www.eti.co.uk

Heavy Duty Vehicle Programme

Presentation to the Construction Equipment Association — 10th June 2014

Chris Thorne – HDV Strategy and Programme Manager

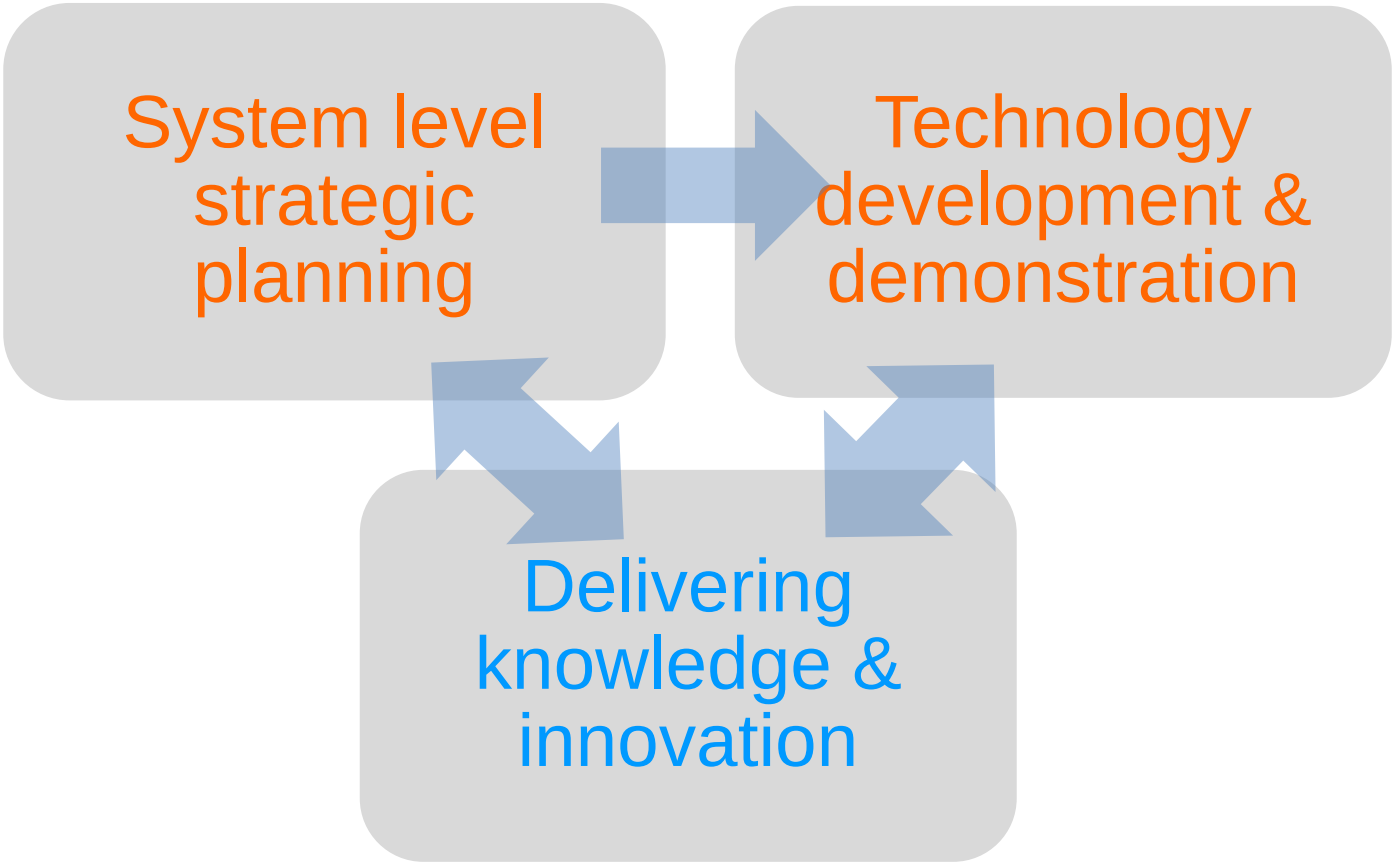
What is the ETI?

- The Energy Technologies Institute (ETI) is a public-private partnership between global industries and UK Government

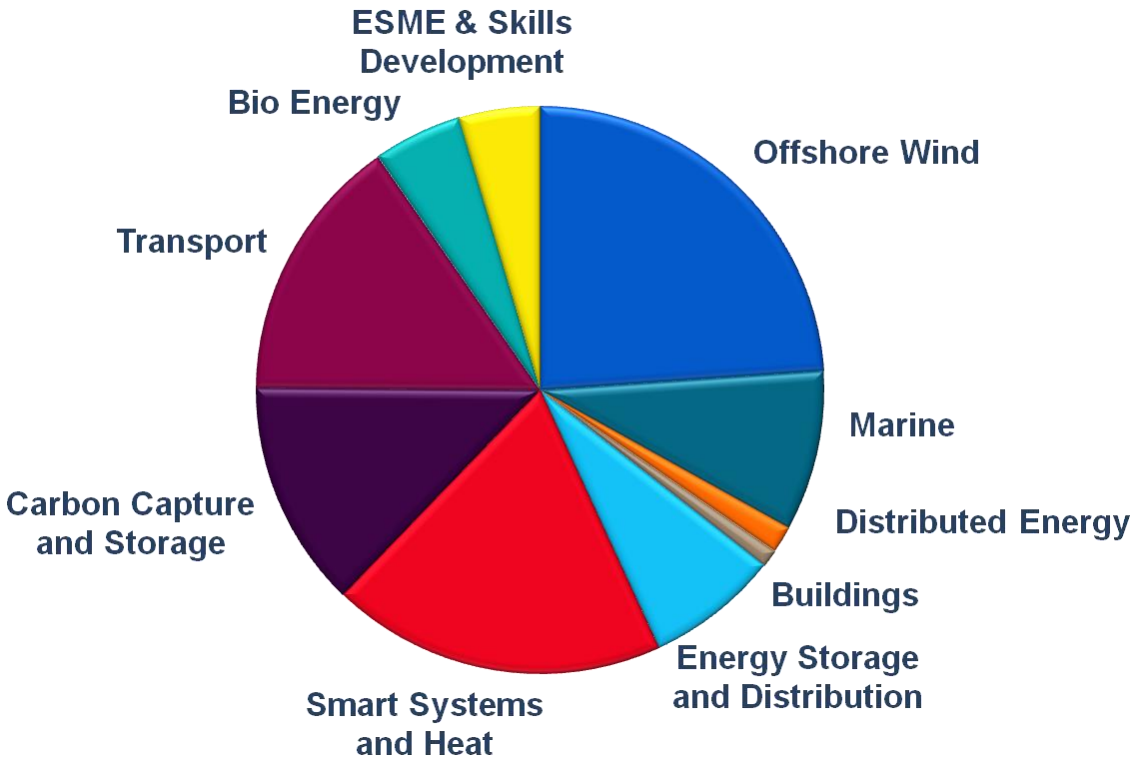
Delivering...

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

What is the ETI?



ETI Invests in projects at 3 levels



9 Technology Programme areas

Delivering...

New knowledge

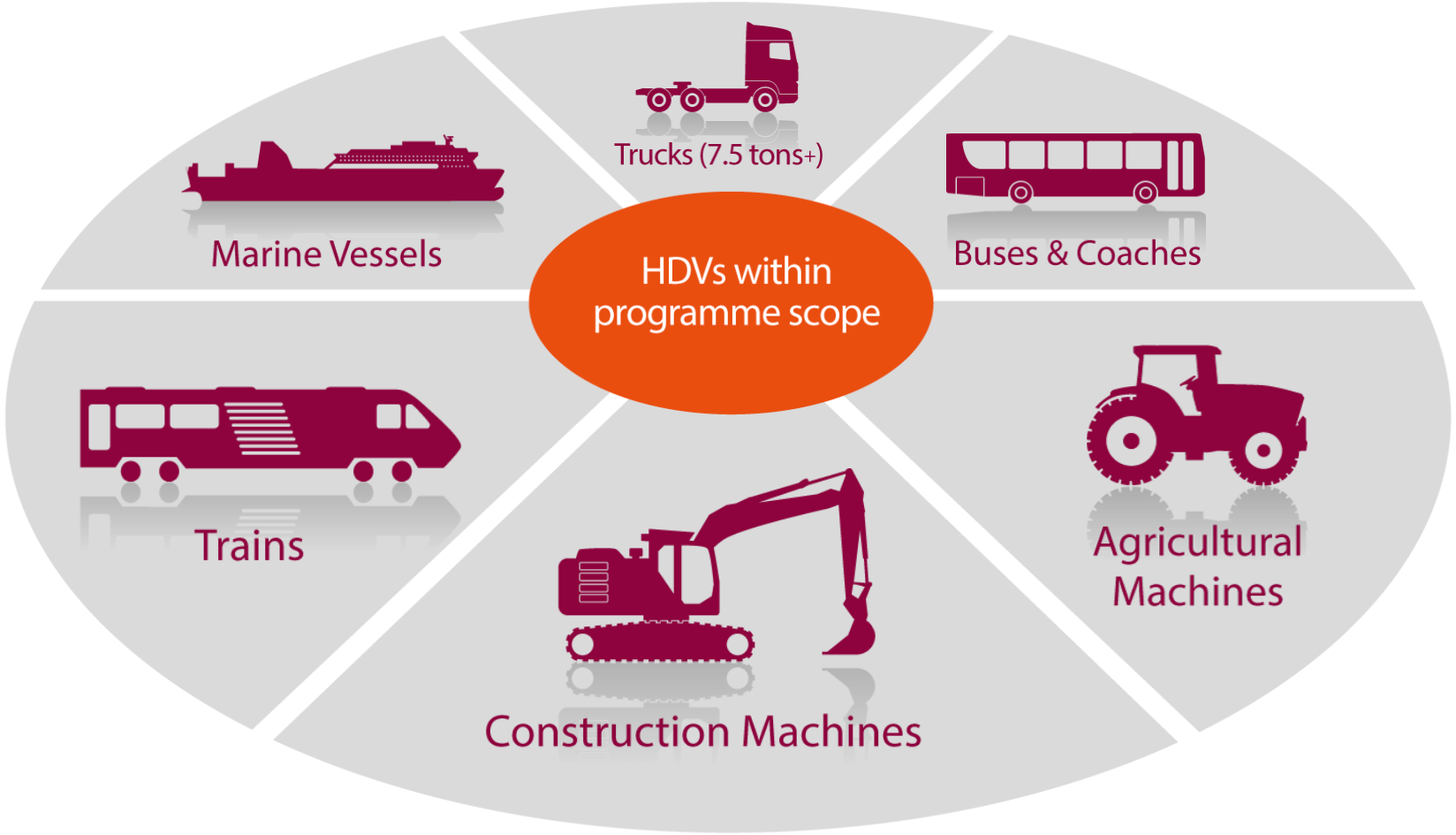
Technology development

Technology demonstration

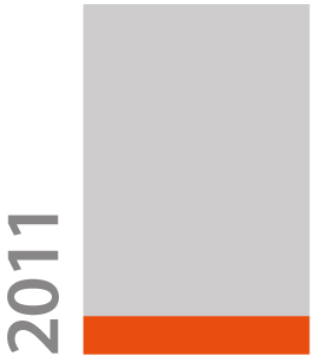
Reduced risk

The ETI works with:

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

- Modelled scenarios consistently point to HDV efficiency as cost-effective way to reduce emissions
- Limited options for low-carbon fuel alternatives

HDV Activities at the ETI

- Two main threads

HDV Efficiency

£40M+ Technology Development and Demonstration Programme

2012 – 2019

Gas as a HDV Fuel

Strategy Phase

2013 – onwards

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HDV Efficiency

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Objectives

Develop new **vehicle concepts**

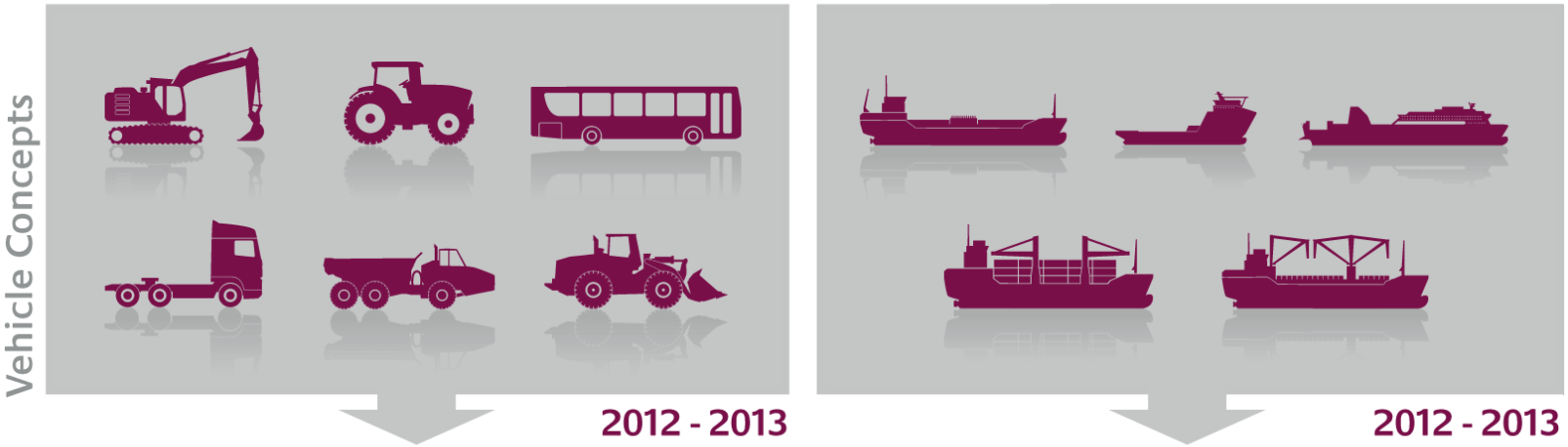
Develop new **technologies** to support concepts

Produce **demonstration vehicles** that are 30% more efficient

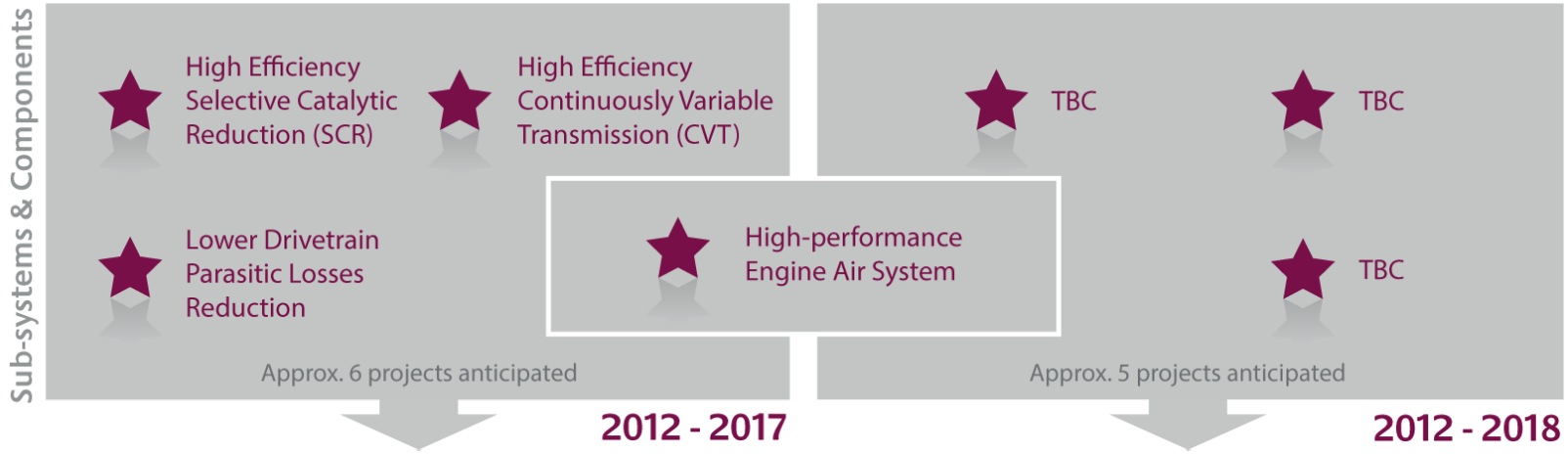
Develop supply chain to enable meaningful market deployment

Enable substantial reduction in CO_2 emissions across sector

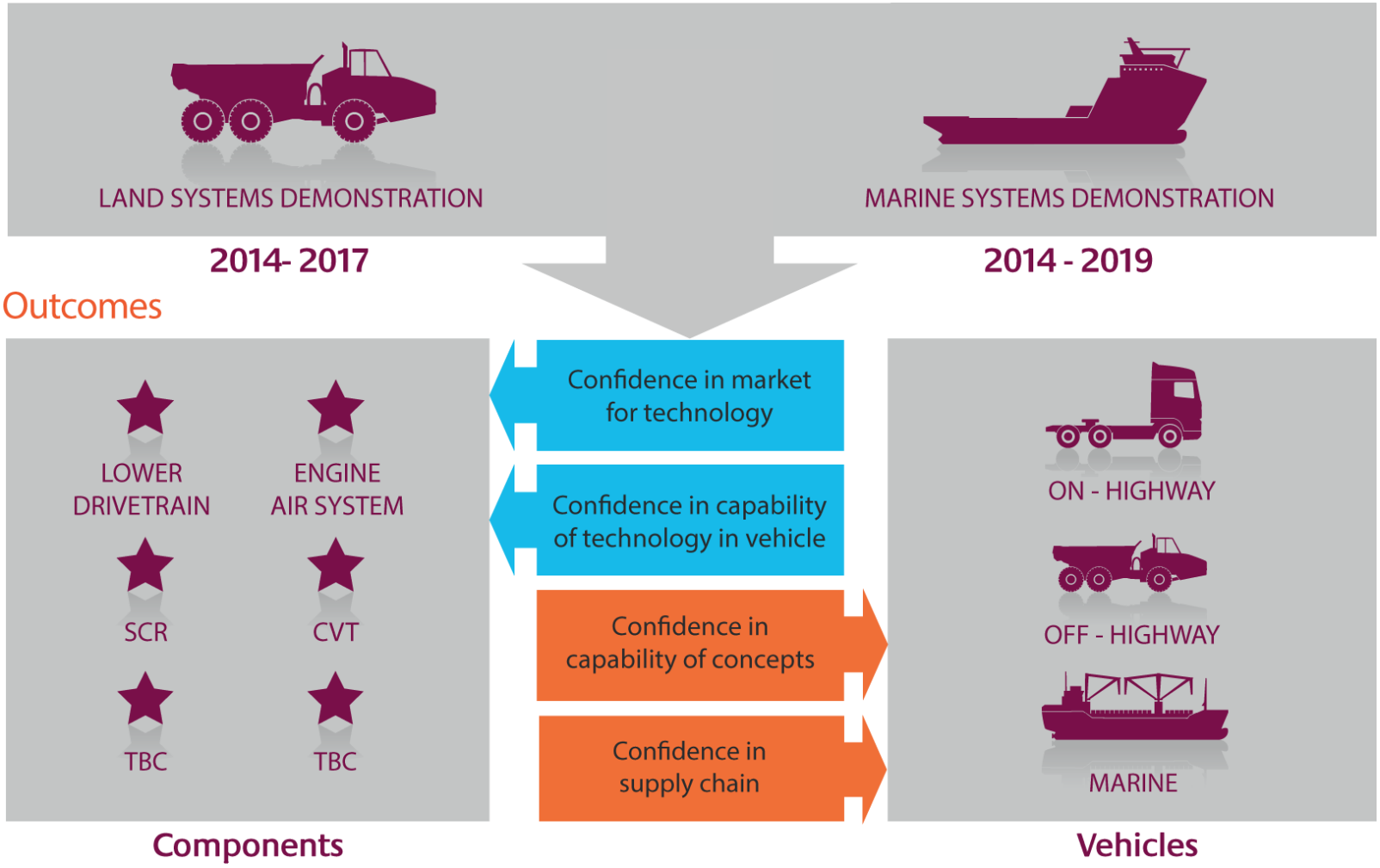
Phase 1 - Market understanding & concept engineering



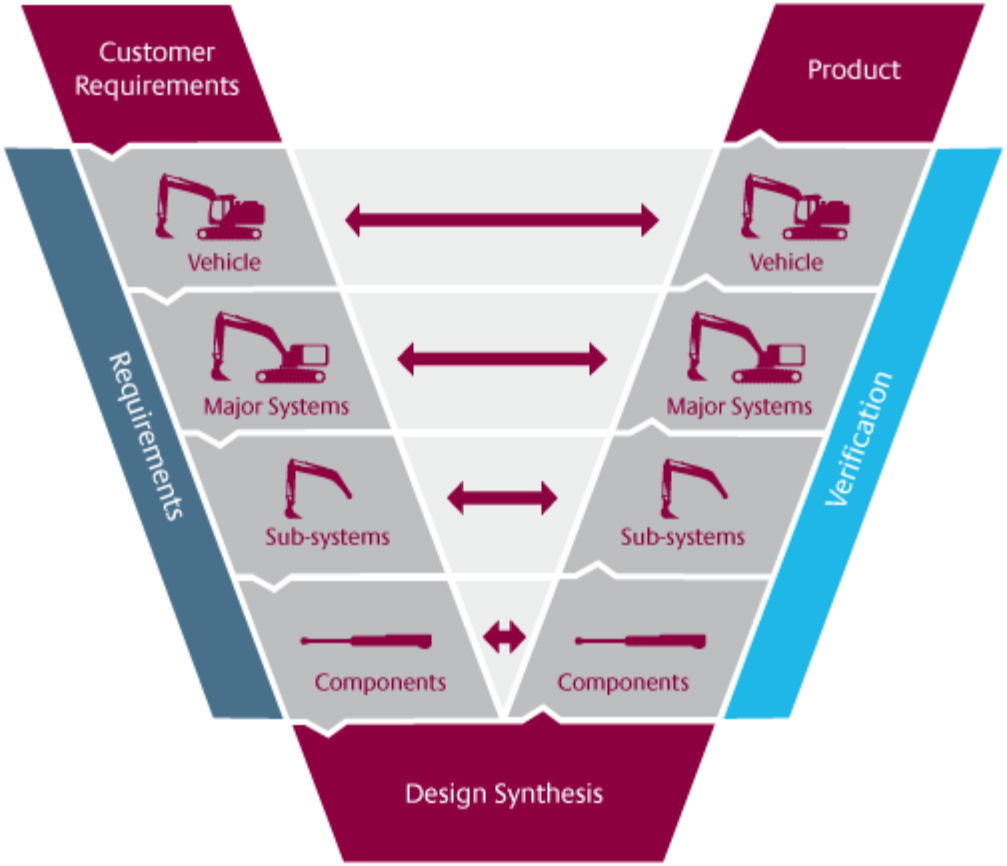
Phase 2 - Sub-system / component development & verification

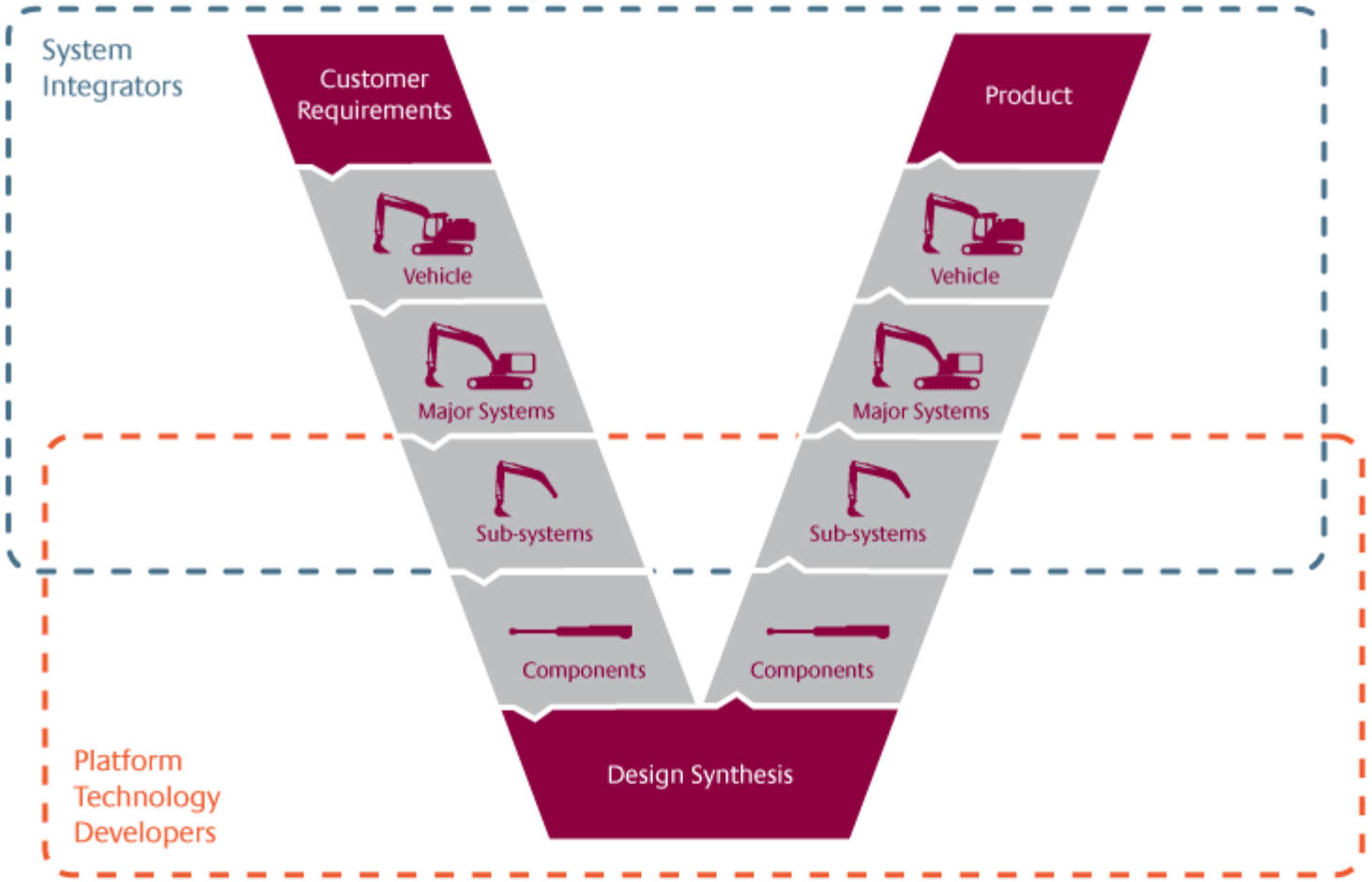


Phase 3 - Technology integration vehicle demonstration

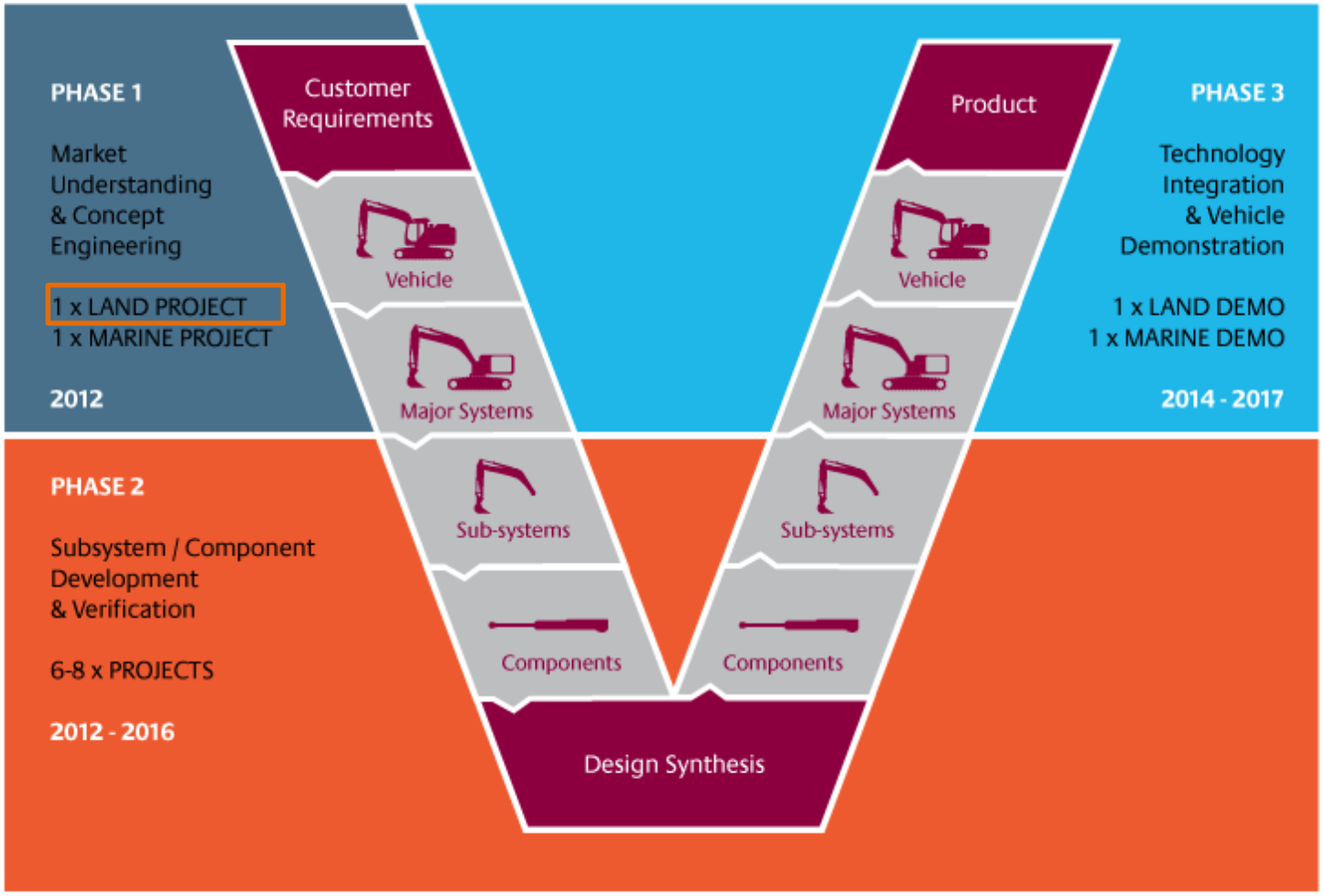


Verification that requirements met





Programme Phases

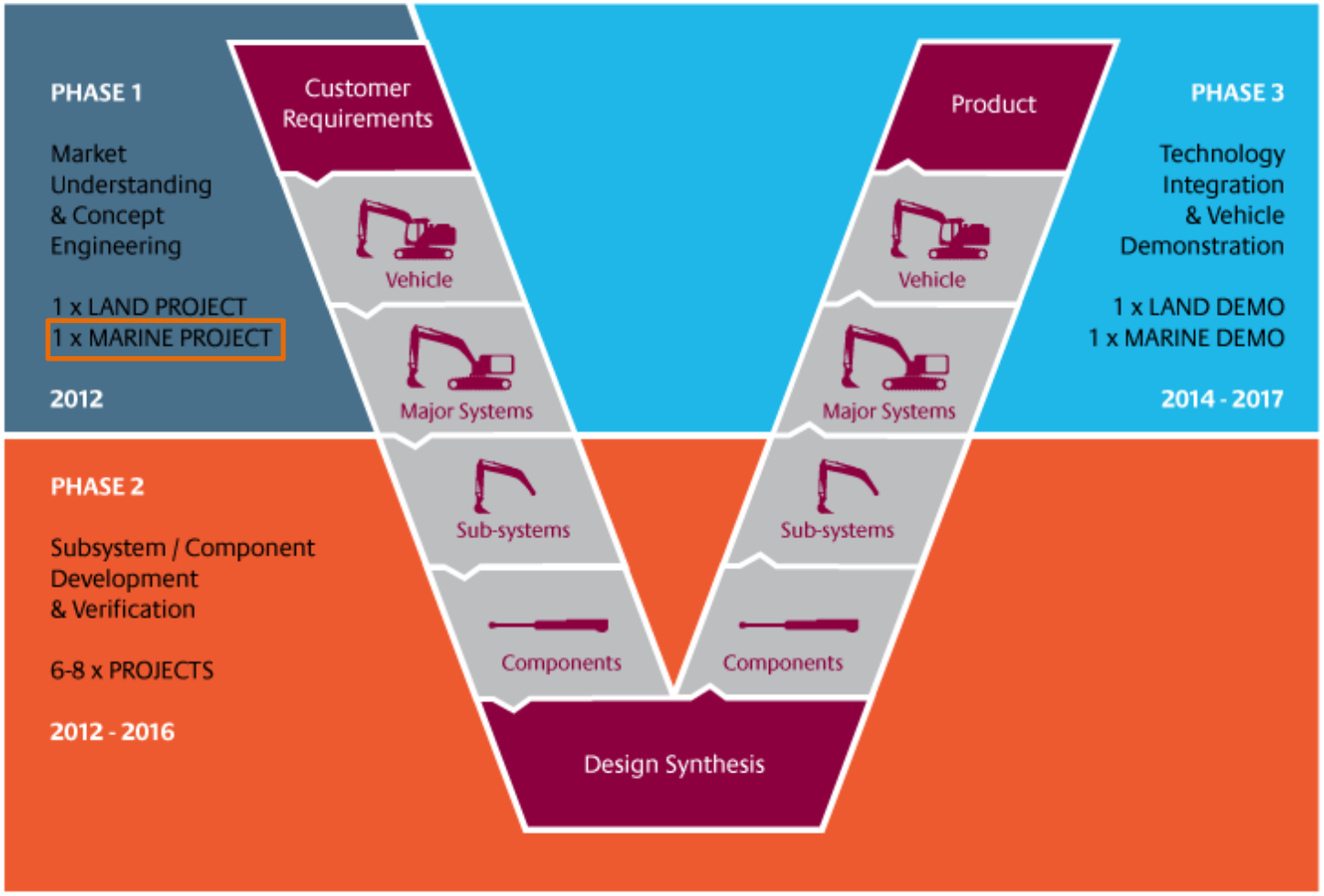


Phase 1 Land Systems Integration Project

- A £2.97M Project
- Caterpillar are the Prime Contractor
- Commenced on 5th March 2012
- It has run for 21 months and delivered the concept design for 6 vehicles / machines
- These machines represent the land HDV CO2 parc

Tana Utley and Vince Cable (UK Business Secretary) at Programme and Project launch event, 23rd March 2012

Programme Phases

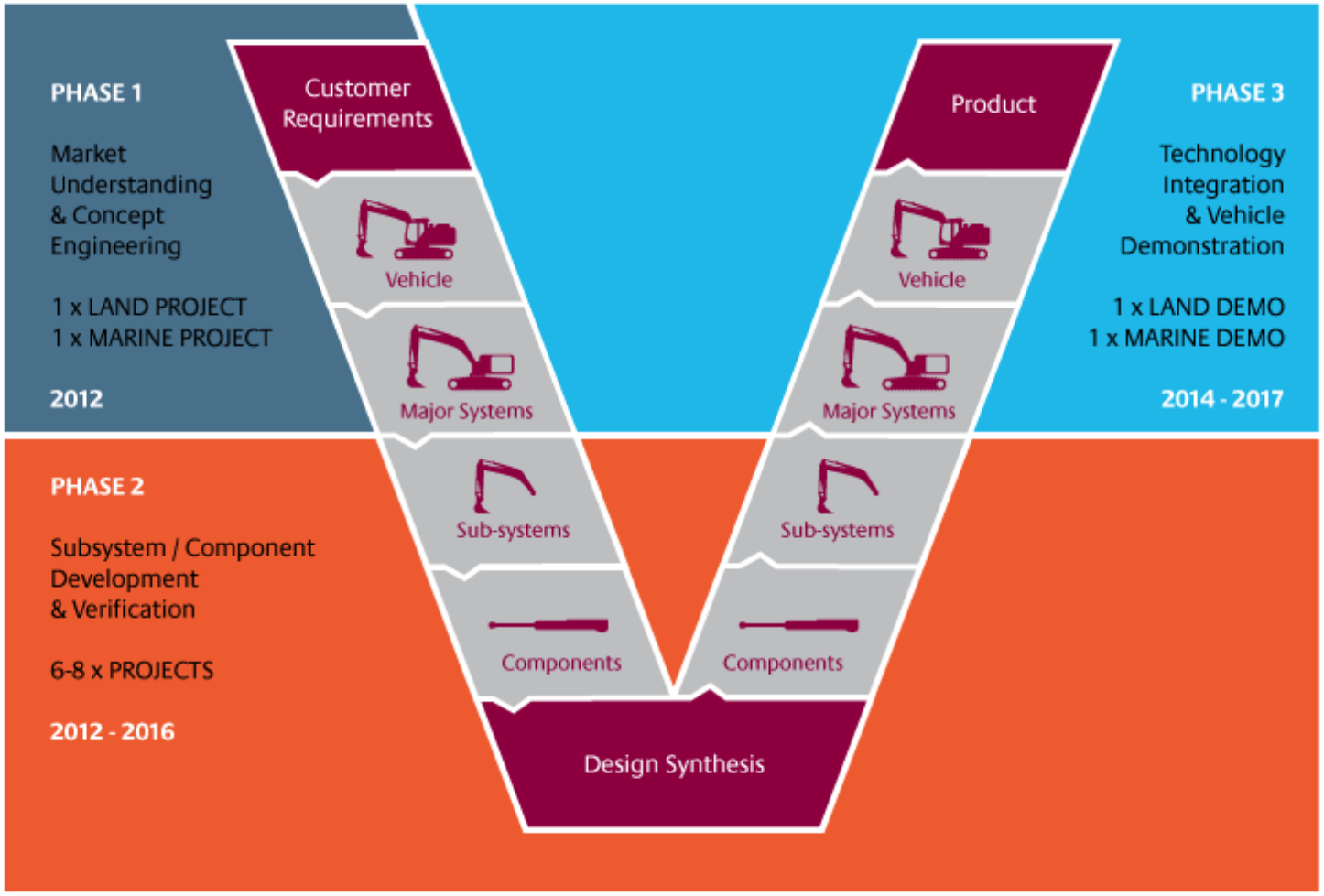


Phase 1 Marine Systems Integration Project

- 2 separate projects
  - £1.91M project with Rolls-Royce (“SI Marine Full”)
  - £0.4M project with BMT Defence (“SI Marine Subset”)
- Commenced on 18th August 2012 for Rolls-Royce and 13th December 2012 for BMT
- These projects will run alongside the Caterpillar land vehicle project and deliver the concept designs for a range of vessels
- These vessels will represent the marine CO2 parc

David Willets attended a project event at UCL on the 11th June 2013

Programme Phases



Phase 2 – Lower Drivetrain Project

- A £2.2M Project
- Commenced on 18th June 2012
- The project will optimise all aspects of the Lower Drivetrain system, using a synergistic approach
- To be delivered by a consortium comprising of Romax, BP Castrol and ANSYS
- It will run over the next 2 years culminating in a test cell demonstration (Cat 725 Articulated Truck Axle) followed by a on vehicle demonstration (Cat Articulated Truck)

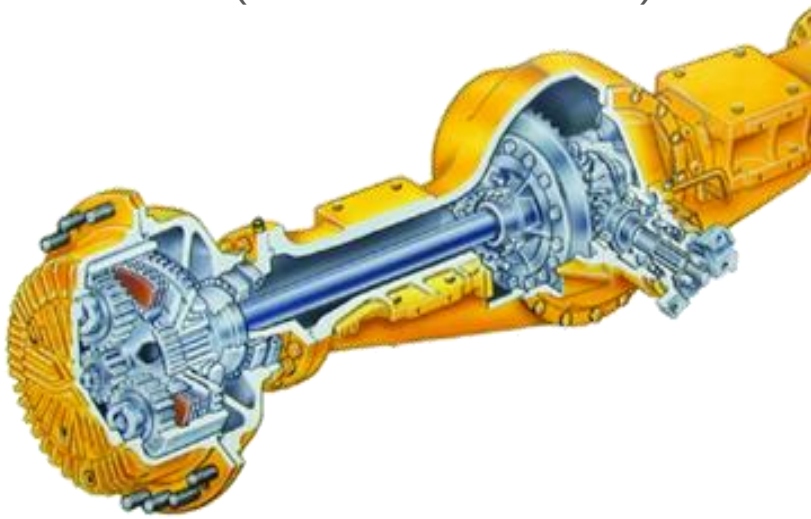


Image Courtesy of Caterpillar Inc.

Phase 2 – High Efficiency Selective Catalytic (SCR) Reduction Project

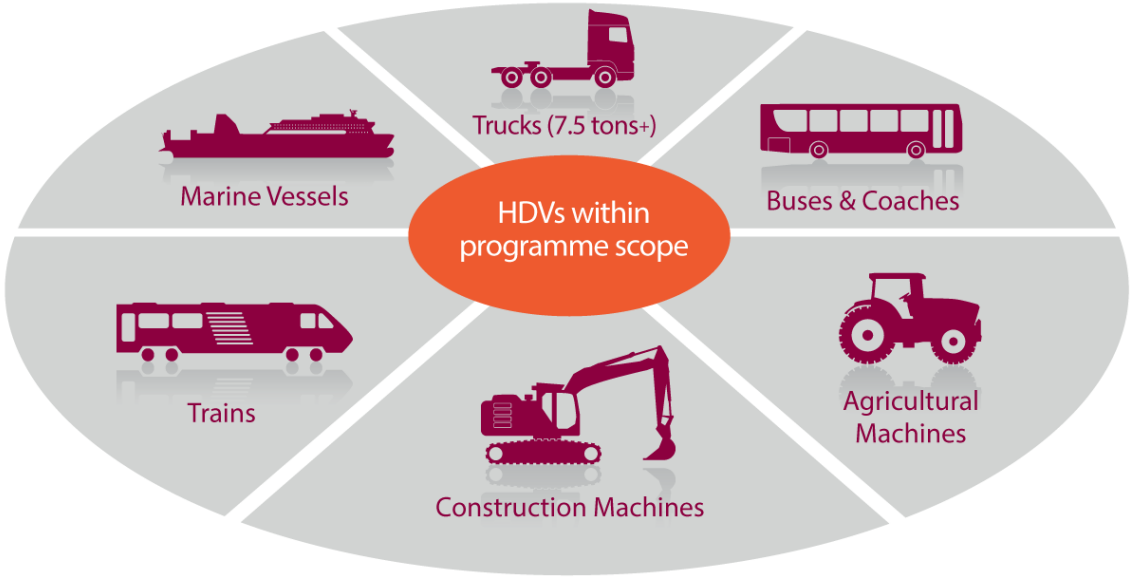
- A £4.5M Project to improve the catalytic effectiveness of an SCR system which in turn allows more fuel efficiency to be gained from the engine
- Commenced on 2nd November 2012
- The project will optimise all aspects of the SCR system, with a particular focus on Urea injection and mixing
- The project aspires to create a new urea injector / mixer design
- To be delivered by a consortium comprising of Caterpillar, Johnson Matthey and Loughborough University
- It will run over the next 3 years culminating in a test cell demonstration (C7.1 engine) followed by an on vehicle demonstration (Cat Articulated Truck)

CATERPILLAR®

JM Johnson Matthey

Loughborough University

HDV Programme Overview



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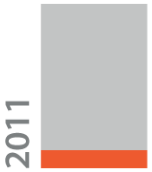

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HDV Activities at the ETI

Gas as a HDV Fuel

Strategy Phase

2013 – onwards

Gas as a HDV Fuel

- The ‘Gas as a HDV Fuel’ topic area is currently within the Strategy Phase at the ETI
- This means that the ETI are building their knowledge of the natural gas system and trying to understand its costs and performance levels
- Currently the ETI is focussing on understanding the well-to-motion Green House Gas (GHG) implications of gas as a fuel – including methane emissions
- As such, the ETI are about to commission a research and modelling study to quantify the various production, distribution and consumption pathways that exist
- A Request for Proposals (RfP) has just closed and we are currently assessing the bids received

Gas Modelling Outline

- Systems analysis and Well to Motion (WTM) model for LNG & CNG for land vehicles and marine vessels in comparison to current diesel fuel.
- The model is intended to deduce:
  - The total WTM GHG emissions for different gas production pathways and engine technologies
  - Which technologies will be most cost effective for different vehicle markets
  - Potential market size for different technologies within different markets
  - Level of displacement of diesel fuel with gas in different markets

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HDV Conclusions

- HDVs are an important and cost effective area for carbon abatement out to 2050
- A unique Programme given the breath of machines considered and the depth of technical investigation
- Tackling some of the issues that exists within this established and competitive industry
- A top down approach has led to some very high performing and yet cost effective solutions to improving HDV efficiency
- Gas is becoming an important topic with respect to HDVs and needs to be considered on a well-to-motion basis due to methane emissions and transportation costs

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