engineexpo2011 north america

RICARDO

Greenest, meanest and leanest …

How Ricardo helped McLaren design and develop the world's greenest supercar engine

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27th October 2011

Engine technical presentation contents

- The Brief
  - Philosophy
  - Engine target specification
- Product engineering
  - The engineering challenge
    - Design/analysis
    - Development
  - The achievements

The Brief – Exceptional performance with world class efficiency

- Class-leading vehicle performance through minimum engine weight and low centre of gravity

- Class-leading engine performance achieved through turbo-charging and downsizing

- Class-leading fuel consumption achieved through low friction and turbo-charged downsizing

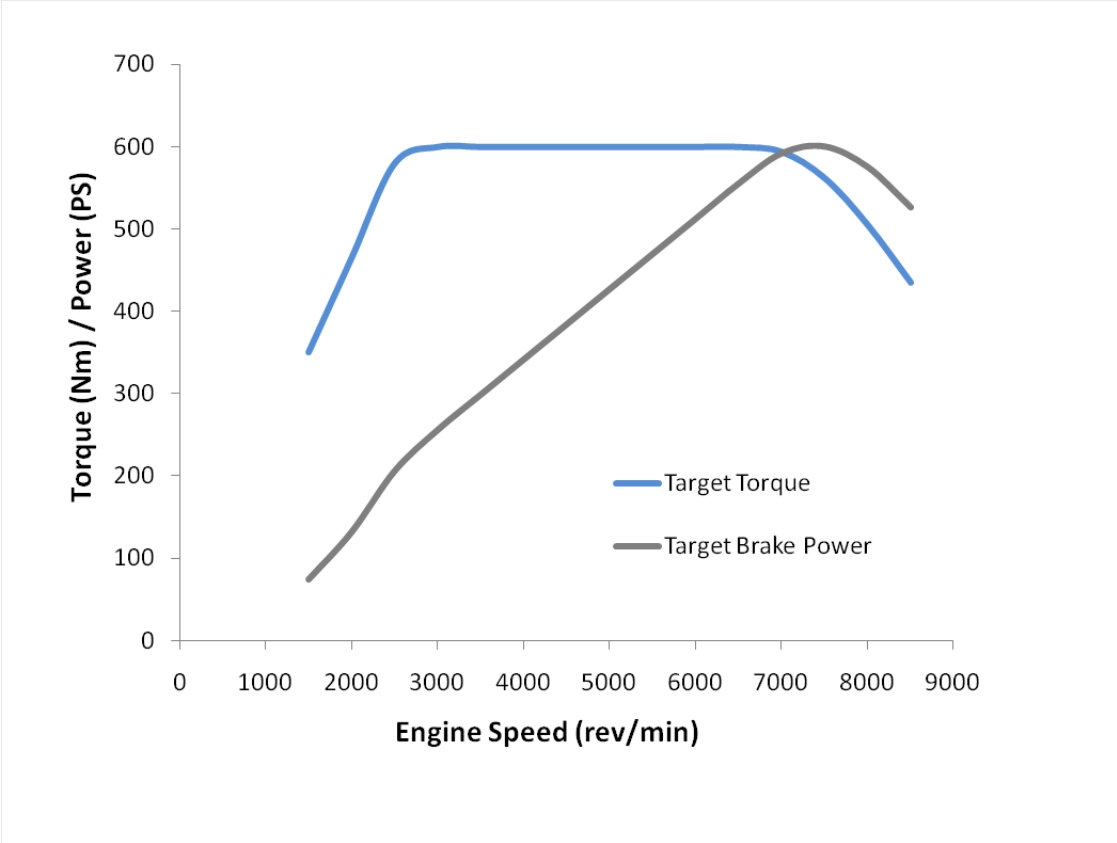
- Benchmark immediacy of response for a high performance turbo-charged engine with instant throttle response and feedback

- A distinctive and inspirational brand defining sound quality that will become recognisable immediately by sophisticated customers

Engine target specification – doing more with less

Attribute		Target
Power		600PS @ 7500rpm
Torque		600Nm @ 3000rpm
Mass		<200 kg
CO_2 (vehicle)		<300 g/km
Speed (rpm) 1500	BMEP Bar 2.62	BSFC g/kWhr 352
Transient response (Start: 50% load 3000rpm Input: 100% throttle		0.5s to 75% desired boost
Max speed		8500rpm
Idle speed		850rpm
Emissions		Eu 5/ ULEV2

Engine power and torque targets

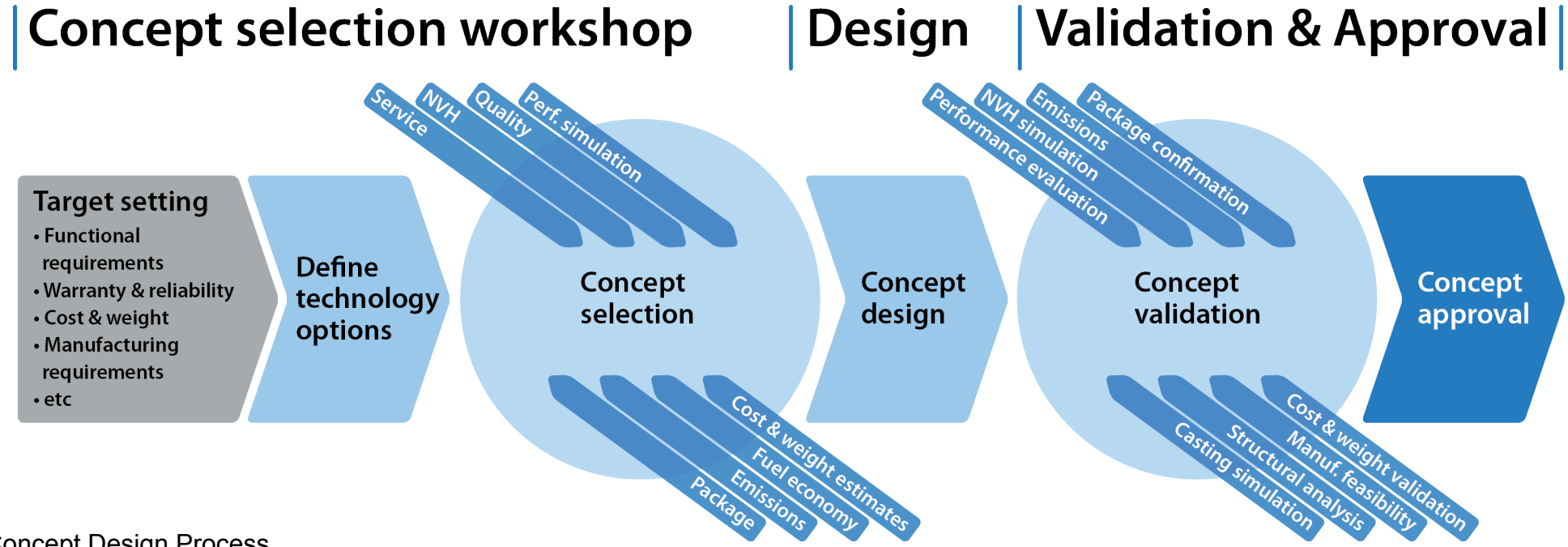


The technical challenge was further enhanced by immense time pressure

- 18 months start to SOP
- Engineering program had to integrate with vehicle timing
  - Development and validation program
- Supply chain development
  - Supplier nomination and engagement for prototypes and production
- Establish manufacturing strategy and assembly facility

Product Engineering Concept Design Selection & Validation

- The compressed development timescale and challenging product objectives required rapid selection of appropriate technologies and concepts that would meet project functional and durability targets “out of the box”
- Ricardo achieved this through a combination of:
  - Concept selection and review workshops across UK, US, China and Europe
  - The extensive use of CAD design and analysis tools



Concept Design Process

Ricardo Software products were used extensively throughout the programme to support the design and development process

- **WAVE**
  Engine performance and 1D gas dynamics simulation

- **VECTIS**
  Automotive CFD software

- **VALDYN**
  Valve train and drive system dynamics

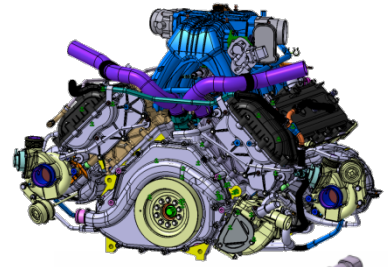
- **PISDYN**
  Piston secondary dynamics and skirt lubrication analysis

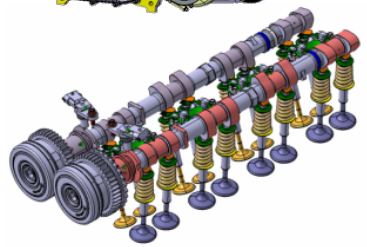
- **RINGPAK**
  Piston ring ringpack dynamic analysis

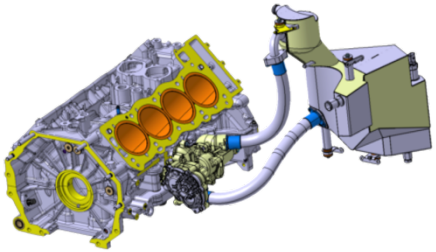
- **ENGDYN**
  Crankshaft/cylinder block coupled

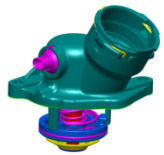
Key engine features, focused on achieving target attributes

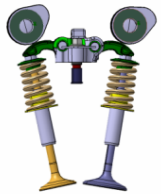
Feature	Function	Benefit
3.8ℓ V8 bi-turbo	Downsized, high performance engine	
Quad cam phasers	Wide range variation of valve events	
Dry sump	Provide oil handling for extremes of vehicle performance	
3 plate electrical thermostat	Control engine operating temp & provide no flow condition	
Finger follower valvetrain	Operate valves to designed profiles	
Single beehive valve spring	Control valve closing within designed limits	









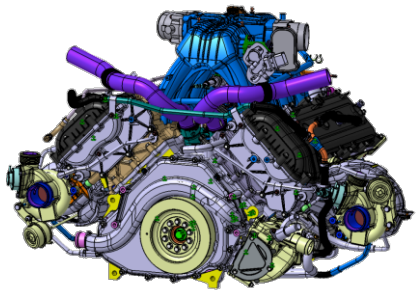


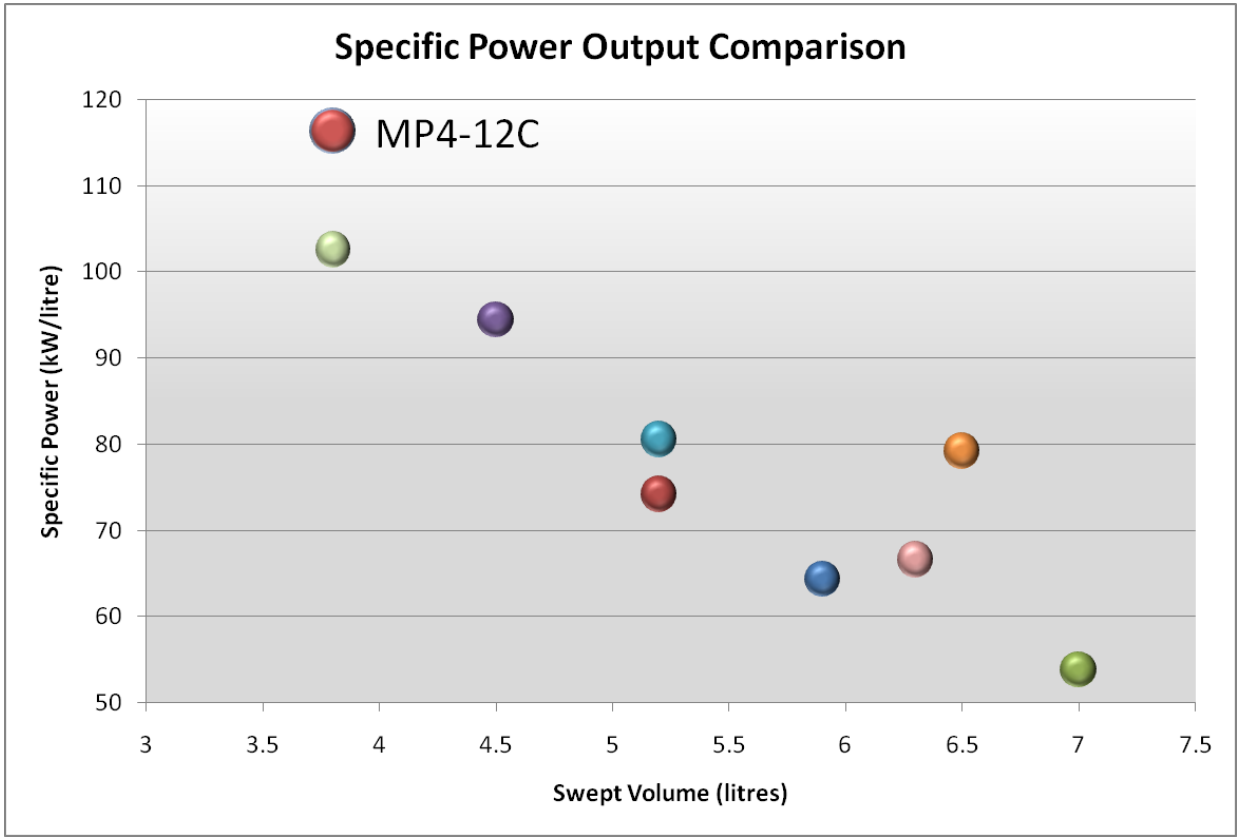
Key engine features, focused on achieving target attributes

Feature	Function	Benefit
Plastics applied to top of engine assembly	Intake manifold, cam covers and oil filter cooler module	kg, CO_2
Aluminium cylinder liners	Nikasil coated aluminium wet liners provide piston running surface	kg, CO_2
Piston guided con rod	Axial control of rod carried on small end	kg, CO_2
Thick shelled main bearings	Allows all aluminium bearing ladder, no iron inserts	kg
Idle speed	Original target 850 rpm, now 600 rpm	CO_2
Integrated sound generator	Controls wave dynamics within the intake system	

Engine configuration is downsized to provide high specific performance with class leading CO2

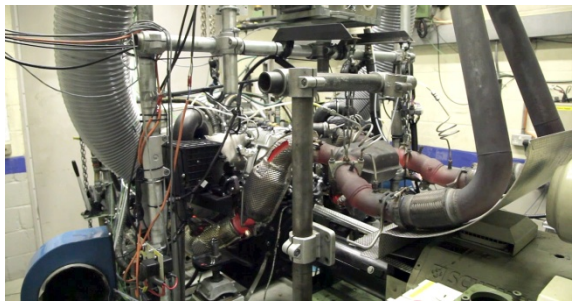
- V8 bi-turbo
- 3.8ℓ @ 600PS (N/A would need to be 5.0 to 5.5 L)
  - Reduced friction compared to larger N/A engine
  - Reduced pumping work compared to larger N/A engine
  - Lower mass than larger N/A engine



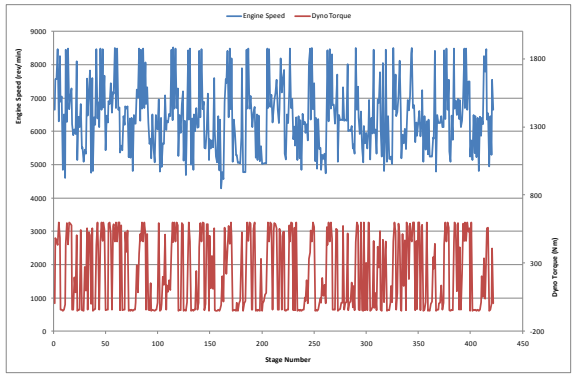


Development activity was concentrated and intensive, involving component rigs, engine dyno, and vehicle based testing, allied to Ricardo CAE techniques

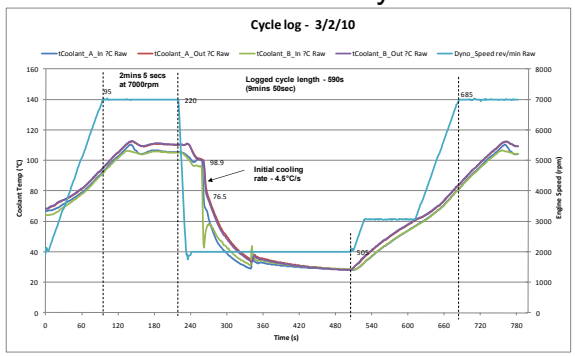
Engine dyno Testing	7 beds running in parallel	All beds ran shift systems to maximise results generation
	> 5000 hrs testing	Testing included functional testing (performance, emissions and mechanical development) , NVH, and durability (cycles included thermal shock, high speed, Nordschleife, manifold cracking, piston scuff and critical vibrations)
	> 3000 laps of simulated Nordschleife	Equivalent of > 73,000 km track mileage, cycle based on real data logged during vehicle track testing at Nordschleife
Component and system level rig tests	Combined test plan including Ricardo, McLaren and suppliers	All major systems and components completed rig tests during development and validation phases, including exhaust and intake systems, pumps, drives, cranks, rods, and cylinder block
Vehicle testing	> 1,000,000 km	Mixture of road and track including Nardo, Idiada and Nordschleife for functional performance and durability development and validation Climatic and in territory trips



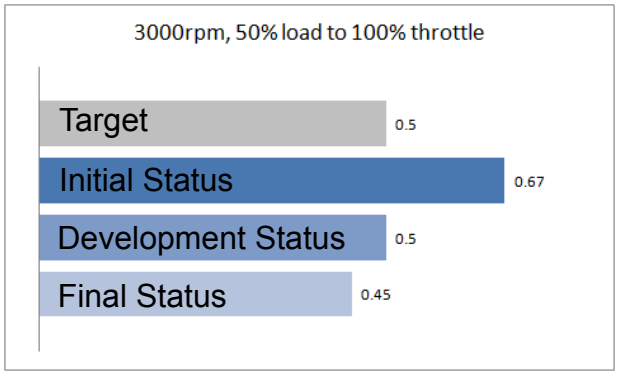
Nordschleife Cycle Simulation

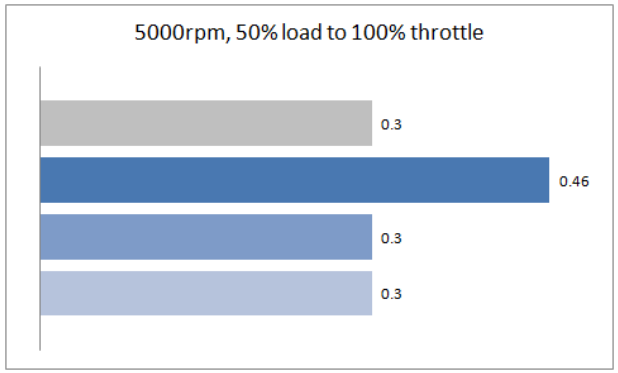


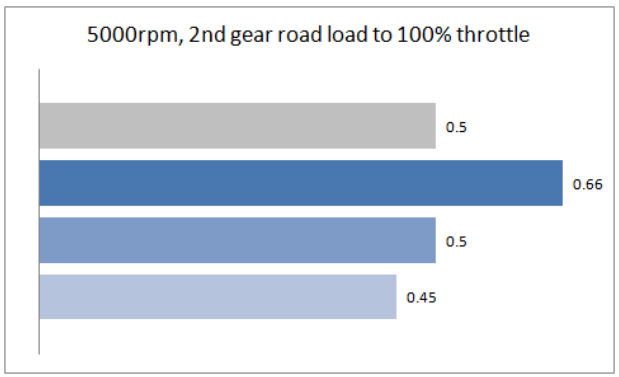
Thermal shock Cycle



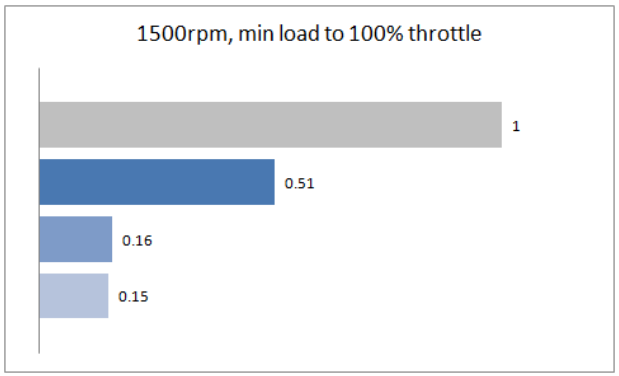
Engine transient response was developed against a set of measurable targets. Successful performance relies on complex interactions of hardware, control and calibration

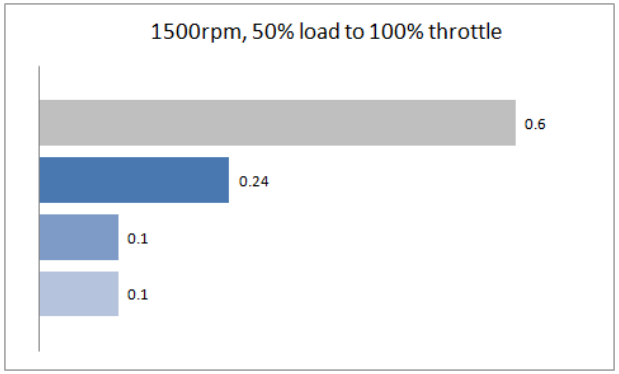






- Transient test is based on time taken to achieve 75% of max boost from a given condition
- Targets were achieved as a maturation over time
- Influencers included
  - Compressor and turbine configurations
  - Exhaust manifold geometry
  - Cam phaser response
  - Calibration variables traded off to provide best compromise between competing factors

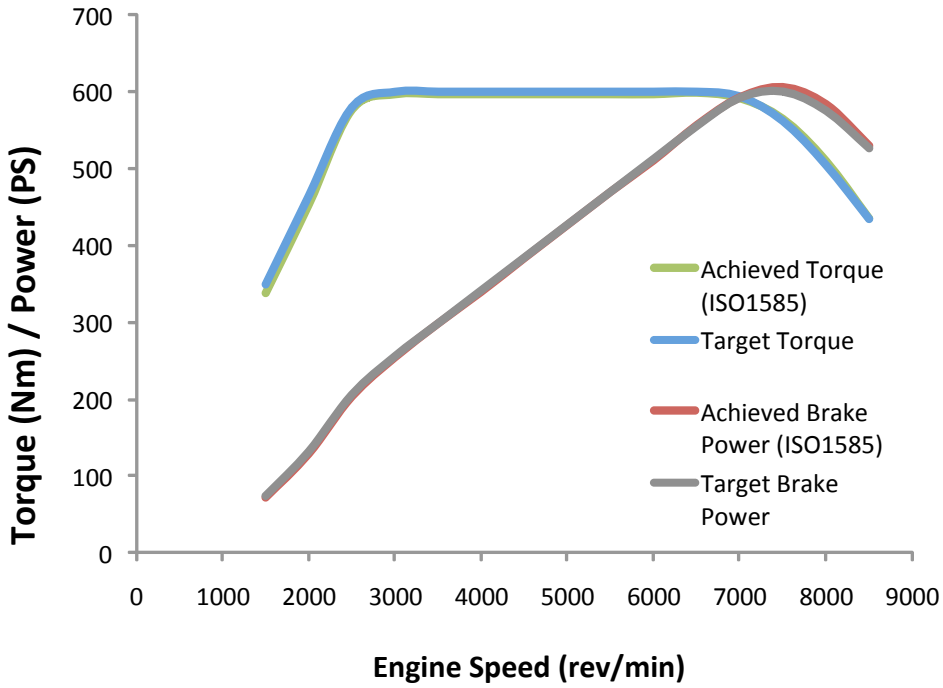




Engine Achievements

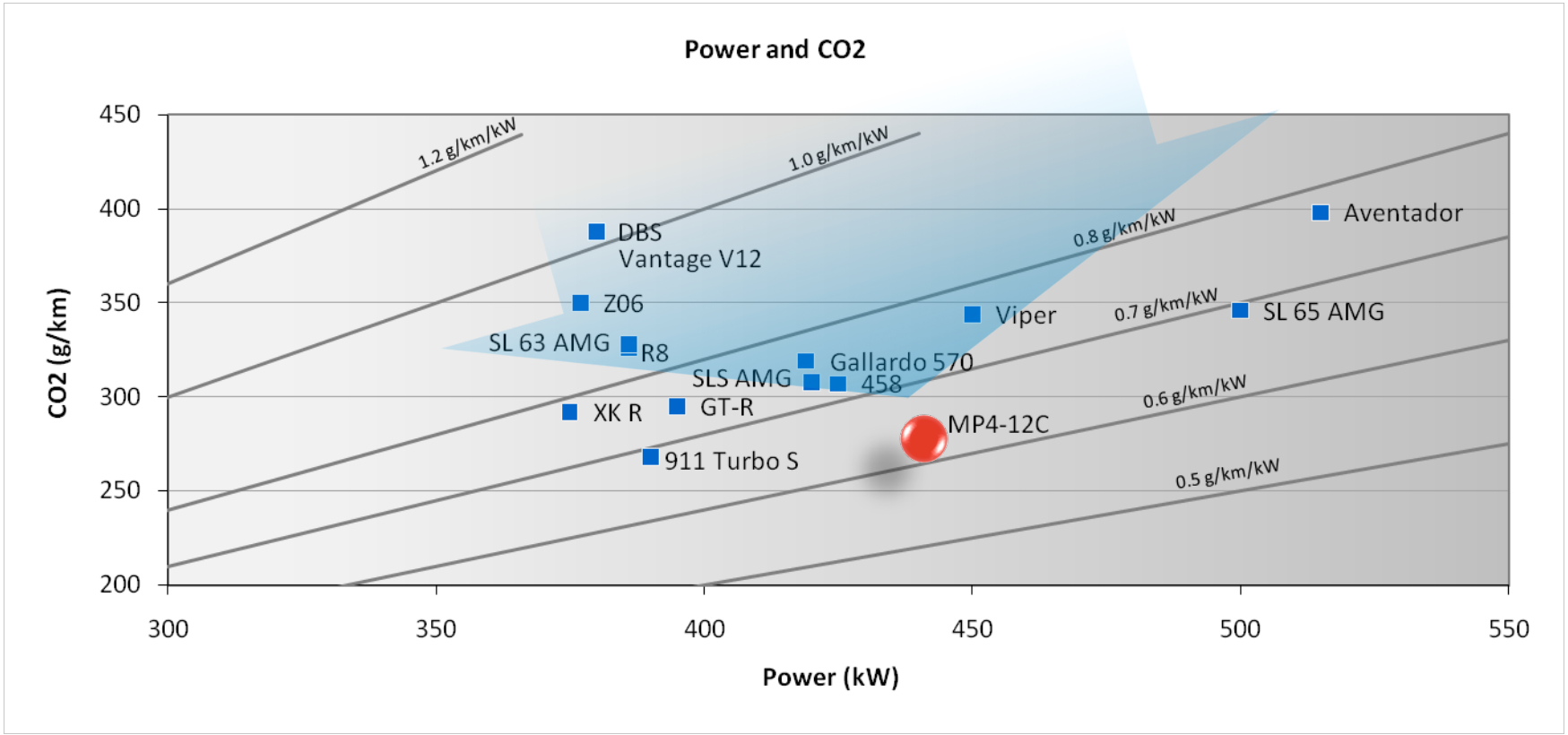
Attribute		Target	Achieved
Power		600PS @ 7500	600PS @ 7500
Torque		600Nm @ 3000	600Nm @ 3000
Mass		200 kg	199 kg
CO2		<300 g/km	279 g/km
Speed 1500rpm	BMEP 2.62Bar	BSFC g/kWhr 352	BSFC g/kWhr 346
Transient response (Start: 50% load 3000rpm Input: 100% throttle		0.5s to 75% desired boost	0.45s to 75% desired boost
Max speed (rpm)		8500	8500
Idle speed (rpm)		850	600
Emissions		Eu 5 / ULEV2	Eu 5 / ULEV2

Engine power and torque targets



The Achievements
Optimised engine integration enables the vehicle to achieve 279g/km

- Best in class CO_2 emissions (CO_2 /kW)



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