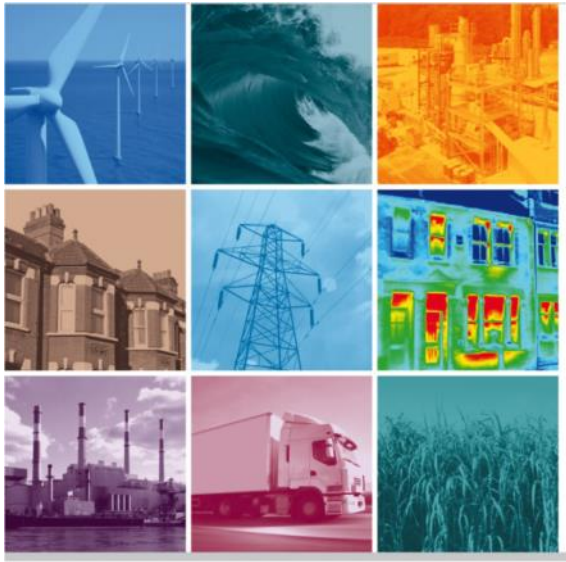

energy technologies institute

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Delivering increased real world fuel efficiency and reduced GHG intensity in Heavy Duty Vehicles

Chris Thorne, CTO – HDV, Energy Technologies Institute

ETI10 TEN YEARS OF INNOVATION 2007 – 2017

Introduction

- What is the Energy Technologies Institute and what are we trying to achieve with Heavy Duty Vehicles (HDV)
- What the ETI is doing to deliver real world benefits in HDV fuel economy
- Next steps for the programme
- Summary

What is the ETI?

- The ETI is a public-private partnership between global energy and engineering companies and the UK Government

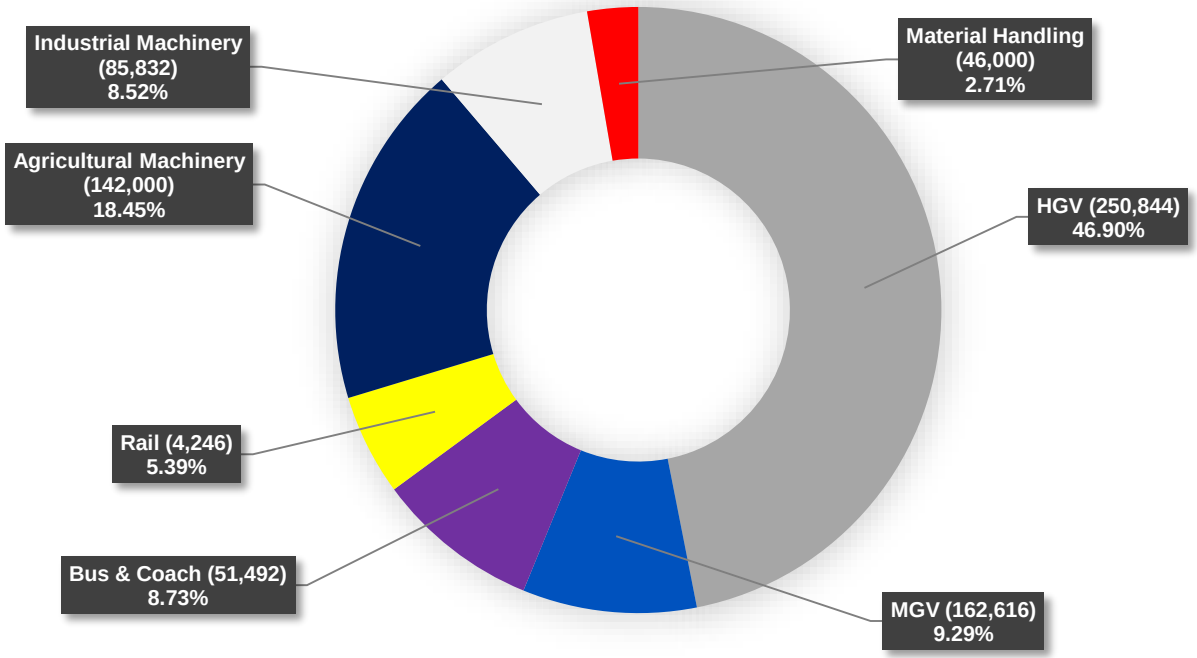
Delivering...

- Targeted development, demonstration and de-risking of new technologies for affordable and secure energy

- Shared risk

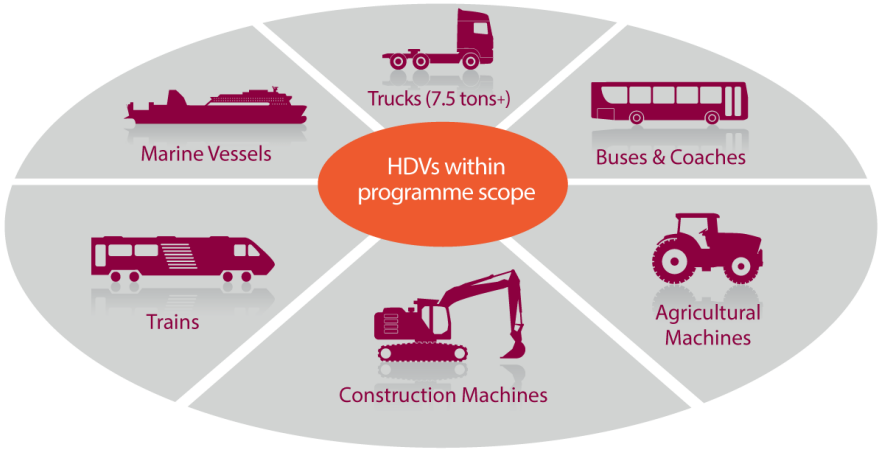
ETI members

UK Land HDV CO_2 Emission Contributors



Source: Ricardo Project Data (DfT & NAEI Data), ETI Phase 1 Project Data, ETI Analysis.

HDV Programme Overview



Why is HDV efficiency so important?

8% of current UK CO_2 emissions are from HDVs

Proportion is set to increase to approx 30% as other sectors reduce CO_2

Limited options for low-carbon fuel alternatives

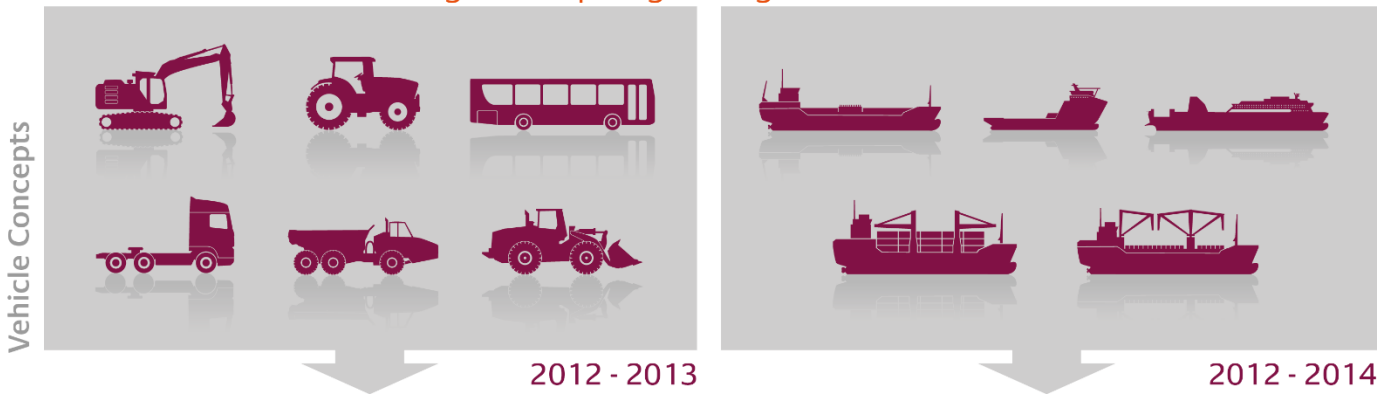
Modelled scenarios consistently point to HDV efficiency as cost-effective way to reduce emissions

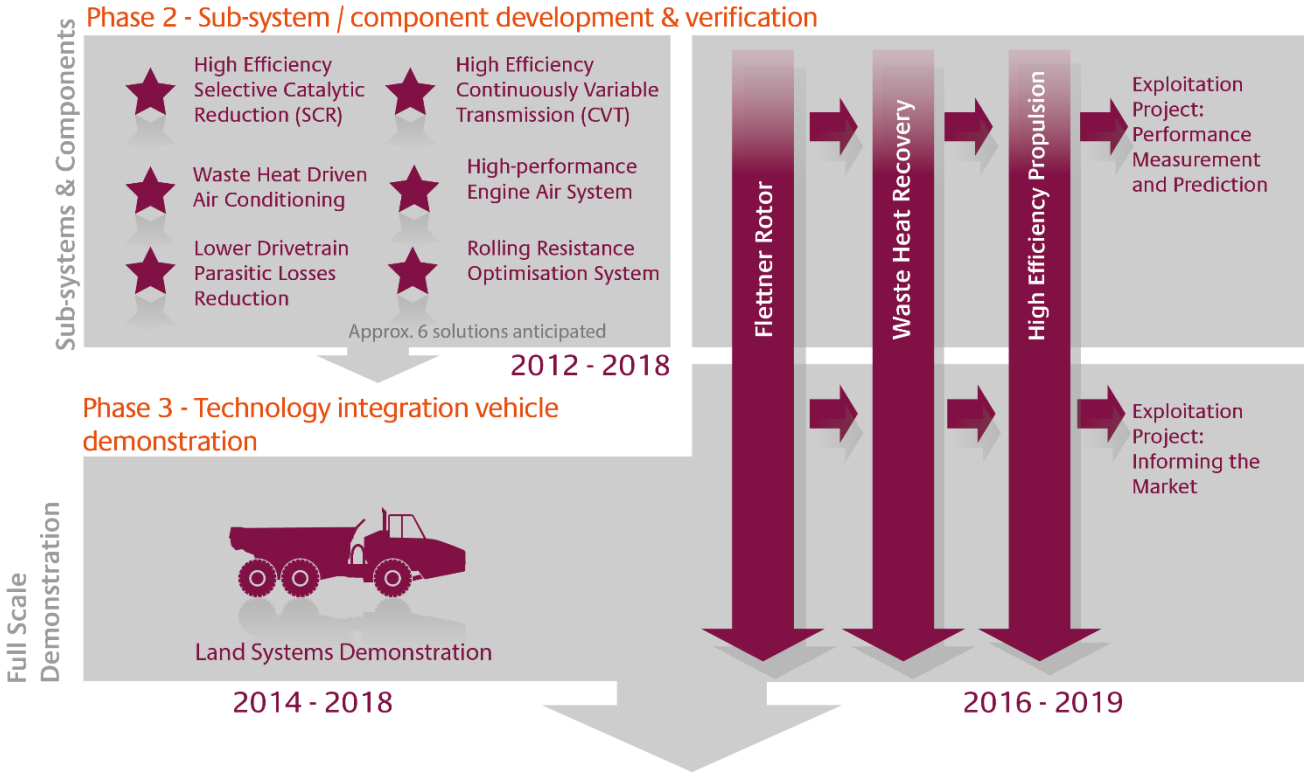
Objectives

- Develop new **vehicle concepts**
- Develop new **technologies** to support concepts
- Produce **demonstration vehicles** that are 30% more efficient
- **Develop supply chain** to enable meaningful market deployment

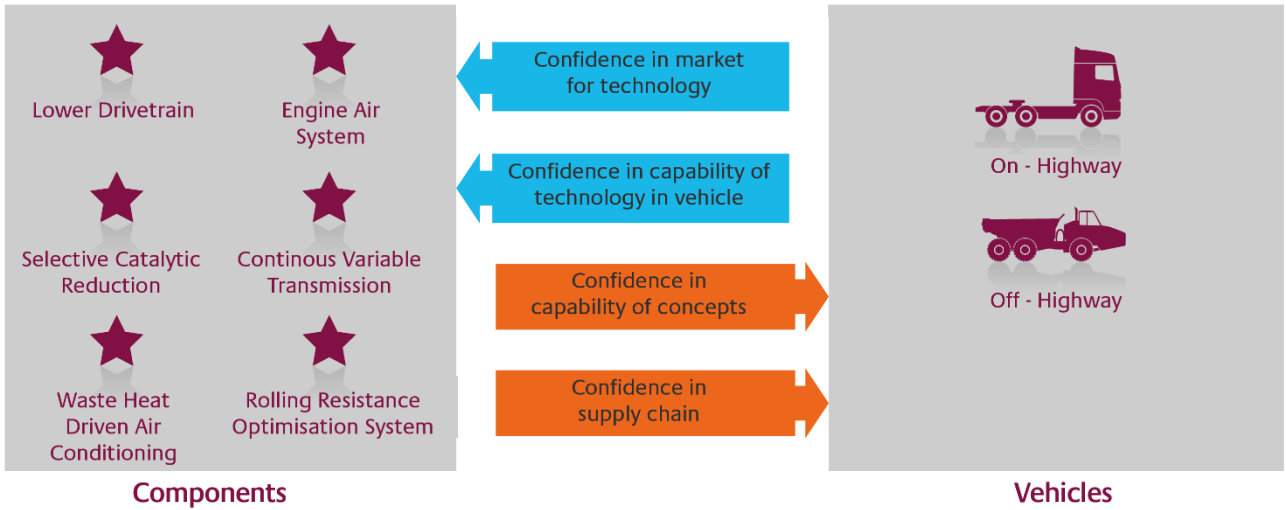
Enable substantial reduction in CO_2 emissions across sector

Phase 1 - Market understanding & concept engineering

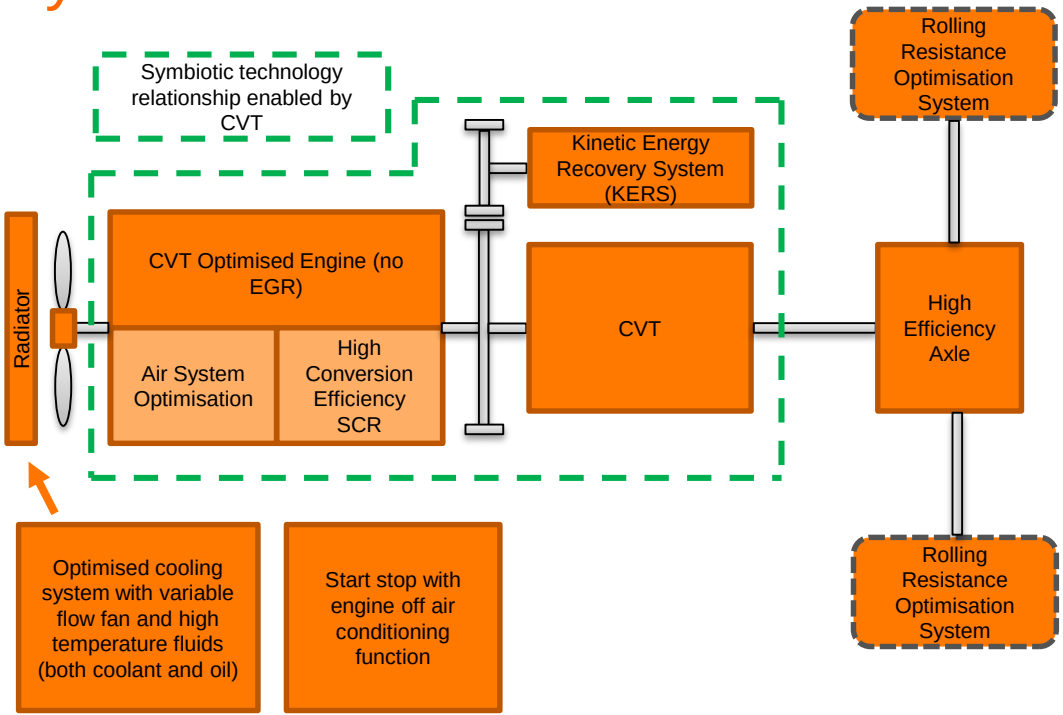




Outcomes



System Architecture



Symbiotic benefits include:

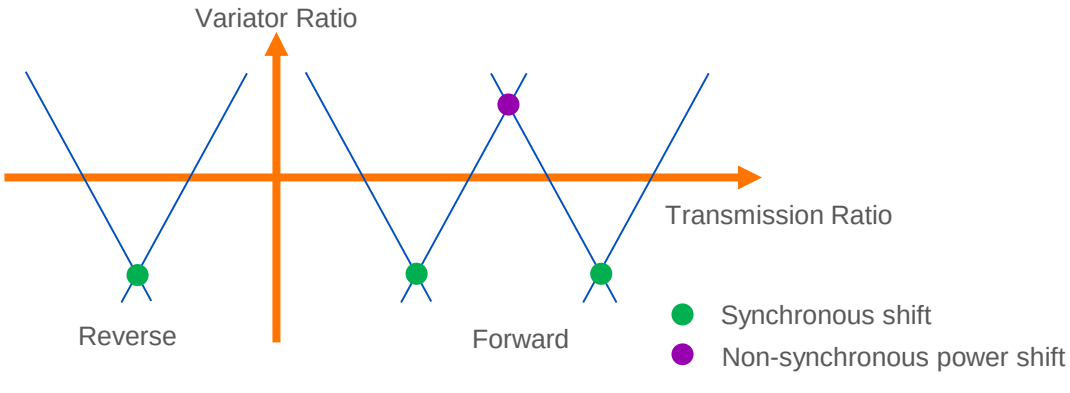
- Best fuel consumption running line
- Better match between engine and turbomachinery characteristics (e.g. less compressor map width needed)
- Air flow better matched to engine power and therefore higher average exhaust temperatures – good for SCR
- Smaller speed range at KERS connection point
- No torque interrupts – good for KERS integration
- Smaller engine speed range good for ancillary parasitics
- Etc…

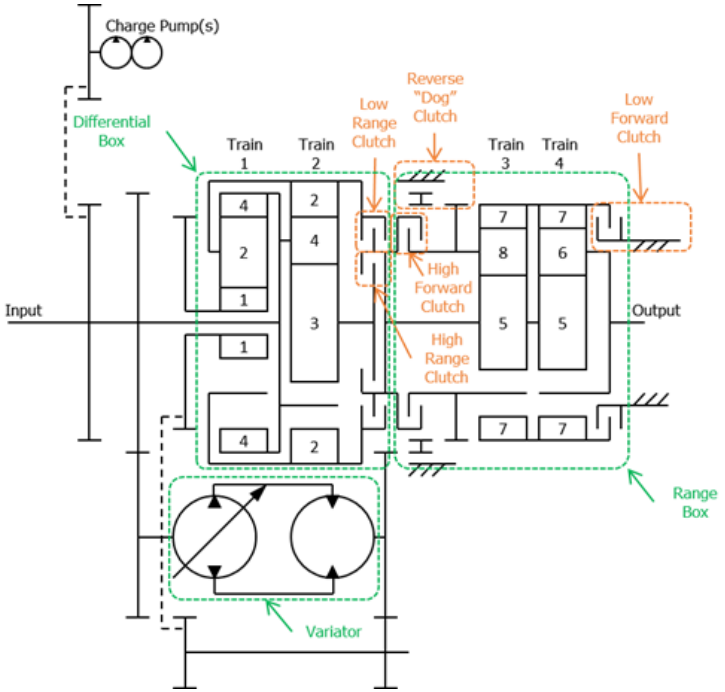
Continuously Variable Transmission – An example

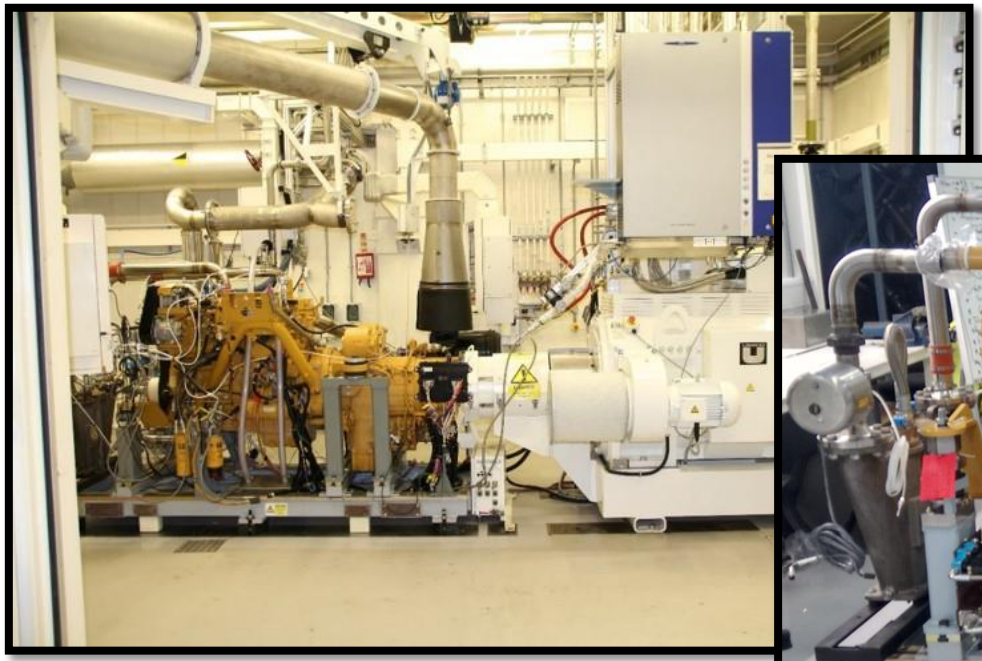
- The project objective was to develop a platform transmission technology that:
  - is applicable to both on and off-highway ‘hauling’ applications;
  - has high efficiency (especially in the HGV application);
  - provides a positive end-user cost vs payback (based upon fuel savings);
  - has fast ratio response capability; and
  - represents a low technical and market risk option to Tier 1s, OEMs and end users.

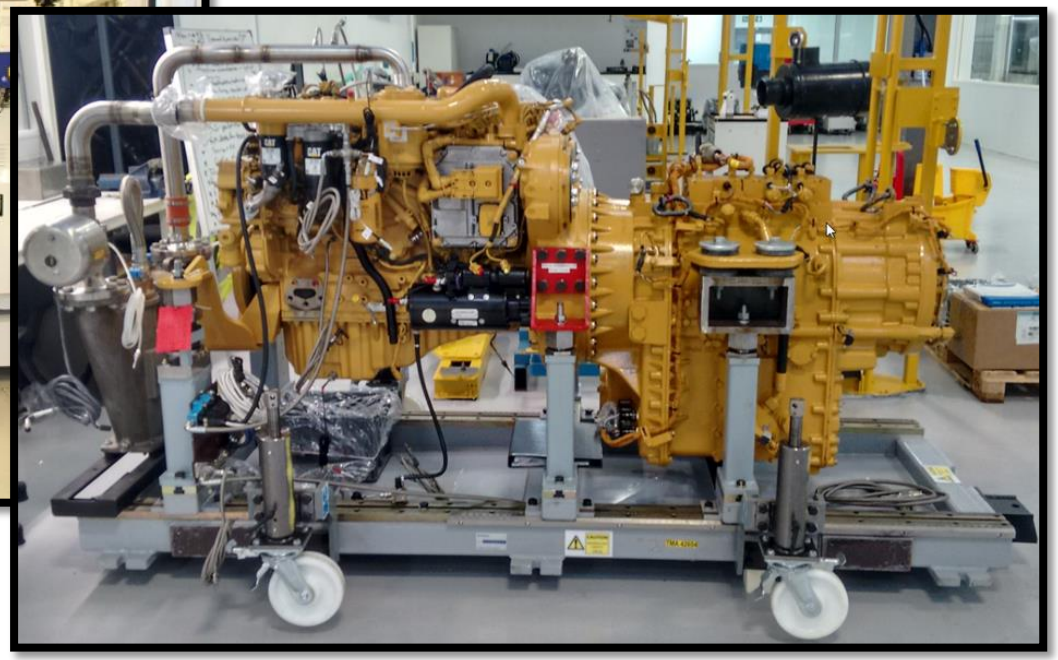
Continuously Variable Transmission Project

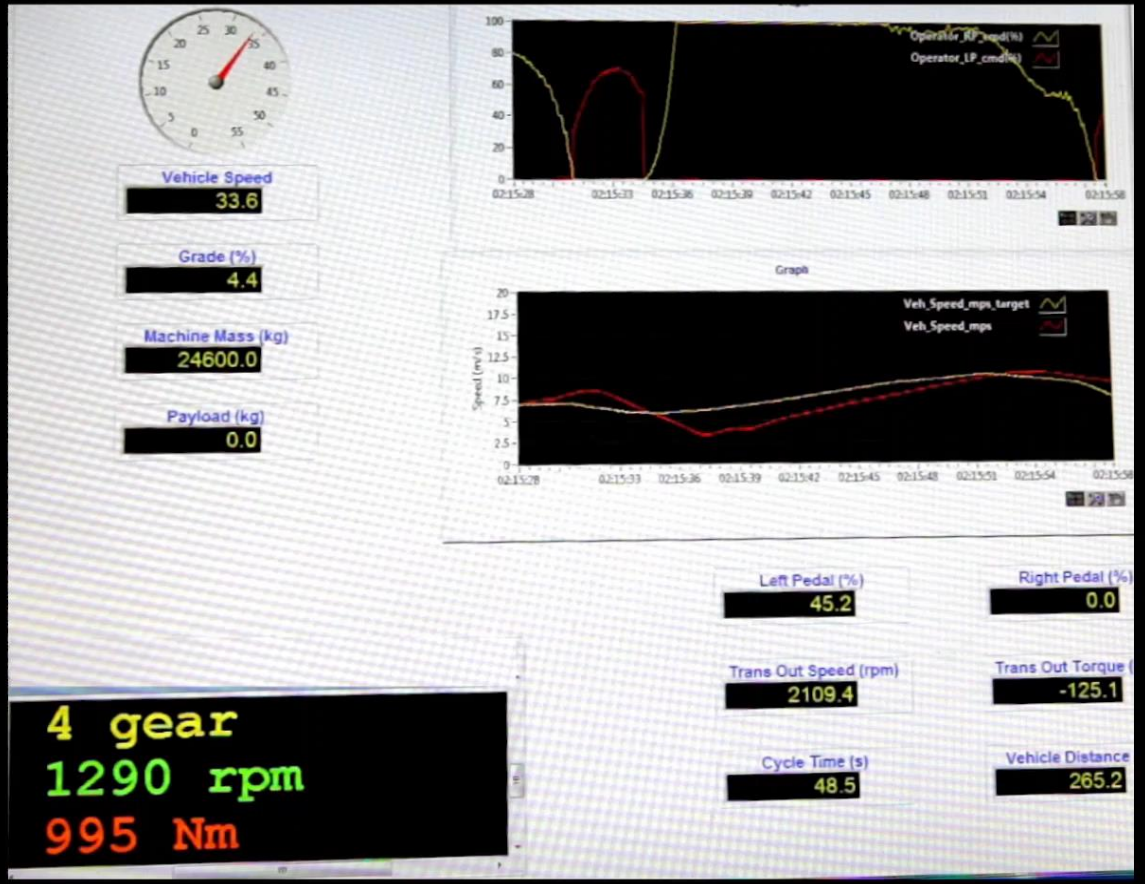
- Input coupled split path hydro-mechanical CVT
- With 2 synchronous shifts and 1 non-synchronous power shift in the forward range
- Tested peak efficiency of 94% (with scope to improve)
- Large ratio range capability



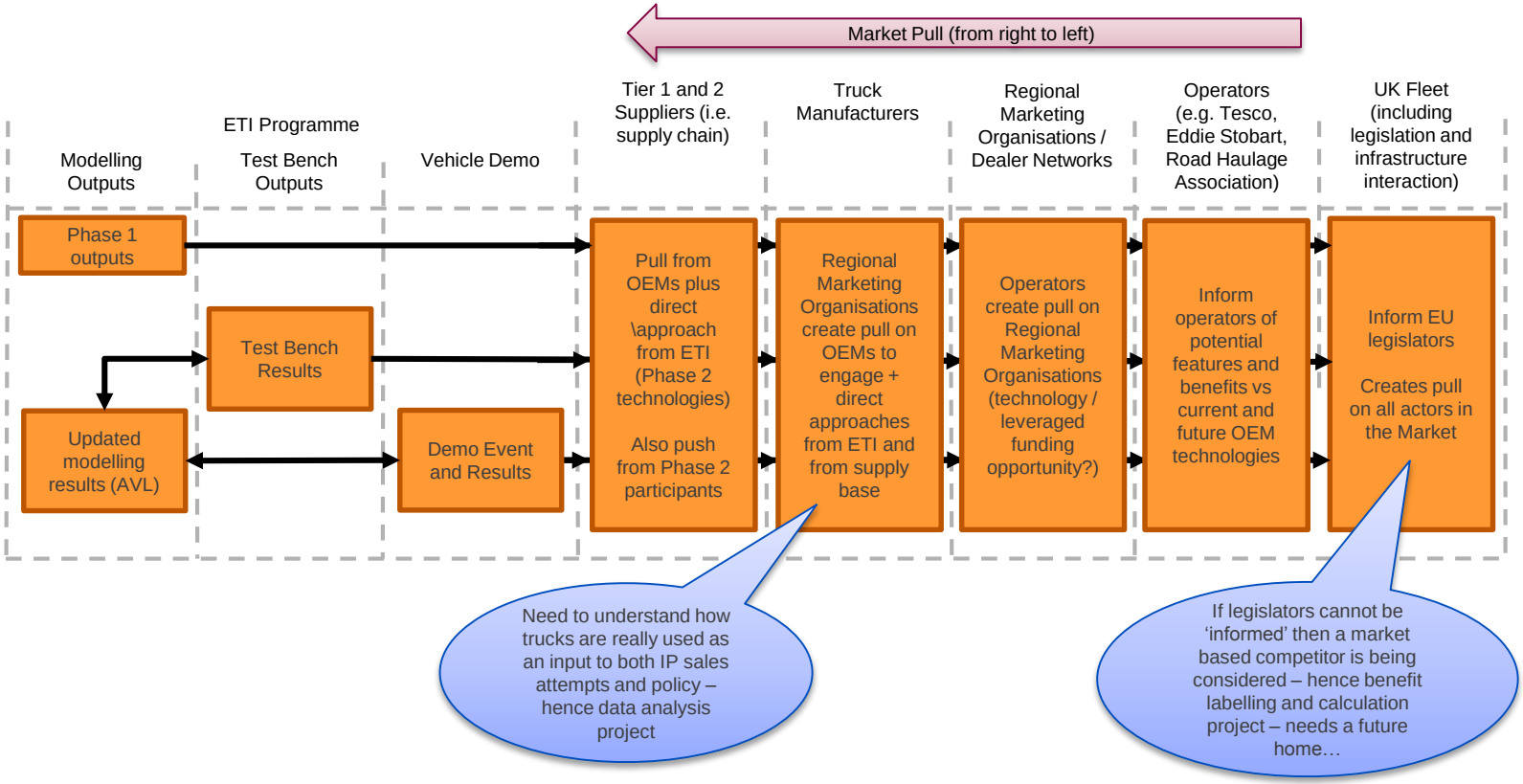








To bring about a meaningful change to the fuel efficiency and GHG intensity of the UK HDV fleets



Next Steps

Technology

- Conclude real world use project this summer (also feeds into Market and Policy work)
- Conclude physical testing of Engine + Aftertreatment + KERS + CVT package (in mid 2018)
- Complete testing of off-highway vehicle with the above technologies (in late 2018)
- Perform a HGV focussed modelling exercise with AVL using AVL-CRUISE™ to integrate and optimise the benefits of the various ETI projects, including CVT (in late 2017 / early 2018)
- Offer outcomes and technology to Tier 1s and OEMs operating in on-highway markets

Market / Policy

- Look at VECTO and compare to real world test data and other modelling tools
- Looking at market based alternatives to VECTO (i.e. information barrier removal)
- Future HGV in the context of the UK energy system

Conclusions

- ETI has identified HDVs as a key sector in decarbonising the UK energy system (with the potential for a paradigm shift in thinking needed) – evidence to come in Matt's presentation
- Therefore, the ETI is running a technology development and demonstration programme to try to improve HDV efficiency in the medium term (2025 – 2035)
- One of the projects within this programme is the development of a CVT transmission which is applicable to a wide range of vehicle / machine types
- The most challenging application is line-haul HGVs; however, the 'whole systems' perspective has shown potential to deliver increased efficiency
- The ETI is seeking industrial input to ensure its work with AVL is as relevant as possible and that the technology has an on-highway route to market
- Looking to integrate medium term approach with potential scenarios 2035 – 2050 such that infrastructure and OEM investments can be minimised

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