52 Optare Versa hybrid buses.
- 41 conventional diesel Iveco Scolabuses, purchased between 2003 and 2009, which were Euro III/IV emission standards and the subject of this project.
- These vehicles operate on dedicated school services across Greater Manchester.

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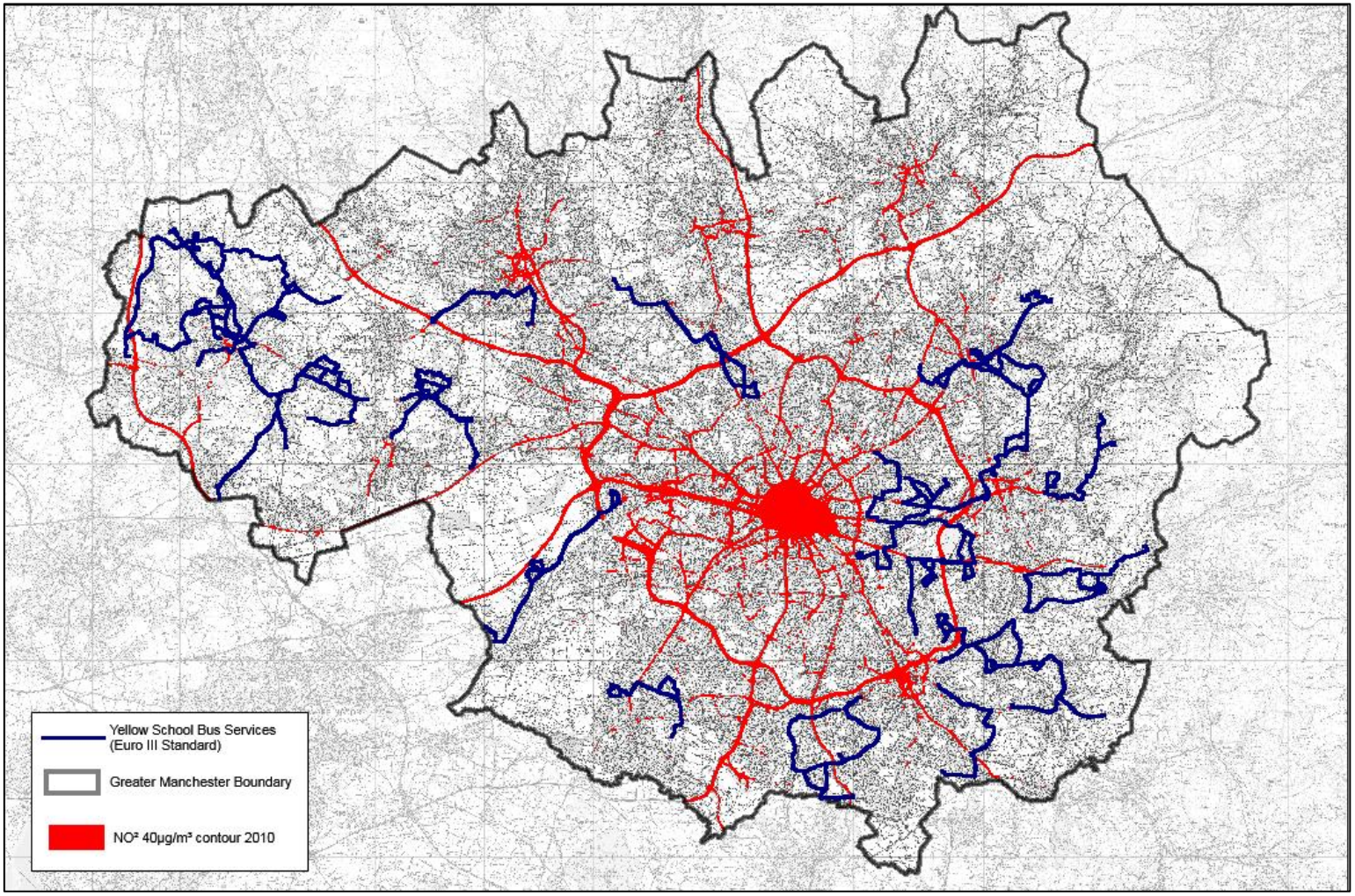
School Bus Operating Area



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Project Objectives

- To improve local air quality in the vicinity of the school services and the communities that the buses serve.
- To reduce tailpipe emissions of nitrogen oxides (NOx) and other harmful by-products with air pollution control equipment to upgrade them to Euro V emissions standards or better for all legislated pollutants (CO/HC/PM/NOx).
- TfGM continue to set example to local operators, with regard to air quality responsibilities.

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Project Scope

- Consider and evaluate alternative retro fitment technologies comprising Diesel Oxidation Catalysts (DOC), Diesel Particulate Filters (DPF), Selective Catalytic Reduction filters (SCR) and Ammonia Generators.
- Focus on significant levels of reduction in PM/HC/NOx/PM without adverse effects on CO2.
- In-service monitoring of emissions performance data and system reliability.
- The installation of idle limiters, to help reduce engine idling time, conserve fuel and reduce harmful emissions.
- The installation of fast acting windscreen de-misting equipment to reduce the need to operate engines prior to commencing the journey.

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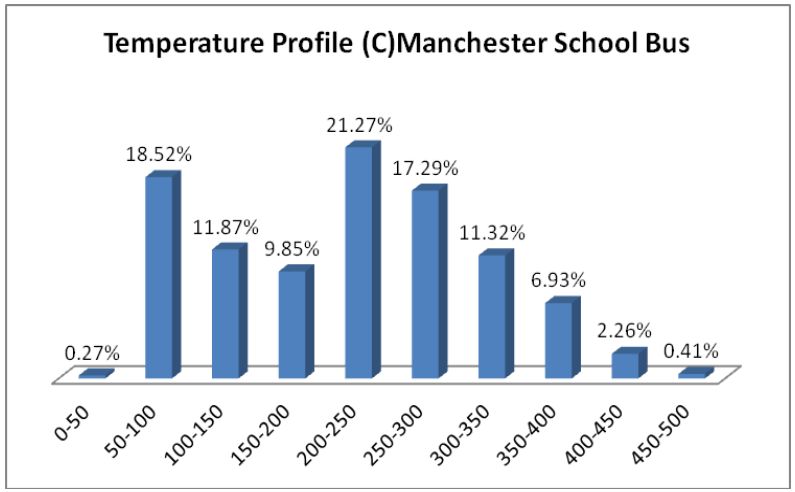
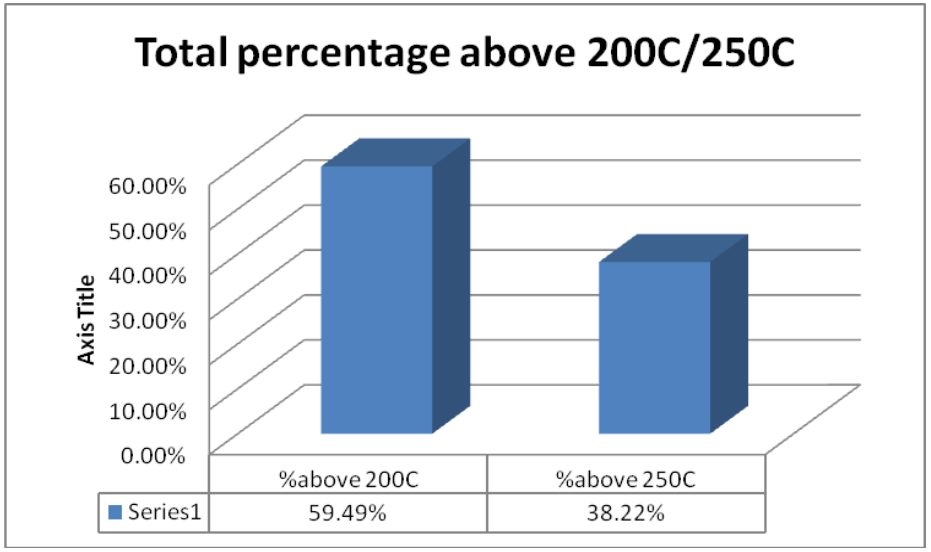
Temperature Profile



To assist with the project, exhaust gas temperature measuring equipment was installed on a representative Yellow School Bus.

Data was provided to allow the selected suppliers to develop a bespoke solution.



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Supplier Selection and Award

- TfGM conducted an open OJEU procurement process. The scoring was evaluated against 60% Technical and 40% Financial.
- Clean Bus Technology Fund 2013 - Baumot UK Ltd and HJS Emission Technology awarded.
- Clean Bus Technology Fund 2015 - Baumot UK Ltd.
- The average retro-fitment package costs across the projects equates to 10% of the purchase cost of a new Euro 6 equivalent Yellow School Bus.

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SCRT® - System (= SCR + CRT®)

CRT-System Stage 1

SMF® - Sintered Metal Filter

Oxi-Cat

Urea (AdBlue®)-Doser

SCR - Catalyst

Ammonia Slip-Catalyst

SCR-System Stage 2

Stage 1

Hydrocarbon (HC)
Carbon monoxide (CO)

↓

Diesel-**O**xidation-**C**atalyst
(DOC)

Particulate Matter
(PM)

↓

Diesel particulate filter

Stage 2

Nitrogen Oxides
(NO_x)

↓

Selective **C**atalytic **R**eduction
(SCR)

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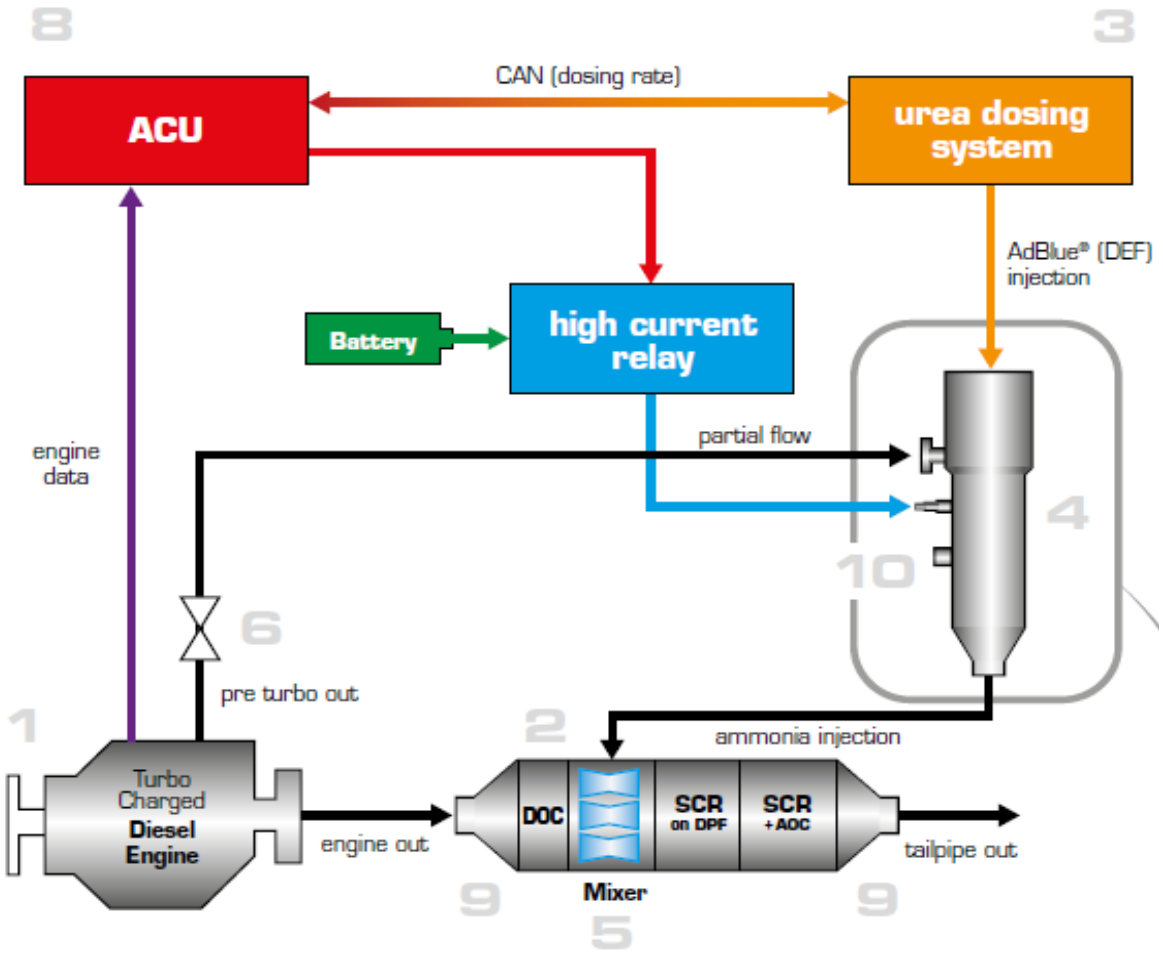
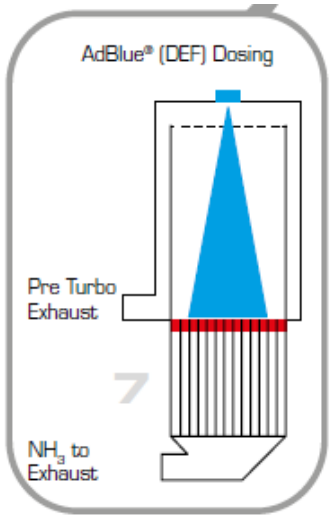
TwintecBaumot B-NOx SYSTEM OVERVIEW





Turbo Diesel engine 1, Exhaust System with PM- and NOx reduction 2, Ammonia (NH_3) Generator 4 and Mixing Unit 5.

DEF (Urea Solution) is injected via Urea Dosing System 3 into Ammonia Generator 4. NH_3 is generated inside and injected into Exhaust Mixing Unit 5.

The generator uses the heat sources from pre turbo exhaust gas 6 and electrically heated catalyst 7

Partial flow is defined by tube diameter 6.

Injection control by ACU 8, Urea Dosing System 3, Temperature- 10 and NOx Sensors 9.

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Emission Testing at Millbrook Proving Ground

- Baseline emission data for a sample Euro III and IV bus was obtained using the Millbrook London Transport Bus test cycle, in conjunction with the Low Carbon Emission Bus test weight.
- The prototype Euro III retro fitments were specified to be tested on the Millbrook London Transport Bus test cycle.
- Follow up testing of the Euro III retro fitment was conducted after 2 years in operation.
- The prototype Euro IV retro fitment was specified to be tested on the Millbrook London Transport Bus test cycle, with the Low Carbon Emission Bus test weight.

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Millbrook Emission Test Results

Twintec Baumot B-NOx SCR System result a on Euro III bus

Millbrook London Transport Bus Test Cycle – Low Carbon Emission Bus Test Weight

	Units	HC	CO	NOx	CO2	PM	Fuel Consumption Litres/100km
Baseline	g/km	1.375	3.677	12.742	1252.1	0.399	47.67
After	g/km	0.008	0.083	0.097	1288.7	0.026	48.67
Level of Reduction %		-99.42%	-97.74%	-99.24%	2.92%	-93.48%	2.10%

HJS SCRT System result on a Euro III bus

Millbrook London Transport Bus Test Cycle

	Units	HC	CO	NOx	CO2	PM	Fuel Consumption Litres/100km
Baseline	g/km	1.375	3.677	12.742	1252.1	0.399	47.67
After	g/km	0.000	0.063	0.14	1390.9	0.005	52.53
Level of Reduction %		-100.00%	-98.29%	-98.90%	11.09%	-98.75%	10.20%

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Millbrook Emission Test Results

Twintec Baumot B-NOx System results on Euro III after 2 years

Millbrook London Transport Bus Test Cycle - Low Carbon Emission Bus Test Weight

	Units	HC	CO	NOx	CO2	PM	Fuel Consumption Litres/100km
Baseline	g/km	1.375	3.677	12.742	1252.1	0.399	47.67
After	g/km	0.000	0.037	0.041	1309.1	0.0226	49.44
Level of Reduction %		-100.00%	-98.99%	-99.68%	4.55%	-94.34%	3.71%

Twintec Baumot B-NOx System results on Euro IV

Millbrook London Transport Bus Test Cycle – Low Carbon Emission Test Weight

	Units	HC	CO	NOx	CO2	PM	Fuel Consumption Litres/100km
Baseline	g/km	0.034	1.769	8.716	1155.9	0.0435	43.76
After	g/km	0.007	0.038	0.081	1239.2	0.012	46.8
Level of Reduction %		-79.41%	-97.85%	-99.07%	7.21%	-72.41%	6.95%

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Project challenges

- New technology challenges.
- Component mounting challenges due to variations in the chassis layout.
- Component ECU failures experienced.

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Next Steps

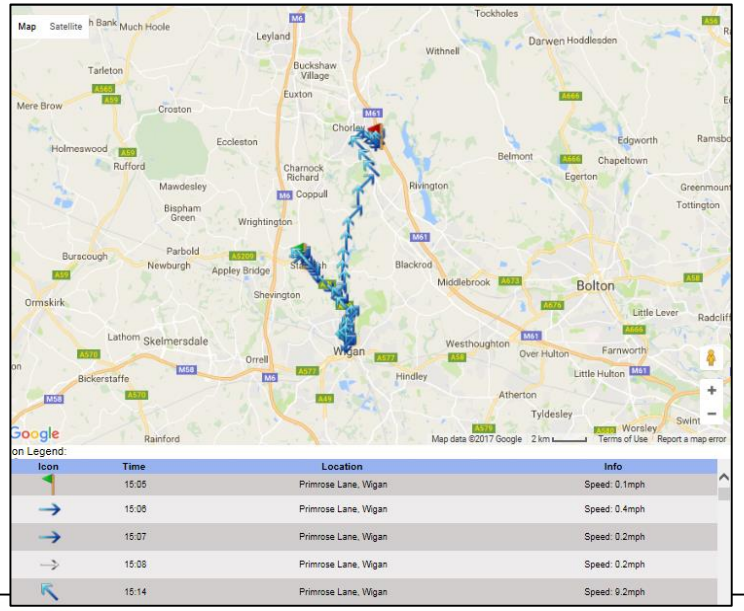
- Installation of telematics onto the 41 Iveco Yellow School Buses.
- To enable real-time monitoring of:

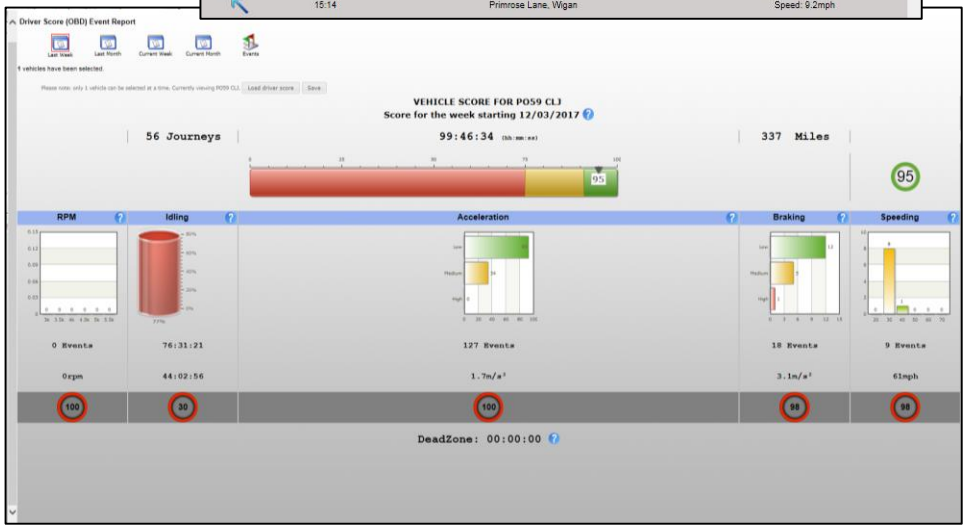
➢ Driver performance including idling, harsh acceleration and braking events.

➢ CAN Bus data for driveline systems.

➢ Exhaust system data and performance.

➢ Real time alerts for active faults.





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Thank you.

David Ives

david.ives@tfgm.com