COMMERCIAL VEHICLES

Delivering value to the global commercial vehicle industry
Contents

3  Targeted Solutions for Commercial Vehicles

4 Ricardo plc

6 Technology Roadmap for CV

8 Case Studies & Capabilities

9 SARTRE (Safe Road Trains for the Environment)

9 Truck Fuel Consumption Reduction

10 New Heavy Duty Engine for HMC

10 European Commission Framework 7 CORE project

11 Wireless Gear Shift Quality Assessment

11 Department of Energy SuperTruck programme

12 Range extended EV control system

12 Medium & Heavy Duty – Bus application

13 Ricardo Kinergy Technology

14 Hybrid architecture study for global market introduction

14 Technology and business case analysis for hybrid truck

15 LCV Diesel Engine Upgrade for China Market

15 LD / MD Truck for Western OEM Entering Indian Market

16 Europe market entry strategy for one of India’s leading commercial vehicle manufacturers

17 Heavy Duty Truck Transmission Programmes

18 Ricardo Knowledge

20 Ricardo Strategic Consulting

21 Ricardo Software

22 Ricardo’s Global Locations

Ricardo has technology to address the issues that matter to your customers

Globalisation
Our local market knowledge and global reach enable us to deliver world class products to a global market. We provide the product strategy and technology necessary to be competitive

TCO (Total Cost of Ownership)
We understand all aspects of this always balancing cost and benefit

Technology selection
We research and understand the alternatives and can help you select the best path

Legislation compliance
Selection and delivery of the most cost effective solutions to drive down emissions and ensure compliance with legislation in all markets

Ricardo has the expertise and technology to address the key challenges facing your industry
We can support you in all vehicle segments and all regions

Ricardo plc
Commercial Vehicle innovation & world class technology

Who do we work for?
We work for commercial vehicle manufacturers and their major suppliers across the globe

What do we do?
We deliver technical solutions and provide expertise to enable our customers to meet their business aspirations

How do we deliver value?
• By delivering innovative technical solutions that give you a competitive edge
• By enabling you to get products to market more quickly
• By fixing problems that are costing you money
• By taking full responsibility for projects that you do not have capacity to deliver
• By the transfer of our knowledge to your engineers - increasing their value and enabling you to develop your in-house capabilities

We are active in all areas of Commercial Vehicle design and development across the full product life cycle

Ricardo - a history of investment in world-class technology concepts.
Recent technologies include:

Twin Vortex Combustion
Low cost combustion system which enables Tier4 interim emission compliance without aftertreatment

WHR
Ricardo have extensive experience in Waste Heat Recovery System (WHR) technology selection and optimisation

TVFE
Total Vehicle Fuel Efficiency - Tool to enable selection of the most cost effective methods for efficiency improvement for entire vehicle fleets
Technology Roadmap for Commercial Vehicles

Ricardo led a study to produce a consensus roadmap. Assumes breakthrough in energy storage for mass market adoption of energy storage technologies.

- **Drivers**
  - CO₂ reductions limited by air quality regulations
  - LD van CO₂ regulation
  - Possible HD/MD CO₂ regulation

- **2010 - 2050**
  - 2010: Drivers
  - 2020: LD van CO₂ regulation
  - 2030: Possible HD/MD CO₂ regulation
  - 2040: “Zero” Air Quality Impact
  - 2050: National CO₂ Targets

- **Gaseous**
  - CO₂ and GHG reduction

- **Light Duty Cycles**
  - Medium Duty Cycles

- **Technology Areas**
  - Biofuels
  - Waste heat recovery
  - Advanced thermodynamic cycles
  - Powertrain efficiency improvements/ancillary electrification
  - Intelligent vehicles logistics – operational efficiency (On & Off-highway)
  - Advanced highway vehicle aerodynamics/selective lightweighting
  - Fuel cell APUs
  - Plug in hybrid
  - Full hybrid
  - Micro/mild

- **2030 - 2050**
  - 2030: Commercial EVs
  - 2040: Fuel cell vehicles
  - 2050: Fuel cell vehicles

- **2020 - 2050**
  - 2020: Niche EVs
  - 2030: H₂ infrastructure
  - 2040: Demos
  - 2050: “Zero” Air Quality Impact National CO₂ Targets

**Case Studies & Capabilities**

**Truck Fuel Consumption Reduction**

Identify highest impact/lowest cost improvements

**Situation**
- Indian market OEM struggling with uncompetitive fuel economy of commercial vehicle platforms
- Objective of 10-15% fuel economy improvement whilst maintaining performance
- Extremely cost sensitive customer base – hybridization out of scope
- Transfer of tools and methods for fuel economy improvement an important secondary objective

**Delivery**
- Unique Indian drive-cycles used to identify key efficiency drivers, very different from vehicle usage in Western markets
- Predictive modelling and simulation-intensive approach eliminated cost and ‘noise’ associated with testing every option
- Focus on low cost, off the shelf technology as well as design optimization

**Value**
- Range of technical changes able to deliver ~23% improvement in fuel consumption (real world) identified.
- Knowledge transfer through training of customer engineers and supply of comprehensive documentation

**Innovation & Technology**
- Application of Ricardo TVFE (Total Vehicle Fuel Economy) approach to identify highest impact/lowest cost improvements

---

**SARTRE (Safe Road Trains for the Environment)**

Vehicle platooning for improved safety, and reduced emissions and congestion

**Situation**
- European R&D project
- 7 consortium members

**Delivery**
- Project led by Ricardo
- Technology demonstrated on public highway in Barcelona

**Value**
- Estimated 10-20% fuel consumption saving
- Safety benefits from reduction in fatigue and faster response time
- Reduced congestion due to closer traffic spacing

**Innovation & Technology**
- Prototype systems developed to facilitate the safe adoption of road trains on un-modified highways
New Heavy Duty Engine for HMC
Design of new engine family in compressed timescale

Situation
• Hyundai Motor Corp. required a new heavy duty engine for the Korean and global market
• Initial launch at Euro 4, potential for Euro 5/Euro 6
• ~10 litre and 400 hp, 1900 Nm

Delivery
• Ricardo responsible for design
  • High Pmax engine design (220 bar)
  • EGR+ PM-kat for Euro 4
• Targets met through the use of:
  • Design for manufacture, design for assembly
  • Early supplier involvement
  • Early use of CAE
  • Ricardo team of up to 38 engineers
  • Use of local suppliers for turbo, EGR cooler, other parts

Value
• Approach supported fast time to production of world class engine
  • Clean sheet to SOP in 42 months
• Knowledge transfer to HMC engineers enabled them to lead engine development

Innovation & Technology
• EGR and PM-kat combustion solution for Euro IV
• Bedplate design for excellent durability and low noise

European Commission Framework 7 CORE project
Reducing CO₂ emissions by 15% from Euro VI heavy duty engines

Situation
• Project with target to reduce CO₂ emissions by 15% from Euro VI heavy duty engines
• European research project with partners including OEMs and Tier 1 suppliers
• Ricardo target to reduce friction by up to 10%

Delivery
• Project started January 2012, duration up to 4 years
• 16 consortium partners, 5 sub projects
• Subjects covered: downsizing, downspeeding, hybridisation, VVA, high Pmax engines, 2 stage turbocharging, friction reduction, LNG combustion, closed loop combustion control
• Ricardo working with partners Daimler and Federal-Mogul on friction reduction (pistons, rings, bearings, oil type)
• Ricardo will model engine friction, and test new engine parts for friction reduction

Value
• Will generate knowledge on a wide range of technologies to reduce fuel consumption of European heavy truck engines
• Will enhance Ricardo position as leader in friction reduction

Innovation & Technology
• Application and development of Ricardo advance friction analysis tools

GSQA WIRELESS
Duty Cycle Analysis for Fleets & Gear-Shift Quality Assessment

Unique Wireless GSQA Solution for Fleets
An intuitive, comprehensive range of integrated measurement and analysis components that make Gear-Shift Quality Assessment and Duty Cycle Analysis simple.

GSQA Wireless is a low-cost in-vehicle data acquisition device with wireless and 3G capability for deployment in a large number of vehicles at a much lower cost than other solutions to enable the root cause of poor quality shifts to be determined.

With the ability to interface to CAN and other external sensors with its own in-built HMI force and moment sensing capability, GSQA allows data collection both during rig and in-vehicle development, providing repeatable conditions for detailed investigation. GSQA allows measurement of in-gear rattle, shift forces, hysteresis, gate definition, synchroniser feel, shift cable flex etc.

GSQA’s subjective to objective correlation algorithms have been developed on numerous applications for leading manufacturers of passenger, commercial and off-highway vehicles.

GSQA gives you real world fleet data on how your vehicles are being used, to help resolve gear shift issues or for use in future development programmes.

Department of Energy SuperTruck programme
Developing hybrid technology solutions for 50% improvement in freight efficiency

Situation
• Ricardo are working with Navistar on a US DOE funded project that is part of the SuperTruck programme
• The SuperTruck target is to demonstrate a 50% improvement in freight efficiency for a class 8 truck measured in ton miles/gallon

Value
• Fuel-saving features provided by the hybrid system
  • Electric vehicle capability
  • Efficient high speed operation
  • Substantial brake energy recovery

Delivery
• Ricardo’s role in the project:
  • Preliminary fuel economy benefits project using system modeling & simulation
  • Hybrid supervisory control development & implementation to coordinate operation of complex hybrid powertrain components
  • Prototype truck (2nd truck ongoing) mechanical and electrical integration (build) support for the hybrid systems and electric accessories
  • Advanced hybrid system driver interface design and implementation

Navistar has granted permission to use their name and images in this case study.
Range-extended EV control system
Robust and rapid implementation

Situation
- Ricardo is supporting a lightweight van RE-EV development project
- New ground-up aluminium vehicle with composite panels
- Currently in demonstration phase the vehicle has a 2014 Start of Production date

Delivery
- Development and supply of vehicle controller
- Ricardo Sentience technology – applies telematics, navigation and intelligent mapping for forward planning
- Detailed simulation for performance including emissions
- Test and integration support for prototype builds

Value
- Proven Ricardo simulation enabled specification of key components to be confirmed with confidence
- Robust and rapid implementation of electrical architecture and control system
- Sentience technology improves fuel consumption at very little extra cost
- Previous application on a hybrid SUV achieved a reduction in fuel consumption of up to 24% for an additional cost estimate of €20,000

Medium & Heavy Duty – Bus application
Real world FE improvement >10% on a Hybrid Bus

Situation
- OEM had tested a micro hybrid bus on known city cycles
- The measured fuel consumption saving was not as expected or required – need to exceed a minimum of 10% improvement (target 12%)
- The OEM was preparing for a small fleet build and urgently needed to demonstrate significant improvements in realised fuel economy

Delivery
- Review the hybrid architecture and implementation against the project requirements
- Carry out simulation of performance and fuel consumption ‘quick wins’
- Review BSG, Hybrid controller and fan system to recommend changes to meet specification
- Knowledge transfer of best practice for BSG systems and strategies

Value
- Simulation of improvements predicted fuel consumption improvement of 10-14%
- OEM measured results confirmed a 12% FC saving
- Problems fixed and targets met

Ricardo Flywheel Technology
Mechanical energy storage

Situation
- Battery based energy storage systems are heavy and expensive which limits their application despite fuel consumption savings

Delivery
- Ricardo is developing a flywheel based energy storage system
  - Funded by Ricardo and government programmes
  - The system has significant technical advantages
  - Extensive rig testing completed and application project on a bus

Value
- System provides a more cost effective way to store and recover energy
- Target cost significantly less than battery or super capacitor
- This improved cost/benefit will enable more vehicles to be fitted with fuel saving technology

Innovation & Technology
- Innovative magnetic drive eliminates the need for vacuum seals and pump
- Ricardo has developed expertise in all components of a mechanical hybrid system and has a suite of IP that is available to customers
Hybrid architecture study for global market introduction

**Situation**
OEM needed to understand:
- Current hybrid market
- Variation of drive cycles over major world market territories

**Delivery**
- Market review of current MD/HD hybrid products, incentives in global markets for subsidy/in-life-use cost reduction and road pattern (drive cycle) analysis to realise the benefits of hybridisation
- Review of hybrid architectures and additional technical solutions (advanced engine downsizing/desaturation and vehicle level modifications)
- Initial architecture development including preliminary motor & battery sizing and electrical ancillaries selection

**Value**
- Delivery of hybrid architecture schemes for 4 different MD/HD applications (bus and truck)
- Customer better positioned to make the correct business decisions about hybridisation

Technology and business case analysis for hybrid truck

**Situation**
- Client was reviewing the business plan to introduce their own hybrid light truck
- They had several options to analyse but no experience of hybrid development
- Ricardo acted as an independent assessor of the technology and business case

**Delivery**
- Technical leadership
- Review Tier 1 proposals
- Define the optimum architecture and technology
- Define modifications required to the powertrain and vehicle systems for the hybrid system integration
- Carry out detailed cost/benefit analysis and market analysis
- Knowledge transfer of best practice for hybrid systems and strategies

**Value**
- Business case approved by client board. Project kicked off to first demonstrator
- Ricardo supported the hybrid systems development and optimisation on the first demonstrator
- Vehicle testing proved the concept met the targets for FC saving, performance and cost

LCV Diesel Engine Upgrade for China Market

**Situation**
- Chinese OEM wants to introduce a diesel powertrain (3WD and 4WD) into its LCV products in China (Pick-Up and SUV)
- Diesel powertrain upgrade to include ability to offer Euro III and Euro IV products (MT)
- Concept confirmation to production to be delivered in 12-15 months with significant local parts content

**Delivery**
- Maximize powertrain and vehicle systems commonality with existing global platforms
- Review Chinese market legislative requirements and ensure that identified solution meets all requirements
- Complete full package DMU of 2WD and 4WD platforms
- Complete all concept and detailed design activities (3D and 2D) including any supporting CAE analysis
- Prototype vehicle manufacture in China, including hand modified electrical harnesses and sign-off tests

**Value**
- All design concepts completed and approved by Western OEM partner
- All supply sources (KD versus local versus new) identified and agreed with Purchasing
- Detailed design activities completed and prototype parts procurement on-time
- Prototype vehicle builds all completed to schedule with fully documented problem logs
- All production prove-out and homologation activities scheduled to meet job#1 target date

LD / MD Truck for Western OEM Entering Indian Market

**Situation**
- Western OEM wants full vehicle engineering support until their own engineering capabilities and capacity had been established in market
- Complete engineering support required from vehicle specification through to styling, design, CAE analysis, prototype build and sign-off testing

**Delivery**
- Review of legacy product and Indian market legislative profile and gap analysis
- Legacy data capture and complete DMU (Digital Mock-up) of platform variants
- Complete cab styling development, ergonomics and structural analysis
- Full CAE analysis of vehicle performance, vehicle dynamics, NVH, thermal, chassis durability
- Electrical systems design, circuit design, harness design
- Prototype vehicle manufacture and sign-off testing

**Value**
- Complete vehicle data pack generated and handed over to customer on schedule and quality
- Styling and engineering design fully approved by OEM
- Full supplier liaison, including on-site supplier assessment and management of prototype parts procurement
- All prototype vehicles built and tested to schedule, in accordance with approved validation plan – minimal rework required to achieve targets
Europe market entry strategy for one of India’s leading commercial vehicle manufacturers

Strategic support for global product

**Situation**
- Indian OEM was exploring opportunities to enter Europe
- Support required to develop market and product strategy, to form business case for Europe
- Development of European strategy based on market projections, customer survey based market research, competitive profiles, sales & service requirements, product benchmarking, technology and legislative scenario

**Delivery**
- Analysis of OEM’s existing product capabilities
- Extensive research of public domain information
- Analysis of purchased market research
- Development of sales forecasts by segment, product family and region
- Coordination of market research
- Development of scenarios for segments, aggregates, regions for development of business case

**Value**
- Delivered clarity of the market to enable OEM to make important decisions with regards to region and product portfolio for Europe:
  - Potential opportunities in European CV market
  - Product expectations of European customers
  - Business case viability of various entry scenarios
  - Product portfolio, organizational and investment requirements for entry into Europe
  - Quality and reliability requirements for Europe

---

**9 Speed M/T**
- New 9 speed manual transmission for Asian heavy duty truck markets
- Concept design, layout and geometry optimization, and supporting analysis
- Review of client’s detail drawings
- Support through all development and validation phases

**9 Speed M/T Range Unit**
- Design of range section of new 9sp M/T being developed by a major Japanese OEM
- Concept design with basic supporting analysis
- Detailed design, detailed drawings and full supporting analysis

**DCT**
- Concept design for a new DCT for an established US manufacturer not currently in the commercial vehicle transmissions business
- Reviewed use of existing torque converter, wet clutch assemblies and synchronisers
- Reviewed cost saving concepts for actuation and hydraulics

**10 Speed M/T**
- New 10 speed manual transmission for an Asian Tier 1
- Concept design, layout optimisation and supporting analysis
- Review of all client’s detail drawings
- Specification, design & supply of 4 square test rig for durability testing
- Support through all development and validation phases

---

Ricardo are the leading independent developers of Transmission Systems, including DCT, MT, AT, AMT, CVT and conventional Powershift.
Ricardo Knowledge is a specialist team who are on hand to listen to your requests and technical challenges of the diverse and complex industries that our engineering capabilities encompass. Join the major OEMs and Tier 1 suppliers already using Ricardo Knowledge to support and sustain their future strategies. Our services include:

Technical Assistance
Training
Information Services

Choose your package

Insight
- Annual meeting with Ricardo specialist
- 5% off Information Services
- One place on a scheduled training course of your choice

Classic
- Dedicated account manager
- 25+ hours of Technical Assistance
- Annual meeting with Ricardo specialist
- One place on two scheduled training courses of your choice
- Discount on further scheduled training courses
- 10% off Information Services

Digital
- Dedicated account manager
- Ricardo Knowledge online client portal
- 50+ hours of Technical Assistance
- Annual meeting with Ricardo specialist
- Two places on two scheduled training courses of your choice
- Discount on further scheduled training courses
- 15% off Information Services

£5k

£20k+

Visit www.ricardo.com/knowledge

Contact
Glen Hall
Manager, Ricardo Knowledge
Tel: +44 (0)1273 794469
Email: glen.hall@ricardo.com

EMLEG Emissions Legislation Service
Keep up-to-date without the need for time-consuming and expensive monitoring

A Ricardo EMLEG subscription provides online access to a detailed emissions legislation database and live enquiry service. Our world-class engine, vehicle design and development experience enables Ricardo staff to provide relevant and concise summary information on current and future emissions limits, test procedures, on-board diagnostics requirements and fuel standards.

Key benefits

Comprehensive reference information is provided so that source material can be accessed. Emissions legislation is evolving at a rapid pace and the database is under continuous revision by Ricardo specialists who are also available to respond to specific, emissions legislation enquiries from EMLEG clients.

Scope
- All regions of the world where information is available
- All reciprocating engine and hybrid applications and all fuels, including gasoline, diesel, bio-fuels, LPG and CNG. All sizes covered (from small, hand held to stationary and marine)

Source material
- Online links to source material are provided, where available.

Content
- Emission limits, test procedures, on-board diagnostics, fuel standards, historical data and downloadable summary slides

The database and enquiry service allows clients to keep up-to-date with legislative requirements without the need for time consuming and expensive monitoring. The EMLEG service includes regular e-mail bulletins listing updates so that keeping track is made even simpler.
Ricardo Strategic Consulting is the global management consulting subsidiary of Ricardo Group and is a natural extension of Ricardo’s high value-added engineering services in the automotive sector. Ricardo is therefore very different from the traditional management consulting firms working in the automotive industry. We bring to each client a deep, detailed industry, product and technical knowledge that other management consulting firms simply lack. We bring industry expertise to our clients that is unparalleled in our sector. As a Ricardo client, you always receive practical, implementable solutions expressed in clear language.
Ricardo’s Corporate Strategy

Ricardo is a global world-class, multi-industry consultancy for engineering, technology, project innovation and strategy. With a century of delivering value, we employ over 1700 professional consultants, engineers and staff world-wide.

Global test facilities

78 engine test facilities
Steady state, semi anechoic and high dynamic test beds. Road Load Simulation (RLS), Constant Volume Sampler (CVS) and heavy duty transient capability.

Performance and emissions beds. Steady state and dynamic. Configurable to utilise advanced techniques such as auto-mapping and Vehicle Calibration on Testbed (VCOT).

Durability beds configurable to undertake most current test sequences including those with thermal, shock and motoring stages. Operation on a 24/7 schedule as appropriate.

Prototype manufacturing and assembly
Fully equipped manufacturing and inspection workshops capable of low-volume production capability.

Emissions chassis dynamometers up to 150kW climatic capability (-25 to +40°C). Dedicated gasoline dilution tunnels, motorcycle emissions, durability and semi anechoic vehicle chamber for emissions testing, calibration development, NVH development and durability testing.

Chemistry
Full chemical capability. On- and off-line techniques (GC, MS, FTIR, TGA).

Intelligent Transport Systems
Hardware in the loop (HiL) is used to replace or supplement the validation of ECUs & systems on vehicles or test beds.
The information provided in this brochure contains merely general descriptions or characteristics of performance which in case of actual use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract. Availability and technical specifications are subject to change without notice.

Contact

Simon Mall
Head of Commercial Vehicles
E-mail: Simon.Mall@ricardo.com
Tel: +44(0)1273 794191
Mob: +44 (0)7880 746212

Ricardo UK
Shoreham Technical Centre
Shoreham-by-Sea
West Sussex
BN43 5FG
UK
Tel: +44 (0)1273 455611

Or your local office, details from www.ricardo.com

Sector Focus

Ricardo delivers increased value and sustainable solutions to a number of market sectors:

- Passenger Cars
- Commercial Vehicles
- Agricultural & Industrial Vehicles
- Motorcycles & Personal Transportation
- High Performance Vehicles & Motorsport
- Clean Energy & Power Generation
- Marine
- Rail
- Defence
- Government

The information provided in this brochure contains merely general descriptions or characteristics of performance which in case of actual use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract. Availability and technical specifications are subject to change without notice.