Diesel Motorsport

An introductory presentation

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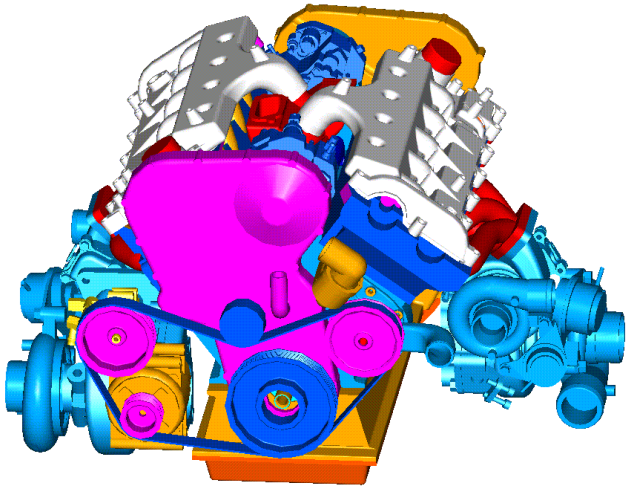
Presentation Contents

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



Diesel Motorsport History

- **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

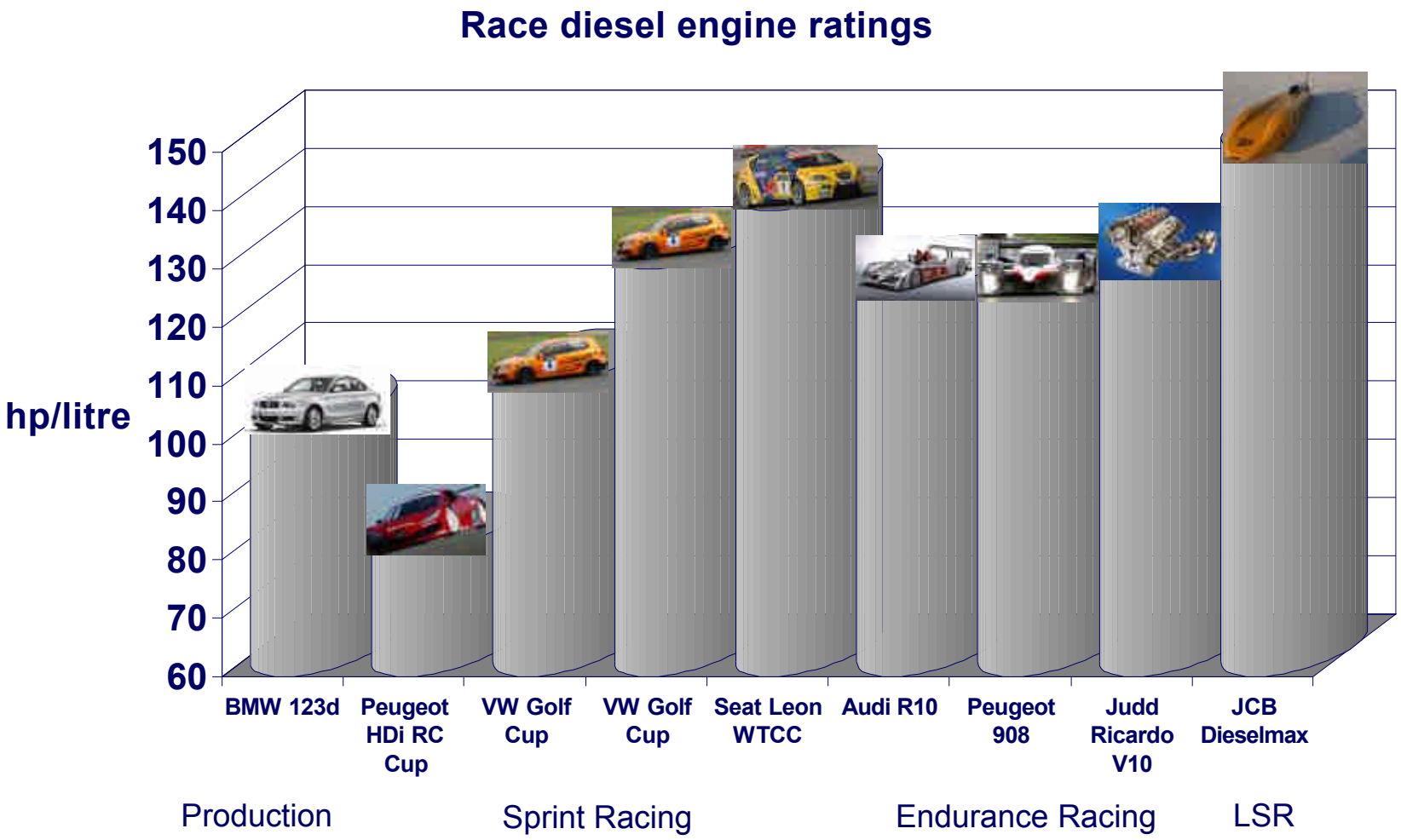
Some Recent Diesel Race Successes

- **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

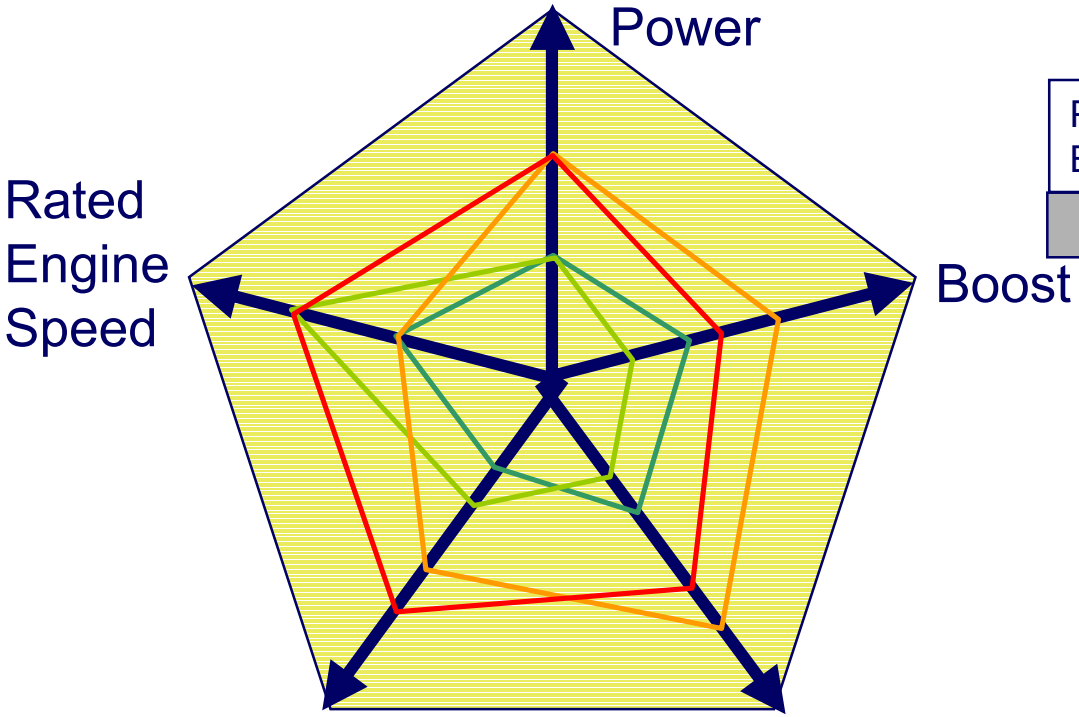
- **Peugeot**
  - 2007 – first LMP1 diesel entry for Peugeot at Le Mans, coming 2nd
  - 2007 – currently leading P1 in Le Mans Series, last race 11 Nov

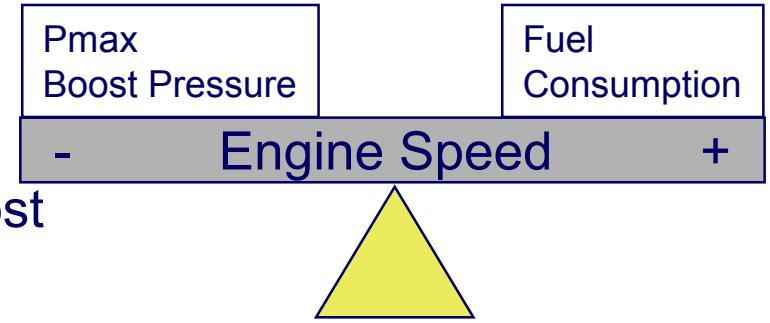
- **Seat**
  - First WTCC Seat Leon diesel – 280hp TDI – wins in Oschersleben

Examples of race diesel engine ratings



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

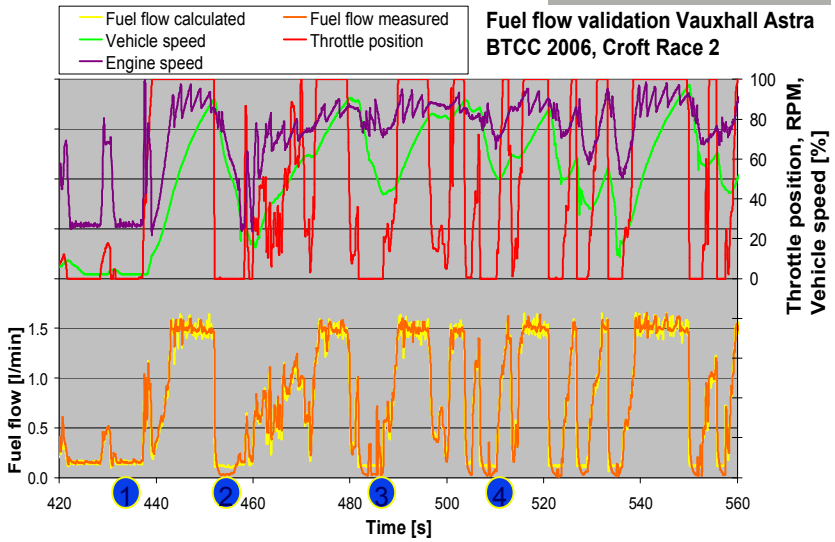
High power high speed

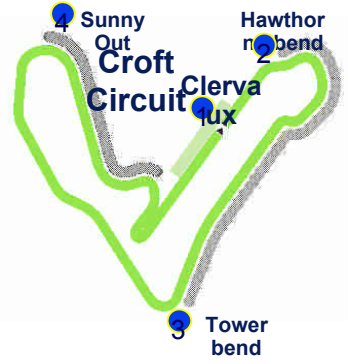
Diesel Motorsport in the UK

- **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

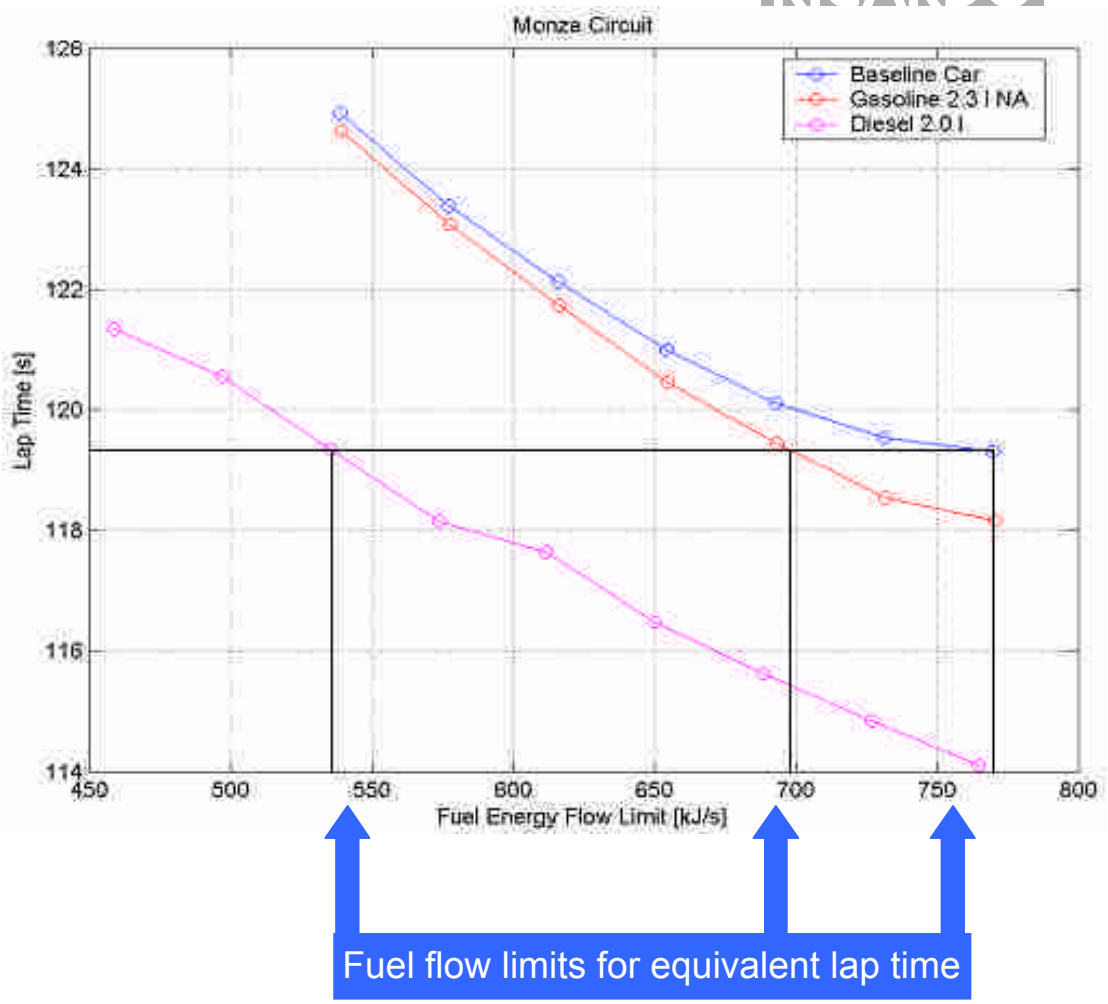
- Ricardo has experience in developing, testing and validating fuel flow control solutions for motorsport applications
- "PACER" (Performance Alignment by Combustion Energy Regulation - *ref SAE 2006-01-3665**)) was developed and tested for over a full racing season in a BTCC vehicle
- Ricardo has developed 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

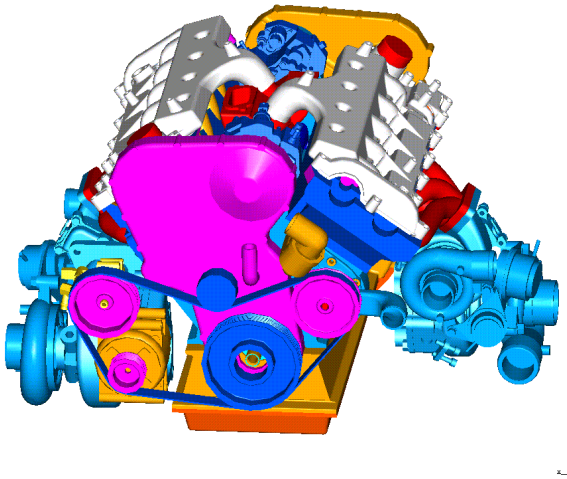
- First issued in 2004
- Diesels only allowed in top LM category – P1
- No special class for diesels – must compete with SI engines in P1
- 4 to 5.5 litre capacity
- Originally no change in fuel tank size but now reduced by 10%
- "The engine must not produce visible exhaust emissions under race conditions"
- 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

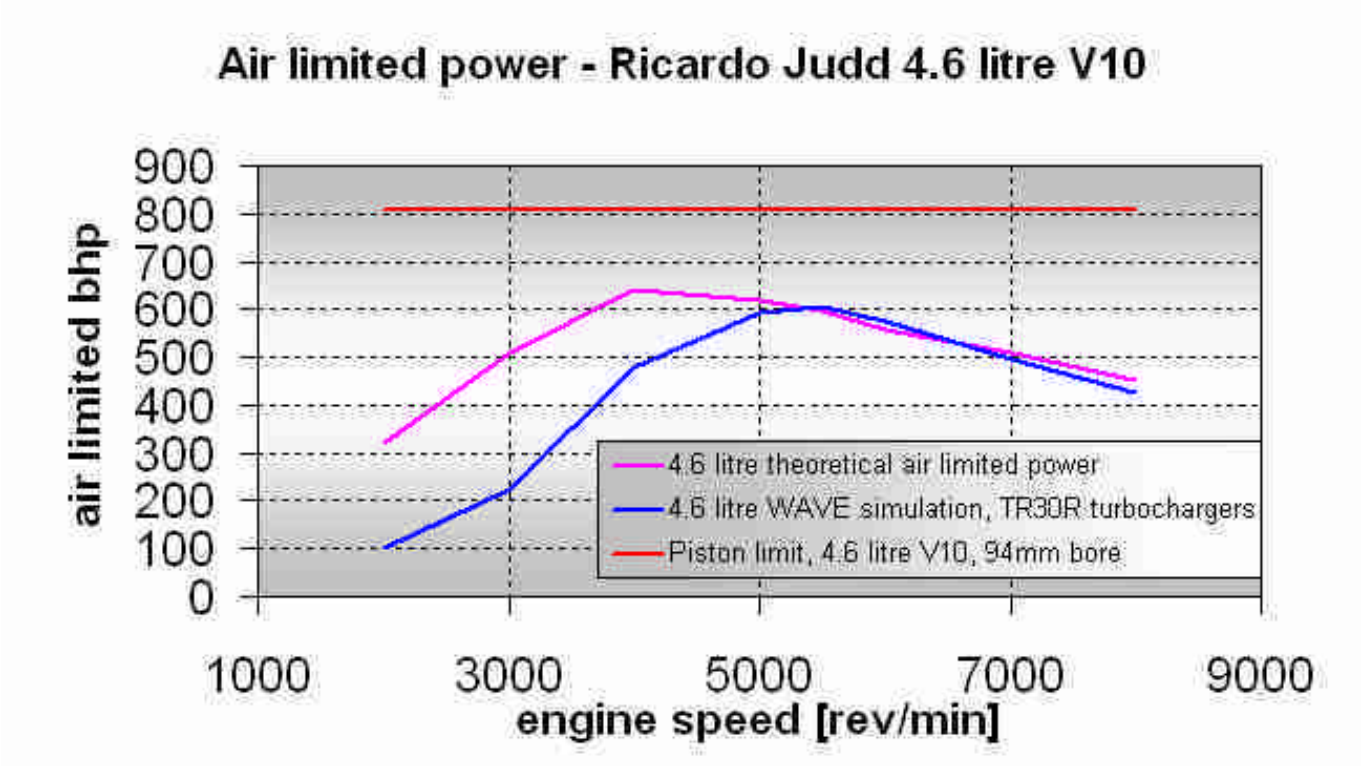
V10 Conversion

- 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 Pmax 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

Dedicated Race Diesel

- **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)

GT

- **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….

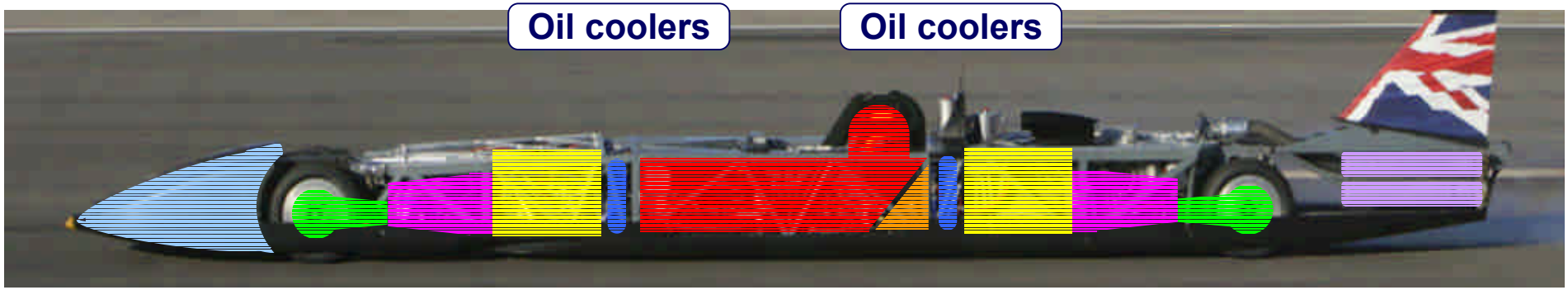
- **Racing powerboats**
  - Race boat series typically specify SI engines but new P1 class allows twin diesels, typically marinised truck engines, 650hp each, weighing 1200 kg each. Nominal rating ~ 80hp/litre. Class is power/weight governed. However, most use SI engines.

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

Diesel Landspeed Racing

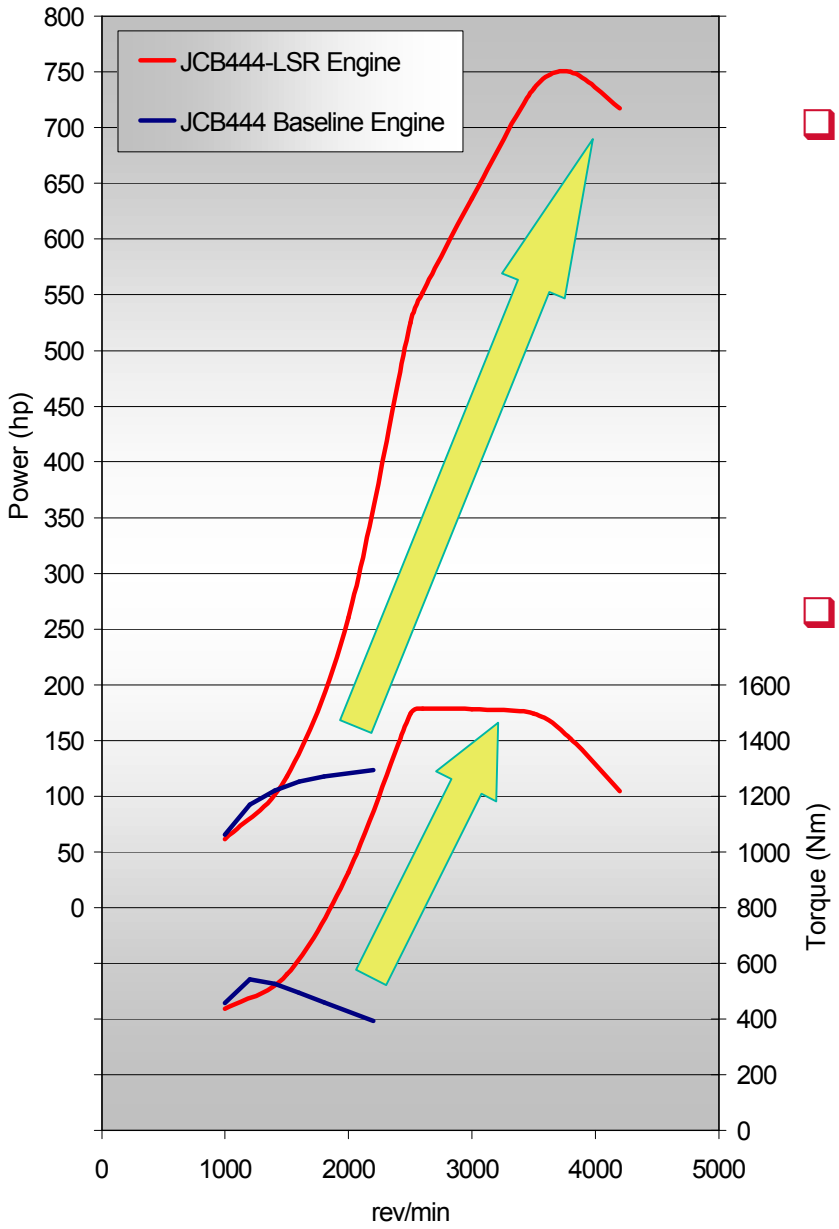
Ice tank | Transmission | Driver cockpit | Transmission

Oil coolers | Oil coolers

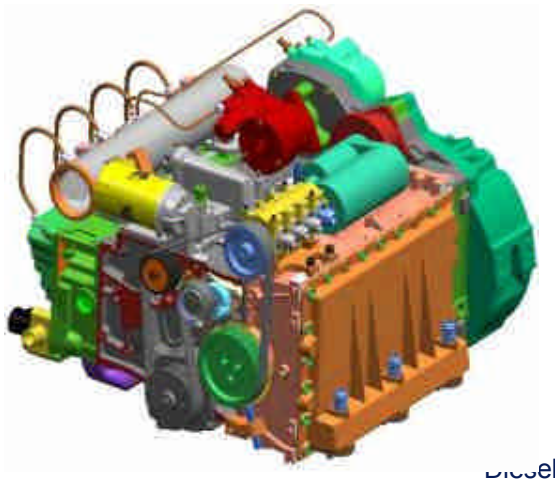


Final drive | Engine | Fuel & Oil Tanks | Engine | Final drive | Parachutes

JCB444-LSR Engine Performance Challenge

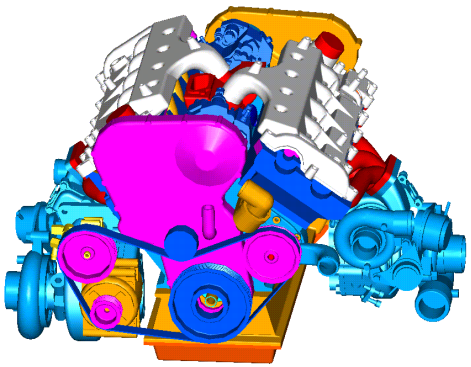


- 125bhp base engine uprated to 750bhp
  - Over 5 times power uprate (150 hp/litre)
  - ~600% increase in airflow, 3.3 tonnes of air per hour required per engine
  - ~450% increase in fuel injected per stroke
  - ~170% increase in engine speed from 2200rpm to 3800rpm
- Bonneville altitude of 1300m results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