

Diesel Motorsport

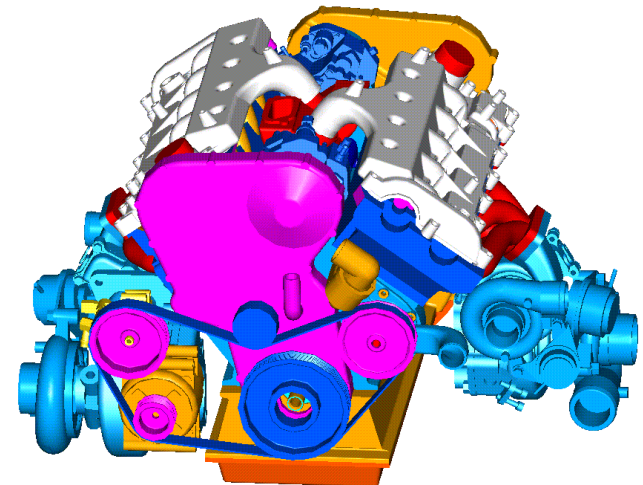
An introductory presentation

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Ricardo**

Presentation Contents



- ❑ Introduction and background – why diesel?
- ❑ Classes for diesel racing – existing & potential
- ❑ Benefits for OEMs
- ❑ The future?



❑ Historical track record

- Cummins entry at Indy 500 in 1931 – other Indy entries in the 1950s
- Diesel entries at Le Mans in 1949, 1950 & 1951
- Diesels raced by Volvo, VW, BMW in various rally and endurance events
- ACO set new regulations for diesel LMP900 class in 2004
- Taurus competed with first LMP900 diesel in 2004 in 24h Le Mans and LMES



Some Early Diesel Race Successes



❑ VW

- 1996 – first entered 2 Golfs in endurance events
- 1997 – 1st victory for a diesel at Vallelunga 6 h race, winning by 8 laps with 2.3 litre 5 cyl Golf
- 1998 – first and second places at Vallelunga
- 1999 – 1st at Vallelunga - 2nd in Manx International Rally
- 2003 – 1st & 2nd in class with VW Tarek in Rallye Telefonica Dakar



❑ BMW

- 1998 – first diesel victory at Nurburgring 24h with 320d



Some Recent Diesel Race Successes



❑ Audi

- 2006 – 1st victory for diesel LMP 1 car at Le Mans
- 2006 – Audi dominate ALMS by winning every race
- 2007 – Victory again at Le Mans but rule changes challenge competitiveness in ALMS



❑ Peugeot

- 2007 – first LMP1 diesel entry for Peugeot at Le Mans, coming 2nd
- 2007 – currently leading P1 in Le Mans Series, last race 11 Nov



❑ Seat

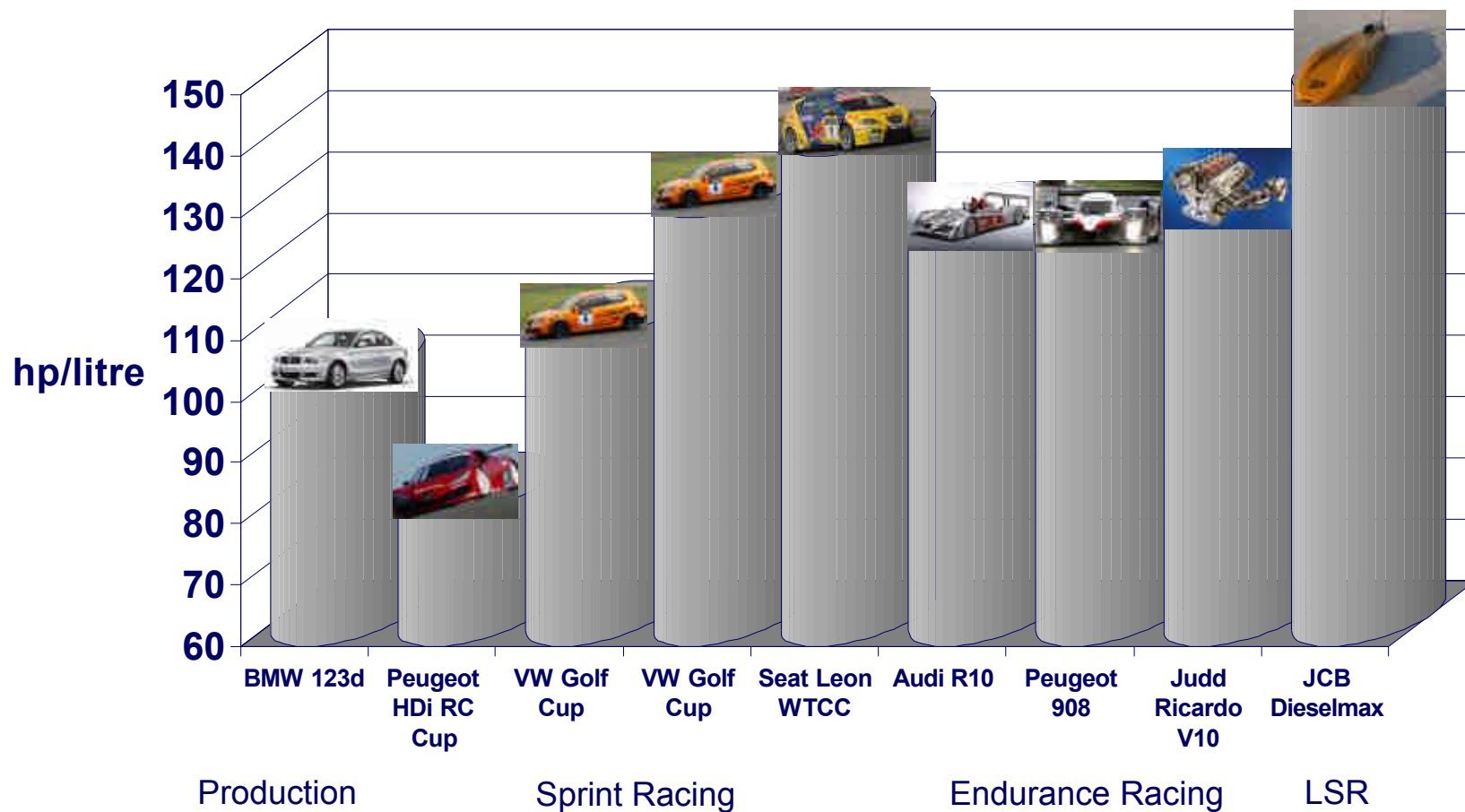
- First WTCC Seat Leon diesel – 280hp TDI – wins in Oschersleben



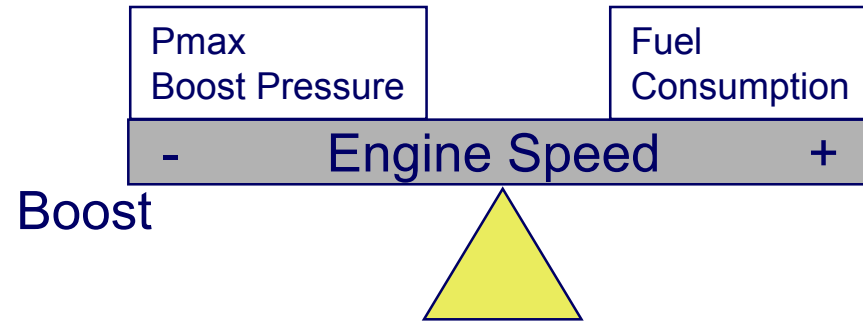
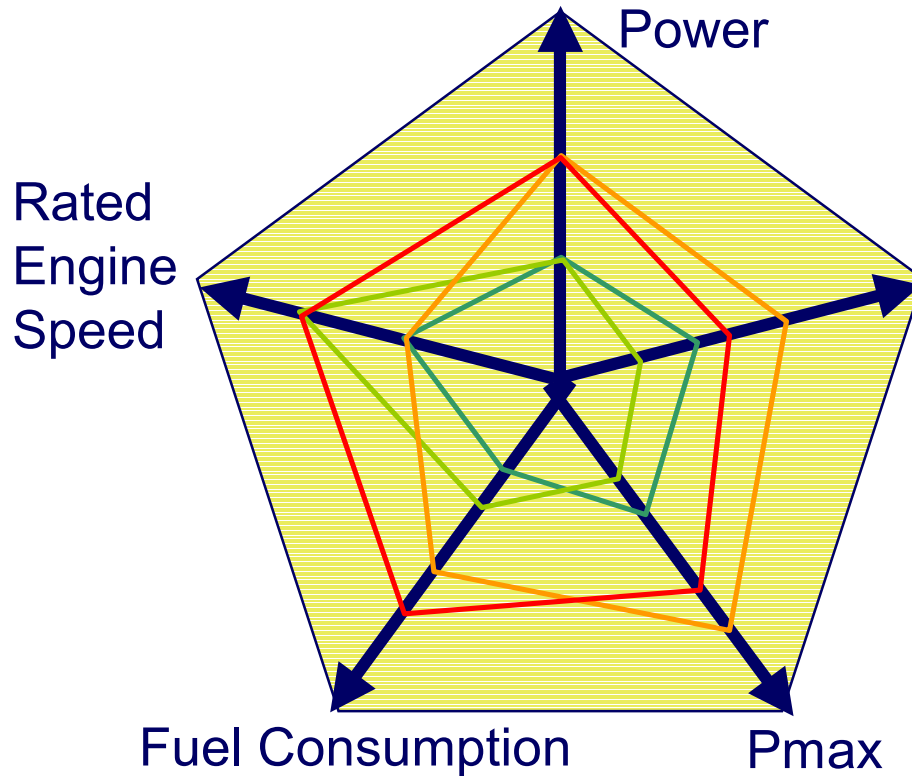
Examples of race diesel engine ratings



Race diesel engine ratings



Some Compromises.....



← Increasing fuel consumption penalty

→ Increasing boosting system and engine structure challenge

Other factors:

- Weight
 - engine structure
 - turbochargers
- Drag
 - charge cooling

	Low power conventional speed		High power conventional speed
	Low power high speed		High power high speed

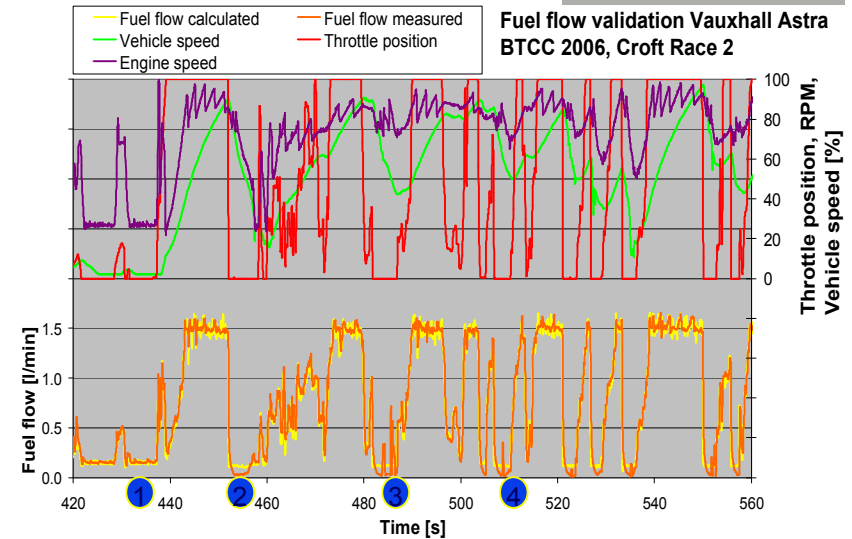
- ❑ **The work of the UK MIA and Energy Efficient Motor Sport (EEMS)**
- ❑ **EEMS initiative started Jan 2002 – 1st conference in 2003**
 - Areas explored
 - Short term and longer term
 - Short term concentrated on Diesel
 - Longer term on alternative fuels and powertrains
 - 2005 Ricardo project to study equivalence to allow different fuelled engines to compete fairly in same series



Ricardo expertise on energy flow systems



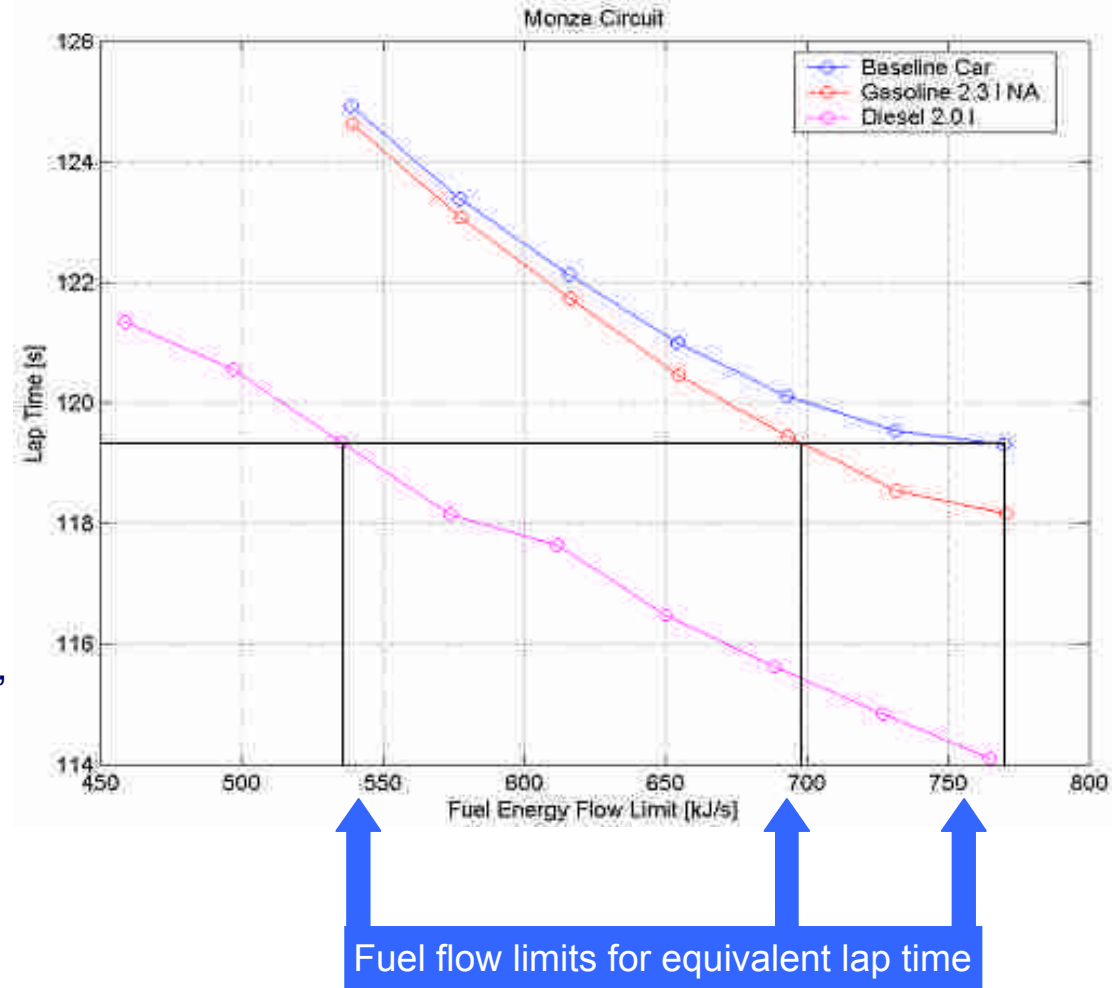
- ❑ Ricardo has experience in developing, testing and validating fuel flow control solutions for motorsport applications
- ❑ “PACER” (Performance Alignment by Combustion Energy Regulation - *ref SAE 2006-01-3665*) was developed and tested for over a full racing season in a BTCC vehicle
- ❑ Ricardo has developed software to simulate fuel flow effects on various tracks for a number of applications



Creating a level playing field with energy flow control



- ❑ Ricardo powertrain and lap simulation software allows fuel flow limits to be specified for equivalent lap times
- ❑ Different powertrain technologies will yield advantages at different parts of the circuit due to different torque curves
- ❑ For multi-race series, the limits are set to give parity across the series
 - But different fuels will have advantages at different circuits
 - Series still won by “team effort”
 - Alternative fuels have real chance of winning – together with PR benefits
- ❑ Regulators may choose to give slight advantage to new fuel types to encourage entry



The Diesel road car Market



- ❑ **The diesel passenger car market is a dynamic market that is being driven by new technologies**
- ❑ **Consumers are looking for cars that are good to drive**
- ❑ **Opportunities to increase market share with latest generation products**
 - Broaden diesel coverage to all segments
 - eg a diesel GT? (BMW 635d)
 - Update engine ranges using latest technology
 - Increase specific and absolute power levels to remain competitive
 - Ensure diesel vehicles have best possible NVH and driving characteristics
- ❑ **Current major challenge for diesel power is maintaining traditionally low CO2 at a realistic cost**
- ❑ **Diesel passenger cars are now over 50% of new car sales in Europe & still growing (over 70% in some countries)**

Diesel Racing Options

Diesel racing is suitable for many motorsport series....



- Le Mans/ALMS
- GT
- Rally
- Touring Car
- One-make Series



Diesel power is not just showing benefits in endurance events, but sprints too....



ACO LMP1 Regulations – diesels



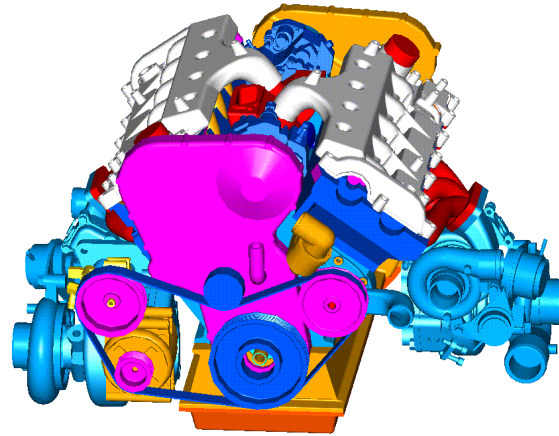
- ❑ First issued in 2004
- ❑ Diesels only allowed in top LM category – P1
- ❑ No special class for diesels – must compete with SI engines in P1
- ❑ 4 to 5.5 litre capacity
- ❑ Originally no change in fuel tank size but now reduced by 10%
- ❑ “The engine must not produce visible exhaust emissions under race conditions”
- ❑ Conformity by airflow restriction (currently the ACO’s preferred method):
 - Restrictor (single 55.9 or twin 39.9 for all capacities – 50% larger than equivalent gasoline class – but changing for 2008)
 - Boost pressure limit (varies with capacity from 3.87bar for 4 litre down to 2.94 bar for 5.5 litre)
- ❑ Despite gasoline engine restrictors being increased by 3% and LMP1 minimum weight reduced to 900 kg for 2008, some are saying a fair diesel/gasoline performance balance has still not been achieved

Some diesel pros and cons.....

- ❑ Diesel engine must be able to compete equally with the “equivalent” gasoline engine and hence produce competitive power

Benefits

- ❑ More fuel efficient
 - Less fuelling stops
- ❑ Smaller coolant radiator
- ❑ Some performance benefits under current ACO regulations
- ❑ Torque characteristics
 - Better driveability
- ❑ Promotes greener image



Drawbacks?

- ❑ High boost demands greater inter-cooling area
- ❑ Powertrain will be heavier (so less option for ballast optimisation)
- ❑ Transmission capacity
- ❑ Low noise needs getting used to!
- ❑ Engine more expensive than SI, and very limited choices in prototype class

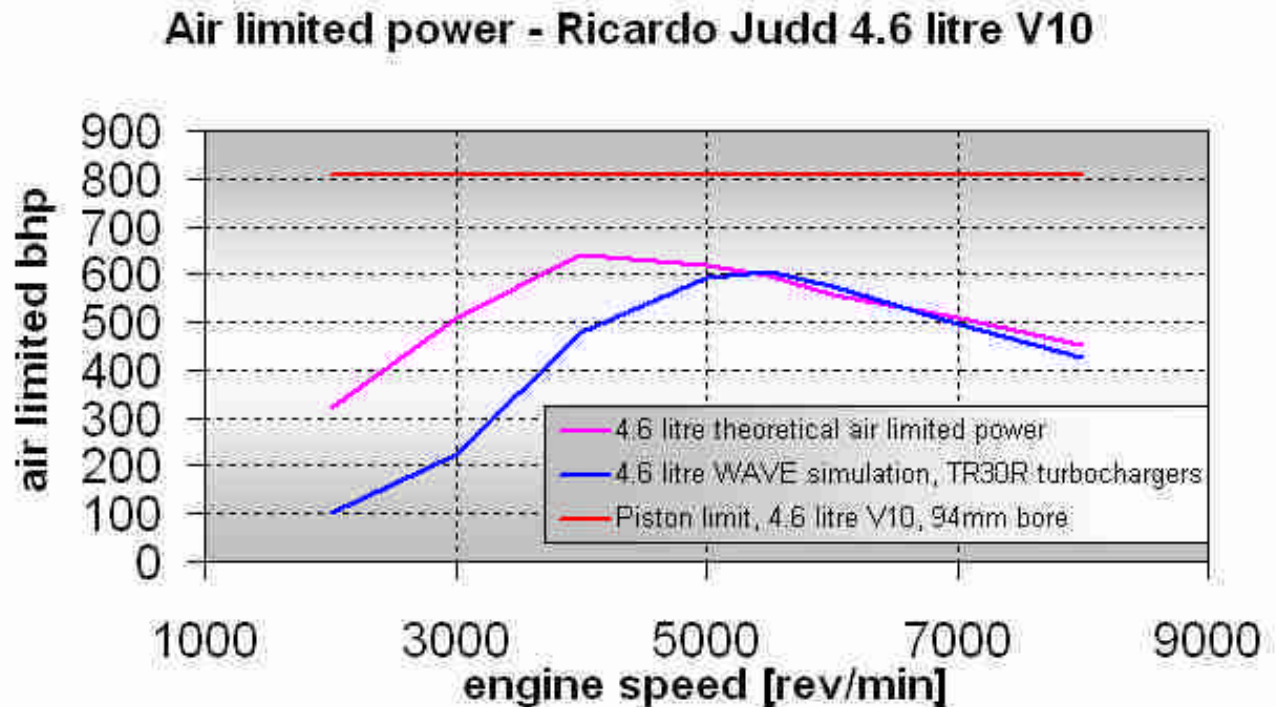
V10 Conversion

- ❑ Conversion of existing race V10 gasoline engine
- ❑ On-going project with Engine Developments Ltd
- ❑ Design helped by no emission or cold-starting constraints or long-term durability requirements
- ❑ Novel approach means restricting P_{max} to save weight



- ❑ All aluminium V10
 - Based on Judd GV5
 - 4.6 litres displacement
 - 130hp/litre = 600hp
 - 850 N.m @ 4000-5000 rev/min
 - 180 kg (estimated)
- ❑ Common rail fuel injection equipment
 - Twin high pressure pumps

- ❑ Predicted Power/Torque characteristics of high-speed dedicated race V10 diesel engine
 - (with 2x39.9mm restrictors)



Audi V12 TDI diesel engine for LMP1

- ❑ 650 hp (Audi figure) V12
- ❑ 1100 N.m (Audi figure)
- ❑ Pioneering endurance engine
- ❑ Competing in
 - LeMans & ALMS



(source: Audi press publication)

Peugeot LMP1 diesel engine

- ❑ 650 hp (Peugeot figure) 5.5 litre V12
- ❑ 1100 N.m (Peugeot figure)
- ❑ Competing in
 - LeMans & LeMans Series



(source: Peugeot Sport press release)

- ❑ **Close to current production engines**
 - Marketing potential for premium diesel car
 - First diesel sports coupe offered by BMW
 - Must produce > 400hp
 - Minimum of 4 litres – probably a V8
- ❑ **May need special dispensation likely to put engine in a suitable vehicle**



Other Diesel Categories

❑ Rallying

- High profile potential at top level WRC & Group N

❑ Touring cars

- Starting to appear & be successful....
strong marketing potential & association

❑ One-make series

- National or international
- Can be closely regulated by manufacturer
- Peugeot's RC Cup series (using 50/50 bio/diesel mix)



Other performance diesel applications....

❑ Racing powerboats

- Race boat series typically specify SI engines but new P1 class allows twin diesels, typically marinised truck engines, 650hp each, weighing 1200 kg each. Nominal rating ~ 80hp/litre. Class is power/weight governed. However, most use SI engines.



❑ Truck racing

- Well established internationally. In BTRA, typical engine is 12 litres, ~1000hp, 3000 N.m



Diesel Landspeed Racing



Ice tank

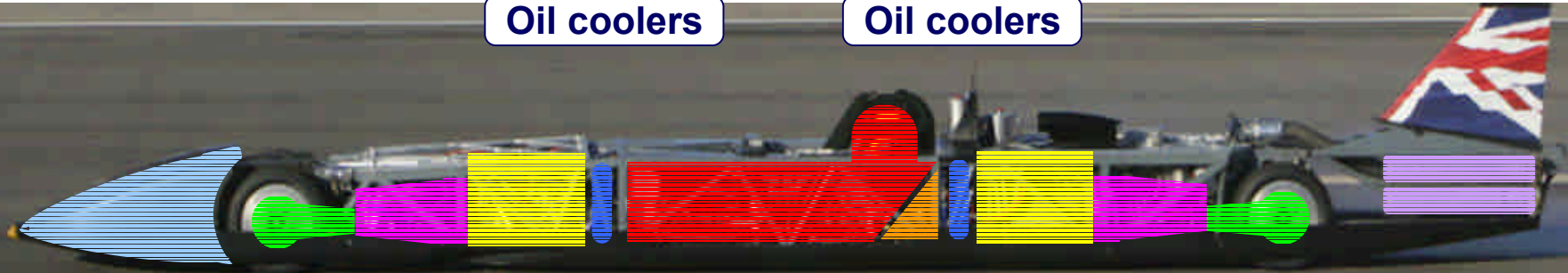
Transmission

Driver cockpit

Transmission

Oil coolers

Oil coolers



Final drive

Engine

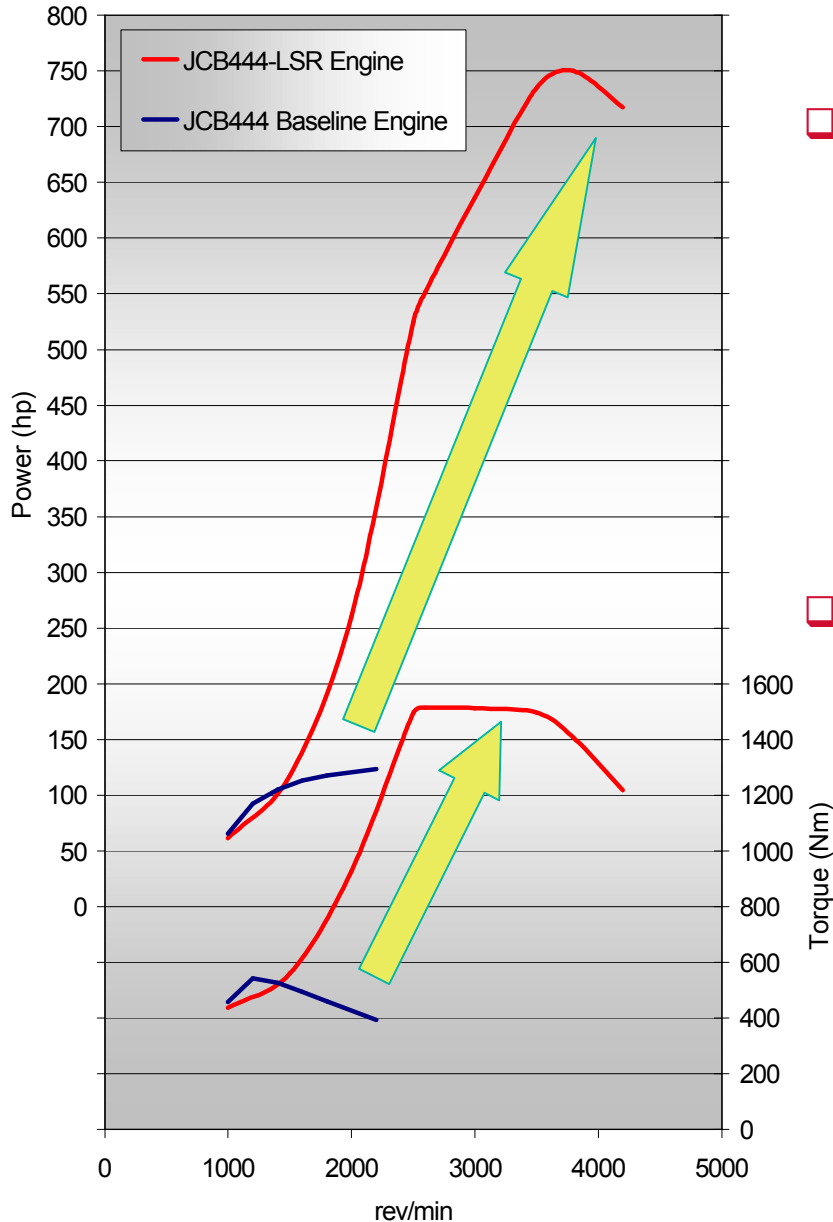
Fuel & Oil Tanks

Engine

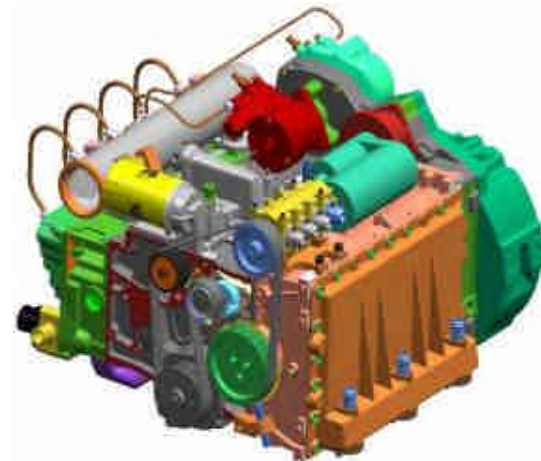
Final drive

Parachutes

JCB444-LSR Engine Performance Challenge

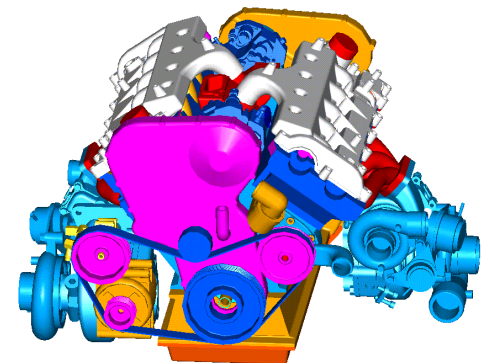


- 125bhp base engine uprated to 750bhp
 - Over 5 times power uprate (150 hp/litre)
 - ~600% increase in airflow, 3.3 tonnes of air per hour required per engine
 - ~450% increase in fuel injected per stroke
 - ~170% increase in engine speed from 2200rpm to 3800rpm
- Bonneville altitude of 1300m results in barometric pressure reduction of ~15%, further increasing turbocharging challenge



The future?

- ❑ Diesel power offers many advantages in many series, not just endurance, and is already winning races..... but some series will never be diesel!
- ❑ Concern about the environment and energy efficiency is driving more interest in alternative fuels, including diesel
- ❑ Diesel racing can meet some environmental needs but still be exciting
- ❑ Diesel racing provides a strong and convincing platform for marketing in “new-diesel” territories, like the USA
- ❑ Achieving a satisfactory balance between equivalence and incentives remains a challenge for the regulating bodies. Some form of flexible energy flow control could be the answer.



Thank you.....