Technology #1

Internal Combustion Engines

Technology Strategy Board
Driving Innovation

Aeristech Ltd

Julien Servant

Electric Superchargers (eSupercharger) & FullElectric Turbochargers (FE^{TT})

Julien Servant – Commercial Director

15th May 2014

Key Topics

The Company and the Technology

The Market, Aeristech's Portfolio and Route to Commercialisation

Case Study - E-Supercharger for Super-compact Range Extender

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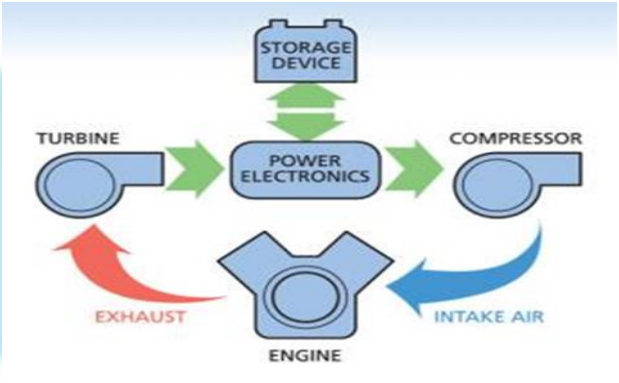
Overview

Who are we? UK based advanced engineering, design and development company with patented technologies for electric boosting

Why Aeristech? The most powerful and efficient electric boosting devices! **Automotive Applications** include:

- FullElectric Turbocharger Technology ("FE^{TT}")
- Electrically driven supercharger (eSupercharger)
- E-Compressors (Fuel Cell applications)
- Turbine Generators for energy recovery



fullElectric^{TT}

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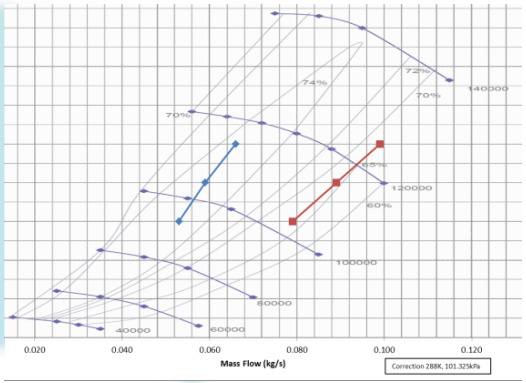
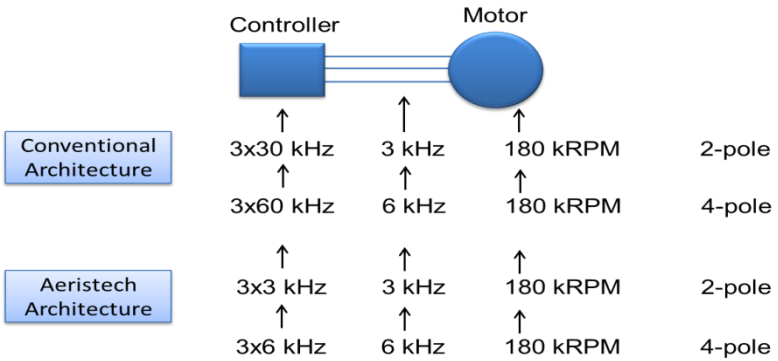
Electric Machine as the Core of Technology

Very low electrical switching frequency delivering **higher efficiency and torque density.** This allows exceptionally accurate **high-transient motor control.**

Aeristech's 10kW eSupercharger





- **Fastest Accelerating**
- **Most Power Dense**
- **Control by the millisecond**
- **Compact, low mass, low inertia**
- **Cheaper IGBT/MOSFET components**
- **High efficiency**

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History

2006 2007 2008 2009 2010 2011 2012 2013 2014

Feasibility

Bench Test

Performance

Vehicle Applications

First OEM collaboration

Engine test with compressor and turbine

14kW eSupercharger test

FullElectric turbo test with energy storage

High-speed PM Motor Rapid Acceleration

Engine test with 48V supercharger

Range extender supercharged for 50% more power

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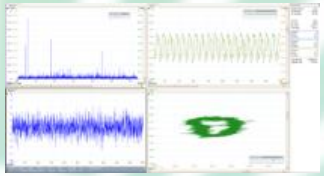
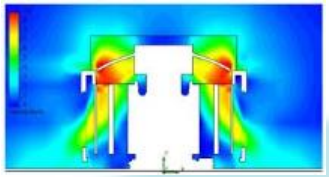
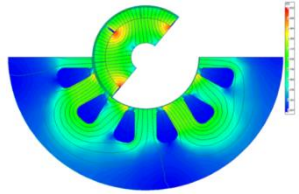
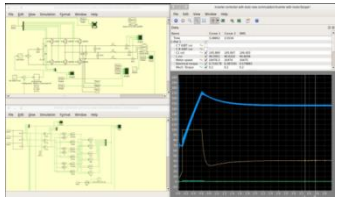
Aeristech Capabilities

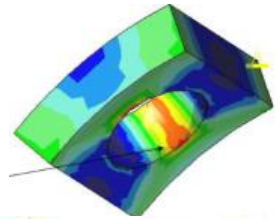




- Prototype design and development
- Control system & ECU development
- Modelling & simulation
- Prototype manufacture and assembly
- Established supply chain
- Prototype & Engine Testing
- Technical Programme Management







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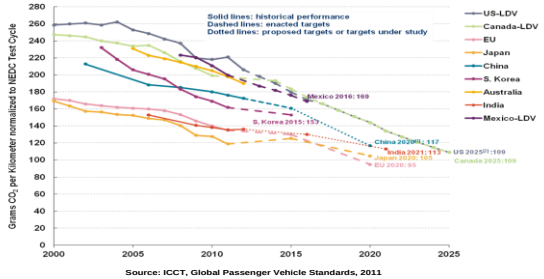
Market Trends and the Role of Electric Boosting

Market Drivers

- Main driver is legislative (global trend)
- Customers expect economical cars with better performance!

→ Industry trend towards **engine "downsizing"**

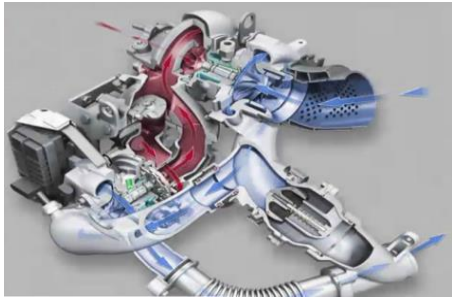


Source: ICCT, Global Passenger Vehicle Standards, 2011

Conventional (Mechanical) Systems

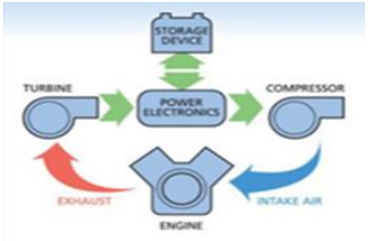
Conventional turbochargers and superchargers can provide boost, but they have inherent drawbacks.

- For extreme downsizing, **single-turbo** systems will not be capable of producing enough boost pressure whilst maintaining **acceptable transient** response.
- One adopted solution is **multi-stage boosting** systems



→ Electric Superchargers (eSuperchargers)

With **very fast response time**, eSuperchargers are very effective in addressing the low-speed turbo lag issues associated with downsized engines.



→ Electric Turbochargers (FE^{TT})

A "old" concept made possible only by Aeristech's motor and control technology

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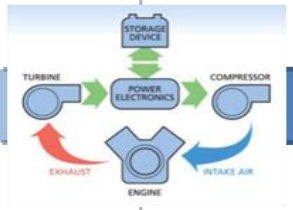
Aeristech's Portfolio and Timing

2010 2015 2020 2025 2030

eSupercharger

FE^{TT}



Fuel Cell Compressor

R&D / Pre-development

Development Prog/License

Volume Production

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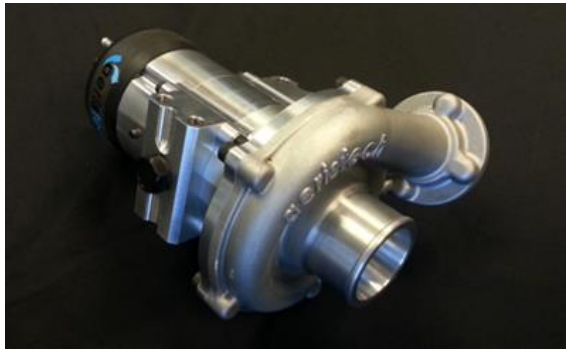
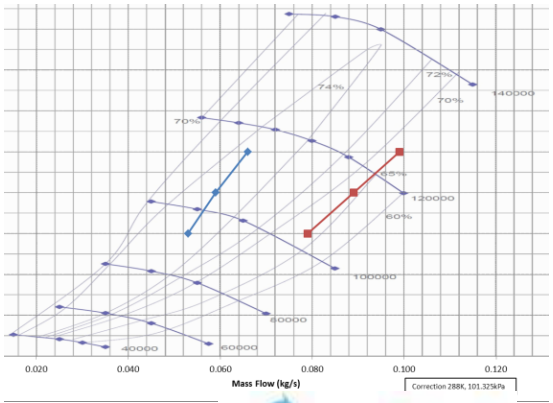
eSupercharger Applications

Application	Target engine	2.0L Petrol or Diesel (or less)
General	Air compressor type	Centrifugal (bespoke design)
	Motor type	High Speed Permanent Magnet
	Max speed	120 000 RPM
	Bearings	High Precision Ceramic Hybrid Rolling Element
	Input voltage	46V – 50V (48V nominal)
Performance	Nominal rated flow (Engine at 1750rpm boosted to 2bar)	0.0715 kg/s
	Pressure ratio (at nom. flow)	2.0 bar
	Minimum rated flow (Engine idle speed of 750rpm)	0.0153 kg/s
	Max boost pressure	2.0 bar
	Range of max boost pressure	1000-1750 RPM
	Flow range at max boost (Engine Speed 1000–1750rpm)	0.0408 – 0.0715 kg/s
	Max Flow	0.0797 kg/s
Transient	Idle to max flow, 1.8bar boost	< 0.5s
Packaging	Motor / Compressor Mass	4.7kg
	Motor / Compressor Volume	< 1.4ltr



Aeristech's 10kW eSupercharger



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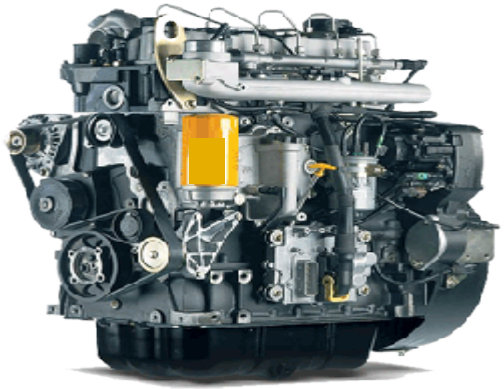
Full Electric Turbocharger Technology (FE^{TT})

full Electric^{TT}

Fully decoupled architecture:
Turbine Generator
Electric Compressor

- **Fully electric**
- **Highly efficient**
- **Power on demand**

Turbine-Generator → Power Electronics and Control → E-Supercharger



Large turbine and independent impeller speeds improve efficiency

Optimised combustion due to precise control of air flow

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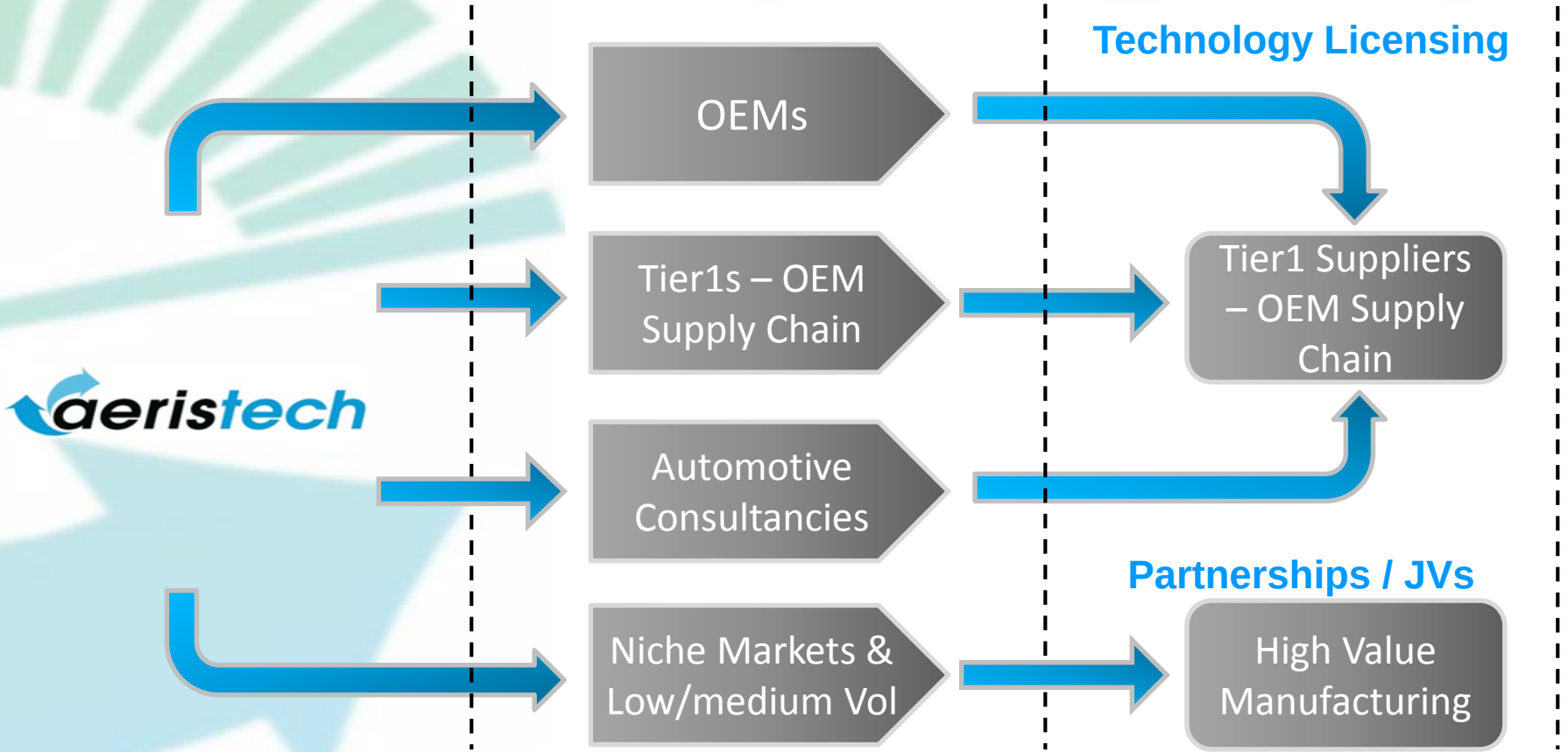
Route to Market through Technology Licensing



E-Supercharger for Super-compact Range Extender

The Consortium Partners:

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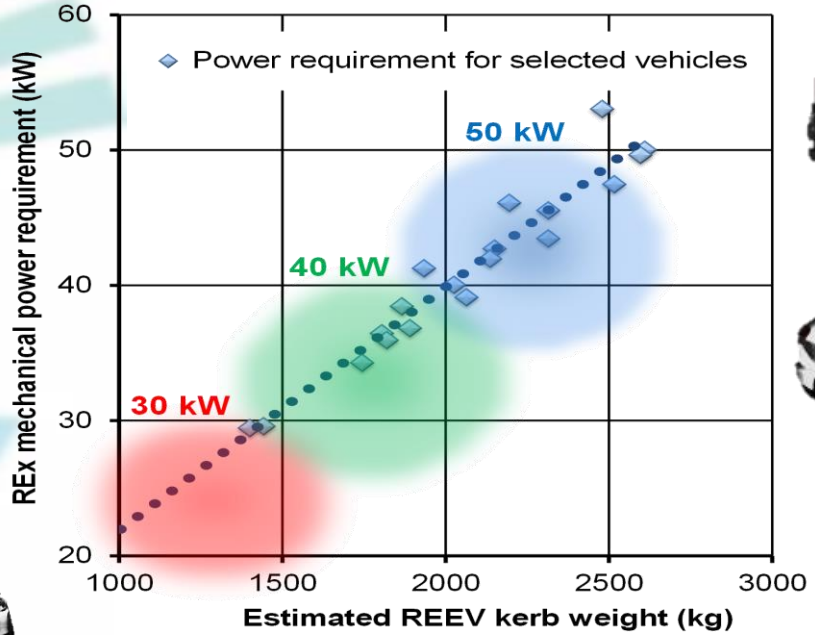
MAHLE Powertrain

Sponsored by:

NICHE Vehicle Network

E-Supercharger for Super-compact Range Extender

Range Extender Engine Family Concept - Increasing power required with increased vehicle weight



MAHLE Powertrain

Source: Mahle Powertrain Ltd

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E-Supercharger for Super-compact Range Extender

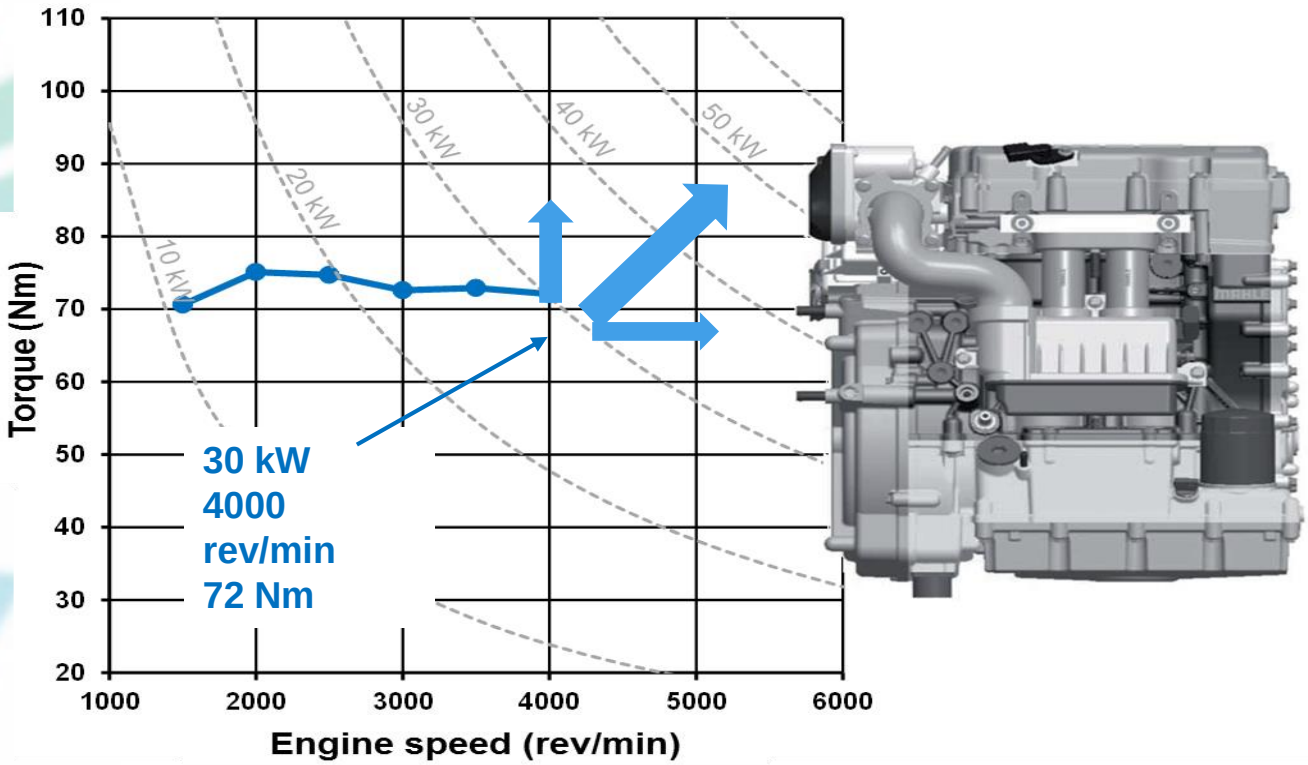
Power Upgrade Paths

Power increase

- Increased speed
- Increased torque

40 kW can be achieved through increasing engine speed **or** increased torque

50+ kW requires increased speed **and** increased torque



Source: Mahle Powertrain Ltd

MAHLE Powertrain

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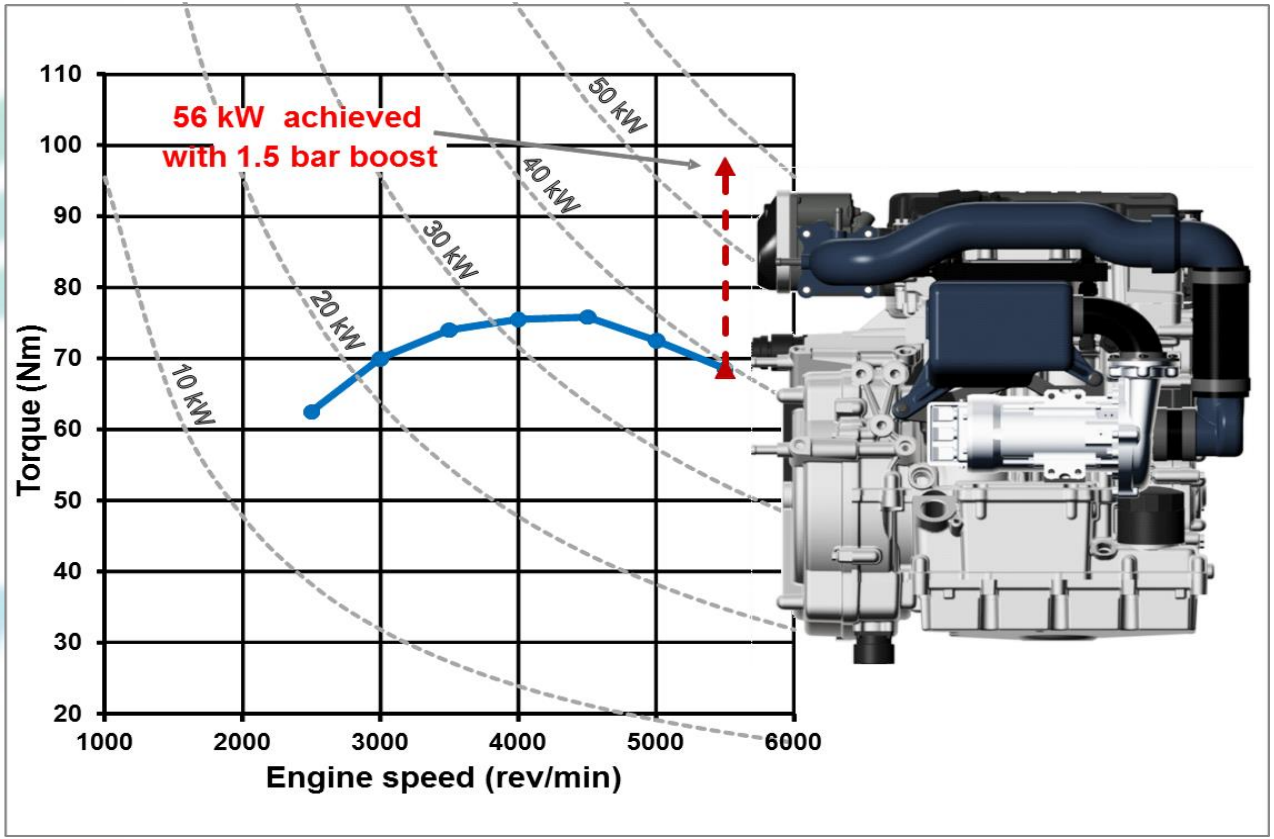
Results - Pressure Charging + Increased Speed

- Initial testing achieved **56 kW** at 5500 rev/min
- E-supercharger power requirement is **4.5 kW**
- **51 kW net** power



Source: MAHLE Powertrain Ltd

MAHLE Powertrain

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Thank You

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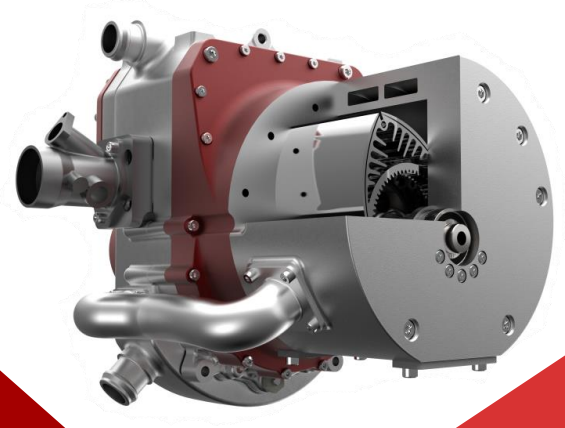
Driving Innovation

Advanced Innovative Engineering (UK) Ltd

Nathan Bailey

Advanced Innovative Engineering



Compound Rotary Engine for Electric Vehicles (CREEV)

Nathan Bailey, Managing Director

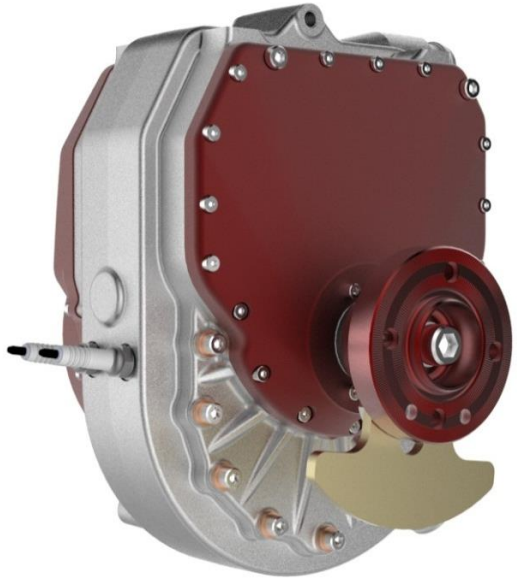
225CS Engine & Expander Design Concept:

First engine to benefit from Compact SPARCS cooling system

- 'Clean sheet' engine design
  - ✓ No baggage from previous engine designs (no artificial constraints)

- Design In:
  - ✓ Experience gained on previous successful rotary engine projects to improve the engines' operational performance.

- Design Out:
  - ✓ Recognised and perceived issues with currently available rotary engine designs.



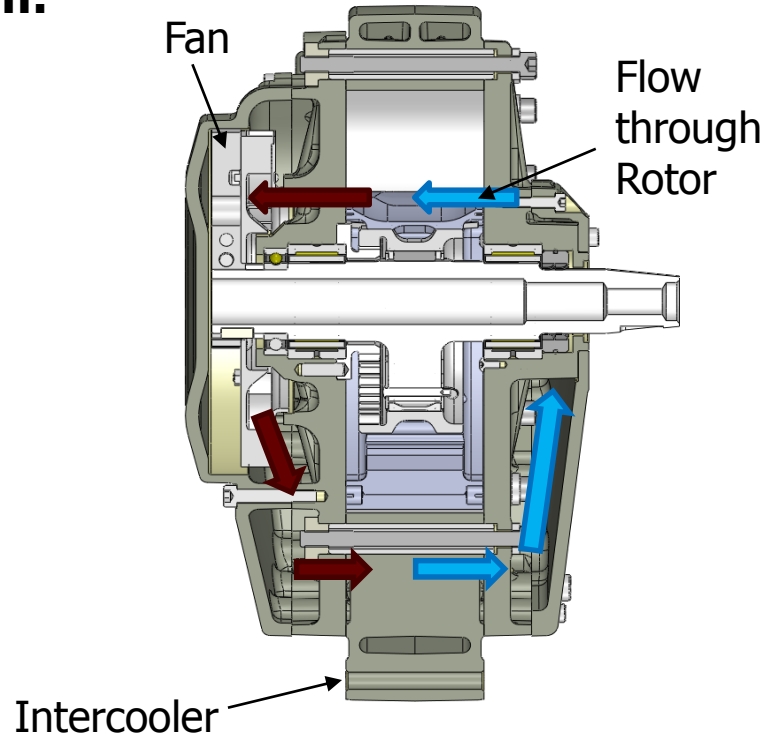
Engine Technology

(TRL Level 5, MRL Level 6)

Self Pressurised Air Rotor Cooling System:

- Utilises self pressuring blow by gases from the combustion process which have escaped into the interior of the rotor.
- Gas is drawn through the rotor circulated by an internal fan, absorbing heat before being forced though an integrated heat exchanger within the engine housing.
- Heat exchanger then rejects heat to the main liquid cooling system through the engine housing.

- **The higher density of the pressurised gas mixture enables higher levels of heat removal from the engines rotor.**



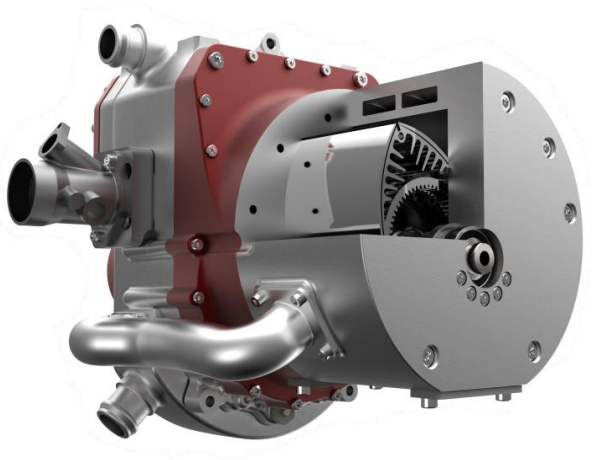
SPARCS Benefits:

- Wet oil loss to atmosphere completely eliminated due to fully sealed circuit
  - ✓ Oil consumption significantly reduced
  - ✓ Clean operation
- Improved thermal balance across engine housing
  - ✓ Improved sealing due to uniform thermal expansion
  - ✓ Increased efficiency
  - ✓ Longer life, improved reliability
- Simple design
  - ✓ Lightweight
  - ✓ Compact space envelope
  - ✓ Fewer components (No oil sump/filter required)

Expander Technology (CREEV):

(TRL Level 3, MRL Level 2)

Through the use of an alternative rotor geometry (single lobe unit) a coaxial expander unit provides a compact and mechanically efficient way to extend the engine expansion stroke in order to recover energy that otherwise goes to waste.



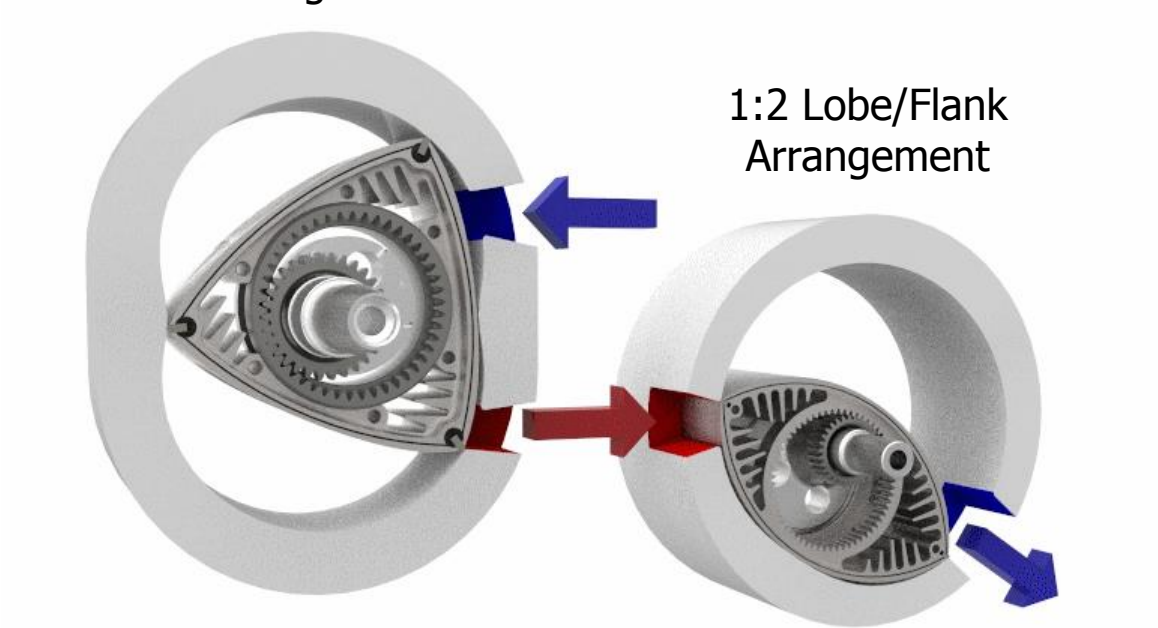
Benefits:

- Predicted net power gain of approximately 20%
- Reduced SFC (Specific Fuel Consumption)
- Reduced exhaust noise as gas close to atmospheric pressure upon exiting expander
- Reduced HC emissions

CREEV Operation:

2:3 Lobe/Flank Arrangement

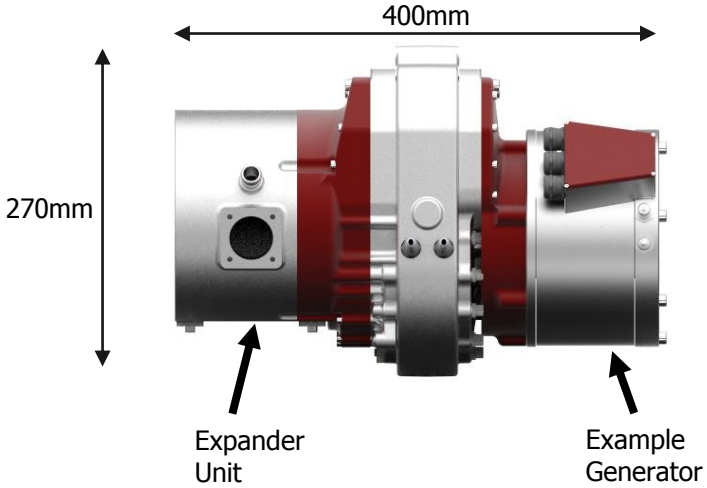
1:2 Lobe/Flank Arrangement



Note: Units shown in same plane rather than co-axially for clarity

Series Hybrid Range Extender Concept:

When paired with a suitable generator AIE's CREEV unit produces an extremely lightweight and compact range extender.

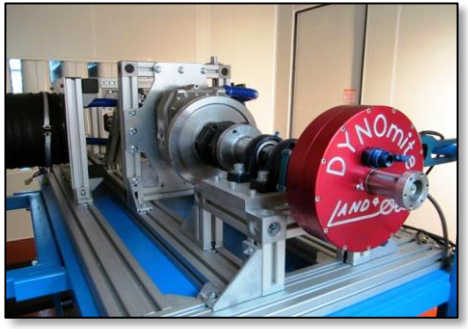


Engine Output Power:	30kW
Unit Weight (excluding generator):	17kg
Power Density (excluding generator):	1.76 kW/kg

Production:

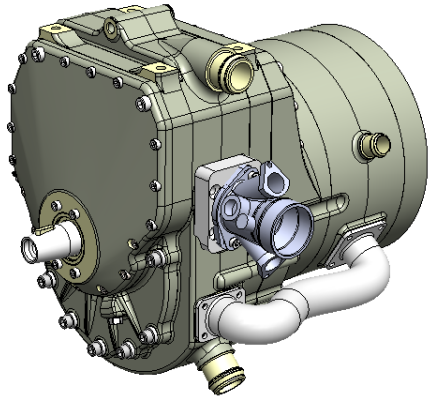
225CS prototype currently in test following initial prototype production (TRL 5, MRL 6):

- Development with production intent
  - Low component count
  - Standard manufacturing processes specified
  - Off the shelf ancillaries



Expander unit feasibility study undertaken as part of NVN programme (TRL 3, MRL 2):

- 3D CAD Concepts created
  - Low component count
  - Designed with ease of packaging and integration as a priority
- Physical RP Concept created



Commercialisation:

Both SPARCS and CREEV technologies are covered with international patents.

- Discussion undertaken with low volume niche vehicle manufacturers
  - Low to medium volume production to be conducted in house
  - High volume manufacture to be licensed to a 3rd party.

AIE is currently funded through private investment and is actively seeking commercial partners to fund further development and commercialisation of its products.

Advanced Innovative Engineering

Thank You For Listening

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Driving Innovation

Vortex Exhaust Technology Ltd

Ian Jameson

MEET THE ENGINEER

High Performance Low Carbon Automotive Showcase

Vortex Exhaust Technology Ltd

High Performance and Low Carbon

in one Package!

VORTEX™ exhaust technology

Presented by Ian Jameson – Business Development

May 2014

VORTEX™
exhaust technology

Patented Technology

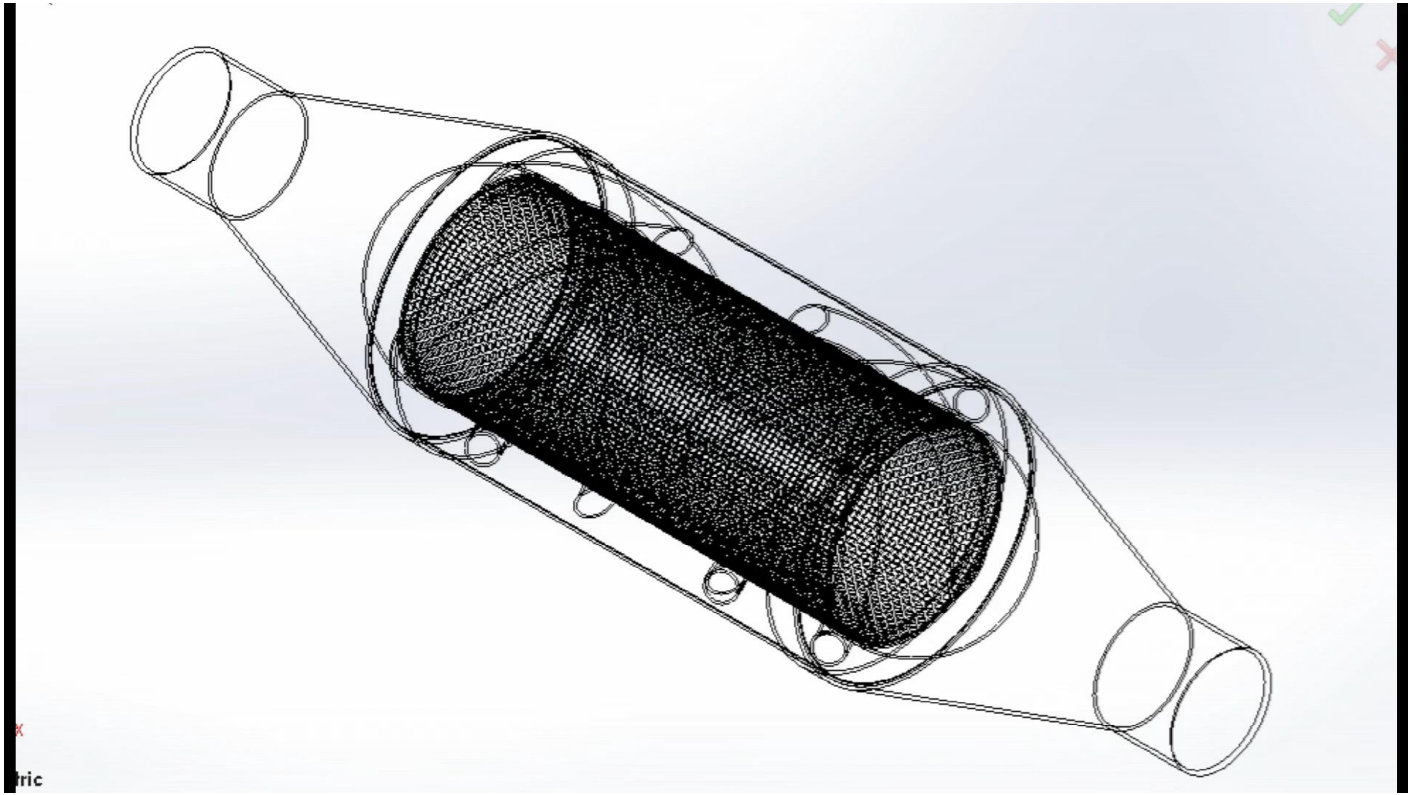
Improves Engine Efficiency

- High Performance
- Reduced emissions
- Reduced fuel consumption

VORTEX™ exhaust technology

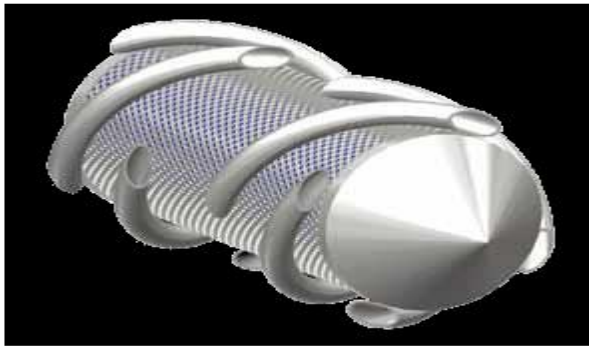
For all IC applications

How it works



Reminder of key benefits

- Reduced engine stress
- Reduced turbo lag
- More power, torque, mpg
- Reduced emissions



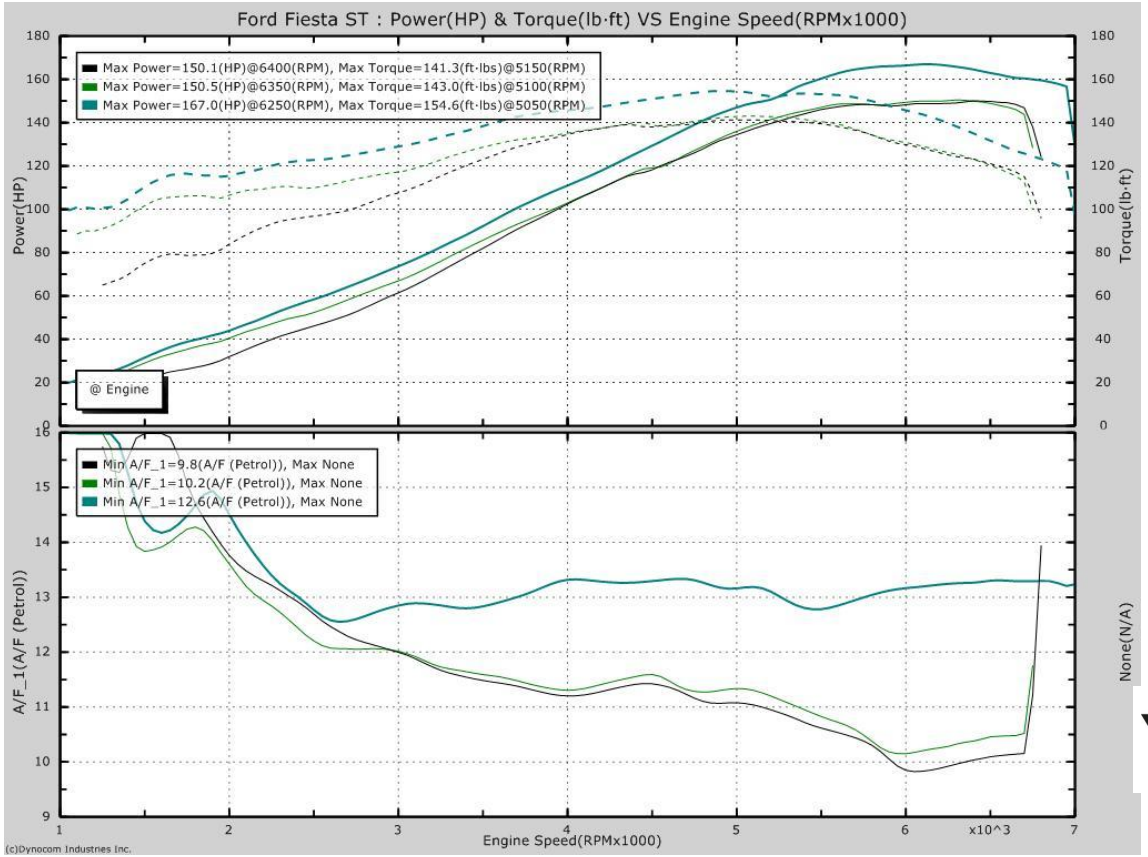
Additional benefits include:

- Longer catalyst /DPF life
- Less carbon build up
- Longer engine life
- Improved heat dissipation
- Potential to increase service intervals

VORTEX™ exhaust technology

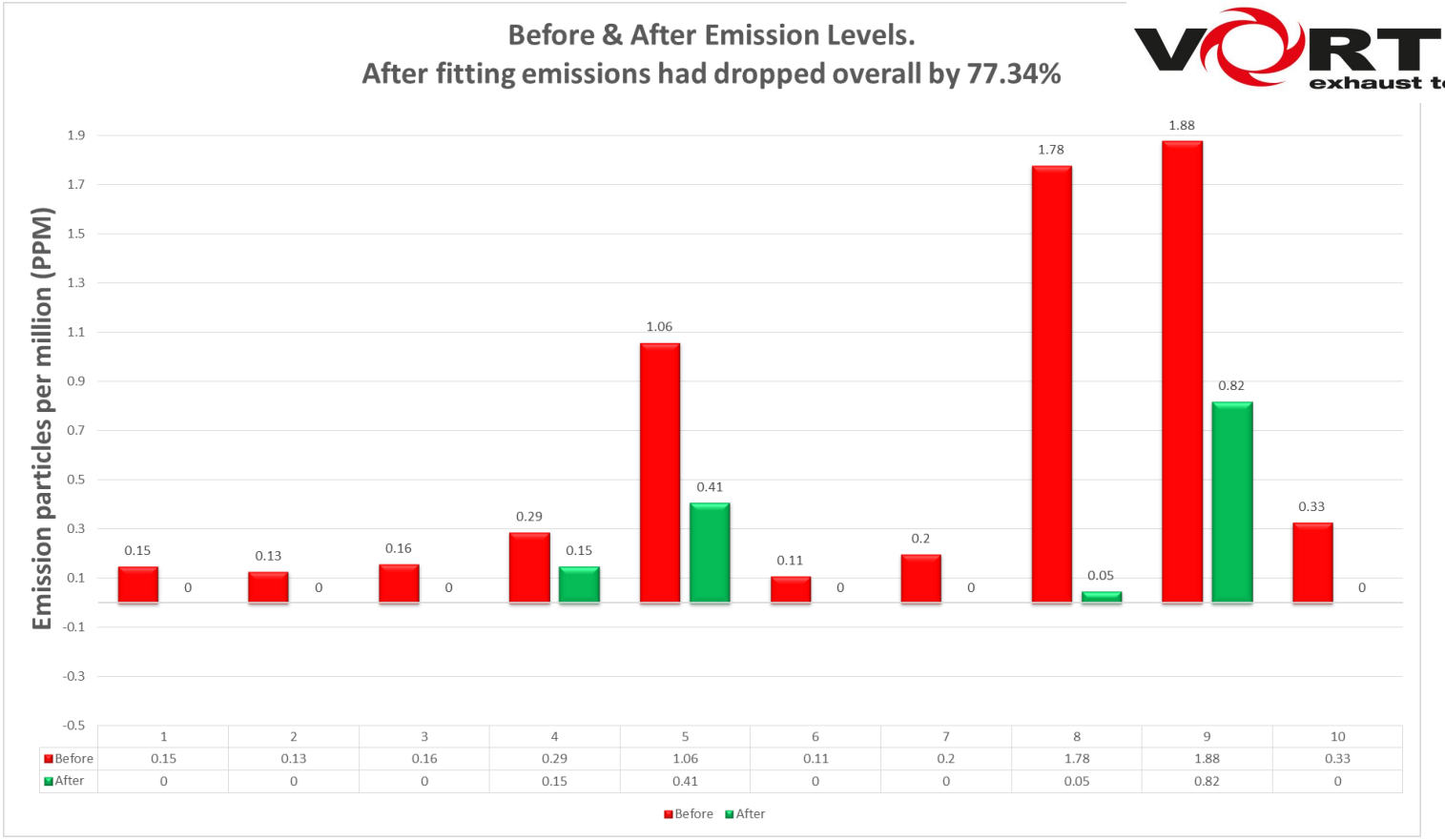
For every IC application

Dyno test on Ford Fiesta

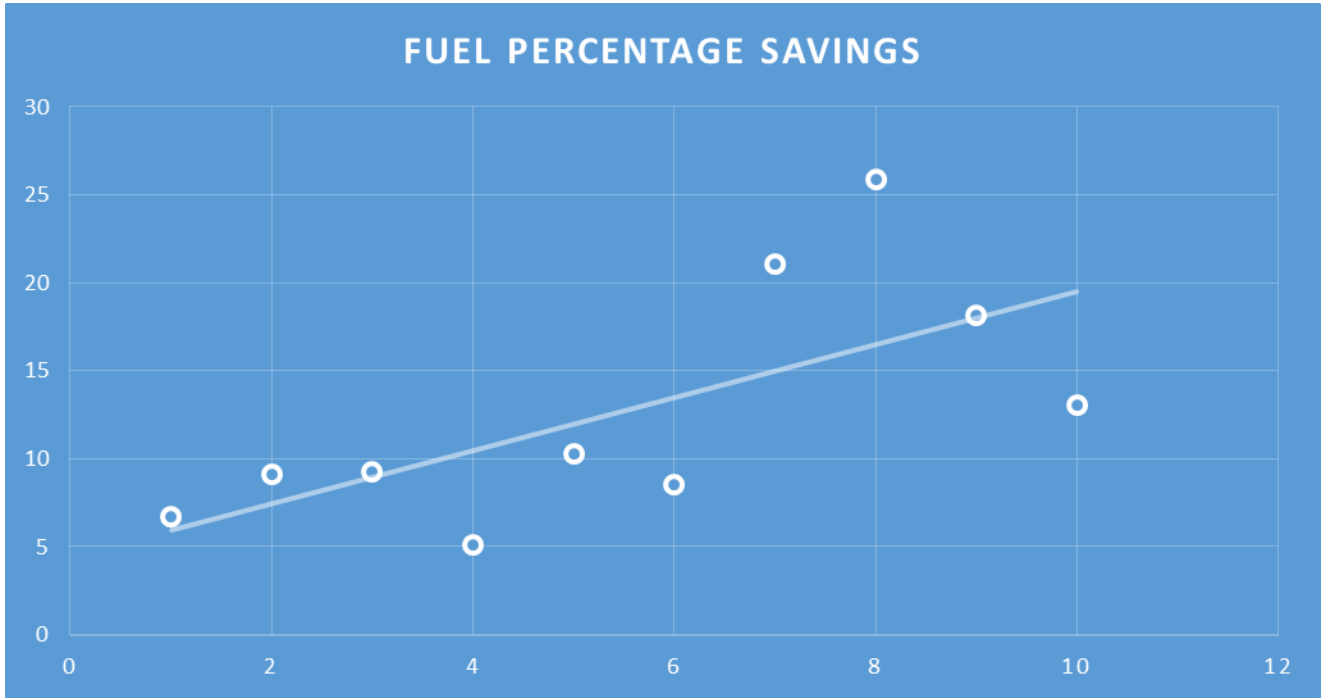


VORTEX™ exhaust technology

S.E coast Ambulance service



Fuel savings across the fleet

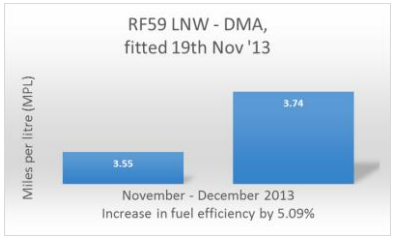


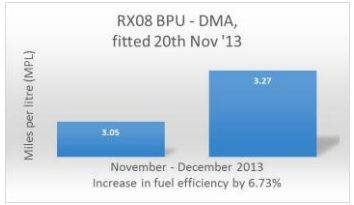
The cluster graph above highlights that the mean fuel saving over the 10 vehicles is 12.71%

VORTEX™ exhaust technology

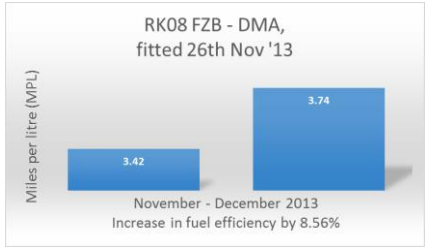
WORST

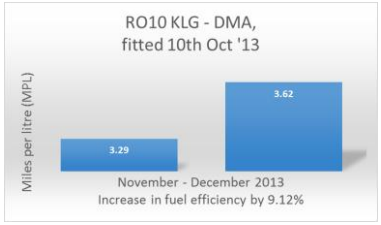
BEST

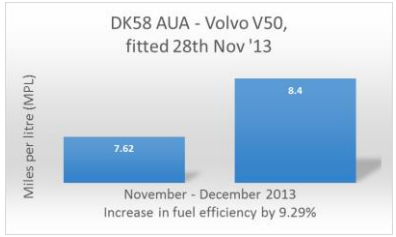




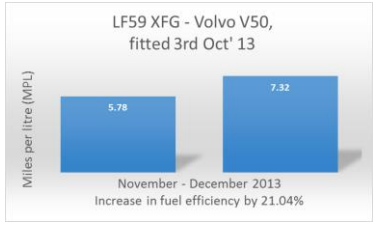
Ambulance

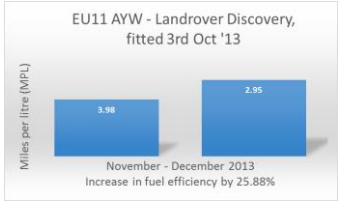


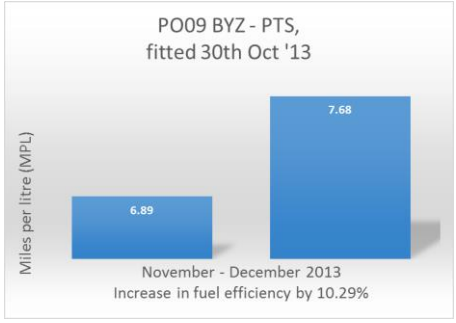




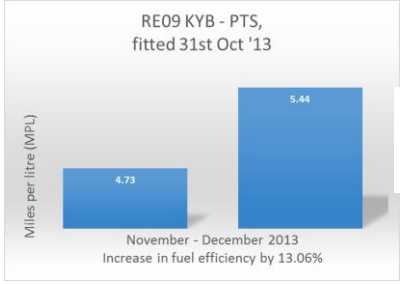
Car
/
4x4







Minibus



VORTEX™
exhaust technology

Noise attenuation

NVN collaboration with Fibre Technology Ltd to utilise their technology to further silence difficult applications.

FibreTech and Vortex Technology together offer opportunity to reduce envelope required for silencer size.

Successes to Date

VORTEX™
exhaust technology

- Annual Energy Reduction 53.17 Tonnes of CO^2
- Annual fuel cost savings £23,466.20

What now?

- Vortex can be custom-built into any IC application, so should be good for next 20-50 years
- To date business self-funded by owner/profits ploughed back
- In discussion with a couple of large potential production/development partners

VORTEX™
exhaust technology

What next?

- Patents applied for and granted in UK, Europe & USA for Vortex exhaust
- Also granted in UK, europe for Vortex catalytic converter and Vortex Diesel Particulate Trap
- Looking for collaboration partners- have various projects in place
- Willing to licence IP, look for investment funding

VORTEX™
exhaust technology

THANK YOU FOR LISTENING

Vortex Exhaust Technology Ltd

High Performance and

Low Carbon in one Package!

VORTEX™ exhaust technology

For all IC applications

Technology Strategy Board
Driving Innovation

E. A. Technical Services Ltd

Ron Driver

Photograph of a New Type of Compressor and or Turbine

New Type of Compressor

The compressor has an orbiting piston with a hinging face

It has been extensively tested a heat pump compressor and turbine at pressures up to 16bar.

The compressor trades friction for fluid leakage and has very high isentropic efficiency

It can be used to inject air into an engine during the exhaust stroke and create a more efficient and cleaner two stroke engine

Automotive Operating Principle

1. Pressurised air is held in the duct between the injector and engine inlet valve.

2. Air is released into the engine through the inlet valve during the exhaust stroke and enhances evacuation of the exhaust gas.

3. The exhaust valve closes relatively early leaving some residual exhaust gas.

4. The remaining air compression is performed by the engine's piston during the remaining rotation to engine tdc.

5. Each engine cylinder experiences a power stroke every revolution.

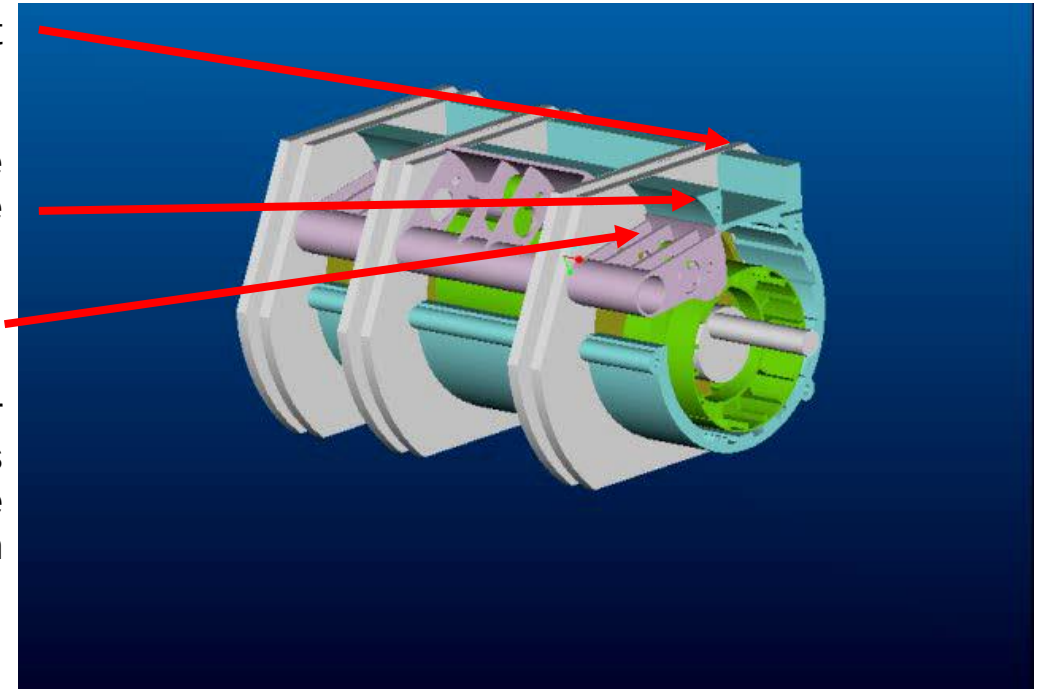
Injector for 2 Cylinder Engine with Manifolds and End Face Removed

Outlet

Piston / Vane hinge

Inlet

The two outer half size pistons balance the centre piston

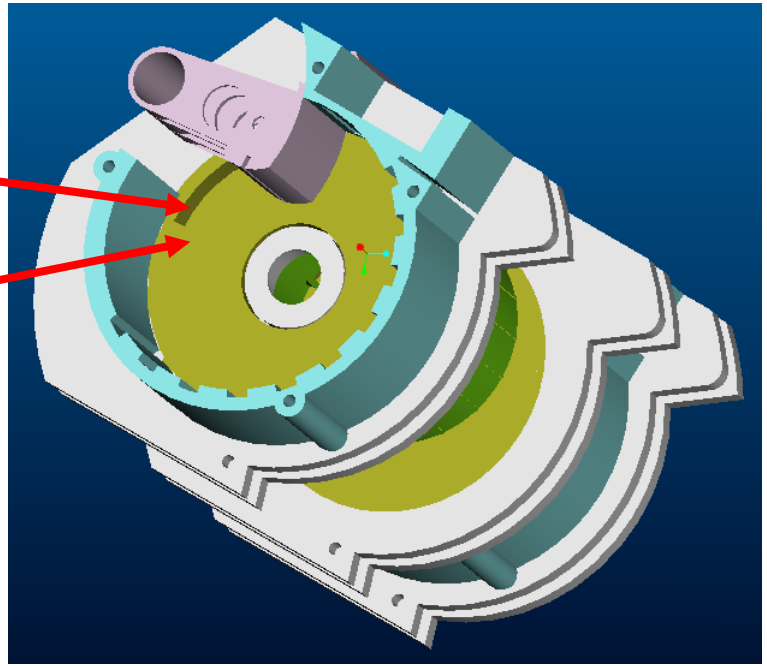


Adjustable Orifice

Position of this orifice controls the mass of air which can be injected into the engine

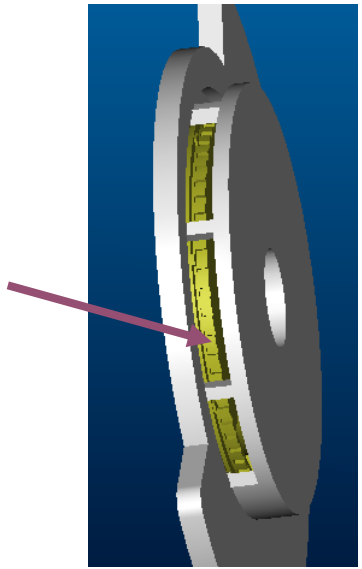
Air massflow adjuster

The orbiting piston pushes unwanted air out to atmosphere through the orifice and air is only compressed after the piston passes the orifice.



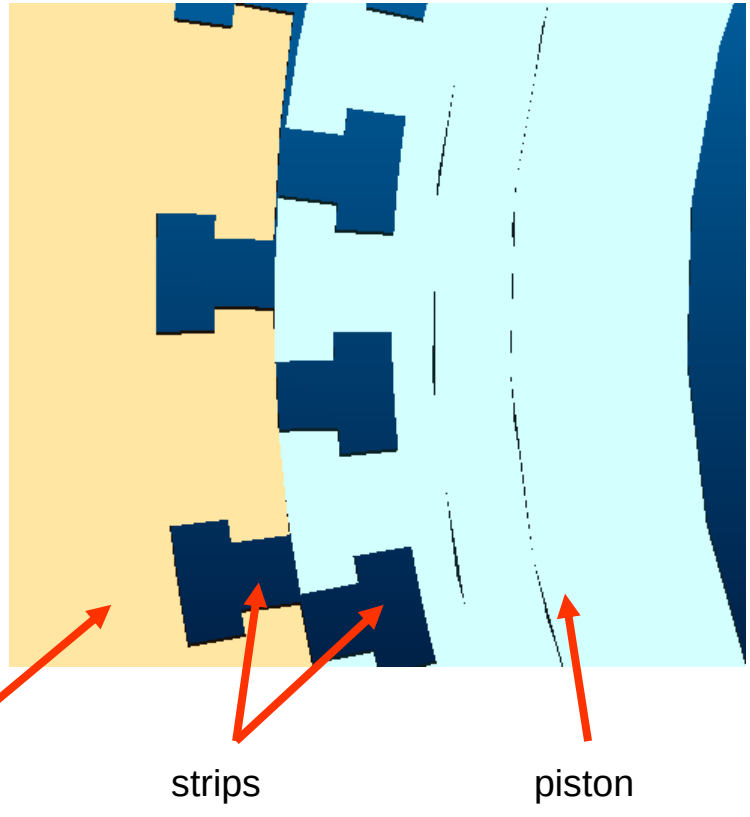
View on Air Massflow Adjuster

Belt actuated disc with integral evacuation orifice which is rotated to vary air massflow



Wear Away Sealing Strips

When the strips are placed correctly in the piston and in the casing they inter-mesh because there is little relative movement between the piston and casing. The average clearance over a relatively long distance is about 50 microns. Because the strips wear or extrude this clearance is achieved irrespective of manufacturing tolerance



Air Injector Compressor
Automatic Clearance Adjustment

Because the compressor piston orbits there is very little relative movement between the piston and casing.

High compression efficiency is possible in all applications by fitting wear away strips to the casing and/or piston which wear or extrude and result in a close running clearance irrespective of manufacturing tolerances

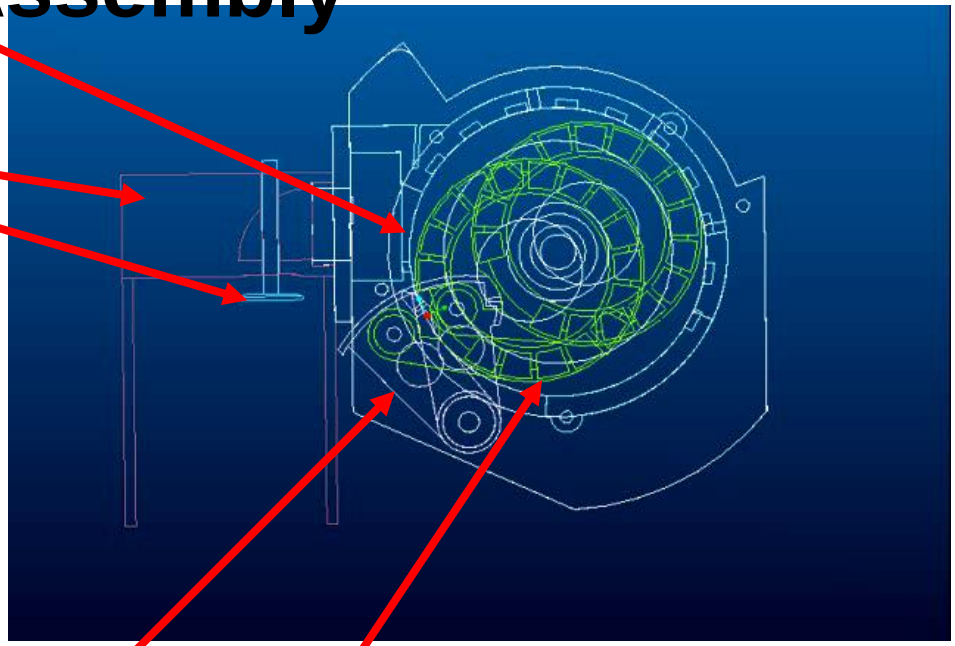
Air Injector and Engine Assembly

None return valve on this face

Cylinder head

Engine inlet valve

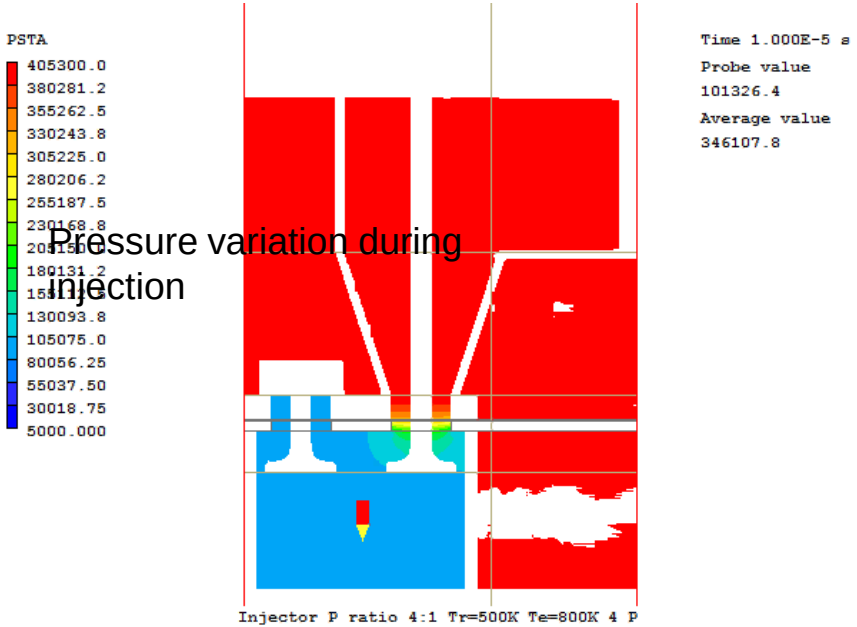
Pressurised air is held in the volume between the none return valve and the closed engine inlet valve



Inlet to air injector

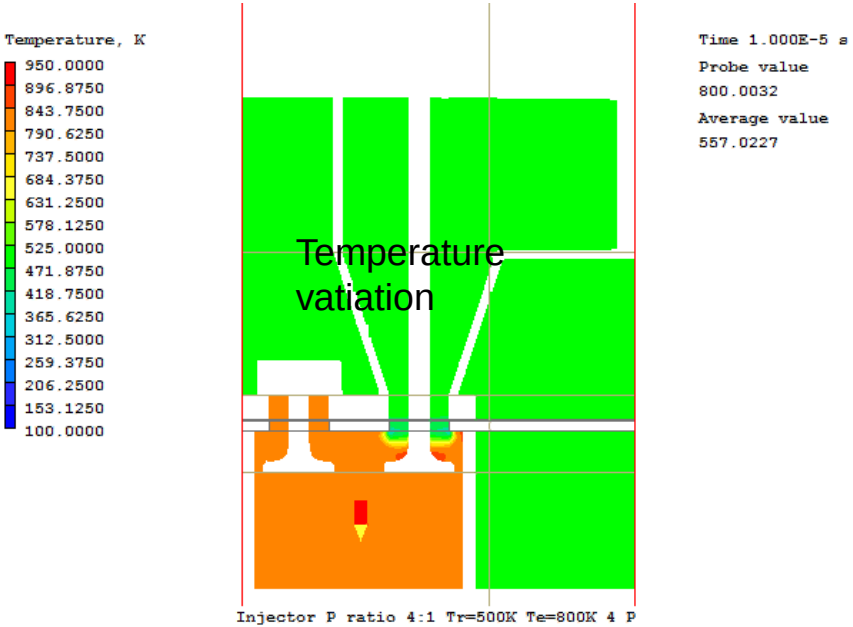
One orbiting piston for each engine cylinder

Pressure During Injection

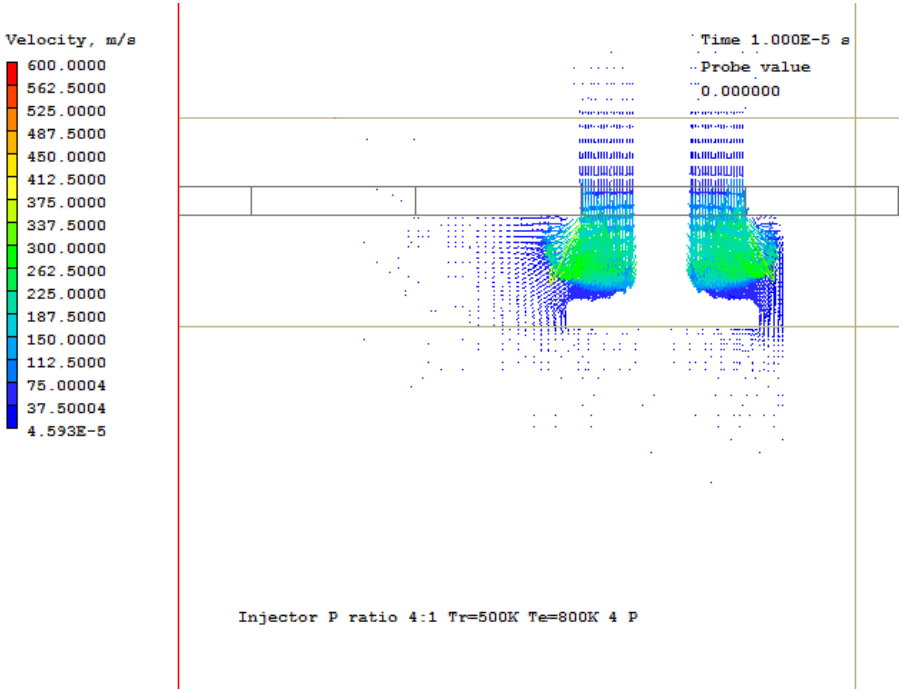


Pressure variation during injection

Temperature During Injection



Velocity During Injection



Air Injector Design Features

1. No contacting moving parts

2. Orbiting compressor piston and hinged vane

3. Automatic working clearance adjustment

4. Air massflow variation at constant machine speed without throttling or other losses

5. Very high efficiency of compression

Engine Air Injection

Air injection provides the following benefits :-

1. The engine is halved in size and weight for a given power.
2. A cleaner two stroke cycle with lower bsfc
3. Either or both the Atkinson and Miller cycle can be performed.
4. Expansion ratio is more than the compression ratio.
5. Friction is reduced because there are smaller or fewer pistons.
6. Charge mass and pressure can be regulated for each individual cylinder cycle

Typical savings are 10% for diesel and 20% for gasoline coming from:

7. 4% from weight reduction
8. 10% by eliminating petrol engine throttling loss.
9. 4% from additional expansion ratio.
10. 5% from reduced friction.
11. Minus 3% for the energy needed to inject the air.

Use as a Small Generator

This type of engine is particularly suitable as an onboard generator for electric vehicles because the efficiency will be more than Grid generation efficiency and will obviate the need for charging points.

This air injection process is probably only possible with the compressor that has been developed by EATS.

Manufacturing Cost and Weight

Estimated manufacturing cost and weight for a 600cc diesel or gasoline engine air injector is:

Air Injector	$100	10kg

The estimated costs are based on Honeywell Transportations Systems costs and Honeywell sub-contractor costs.

More detailed information is available from:

Ron Driver

Email ron.driver@eats.ltd.uk

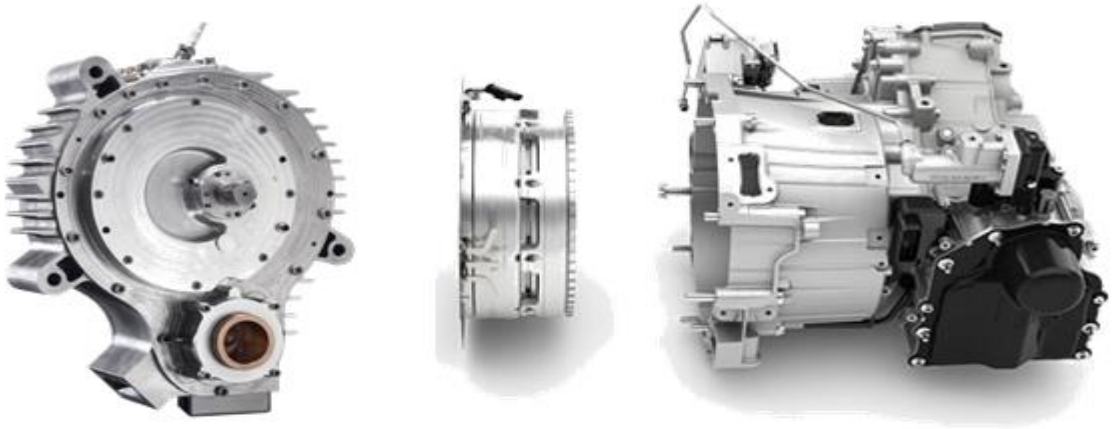
Tel. +44 (0)1200 441492

Mob +44 07768833678

Technology Strategy Board
Driving Innovation

Libralato Ltd

Dan Aris



Libralato Engine & TC48 Powertrain

Aligned with UK Automotive Strategy

Key Strengths

- Globally recognised premium, niche and luxury brands
- Powertrain design and manufacture
- World leading motorsport capabilities
- Ability to innovate including internationally strong research base

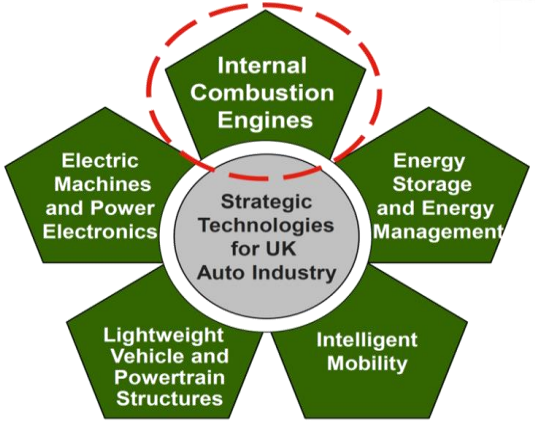
Opportunities

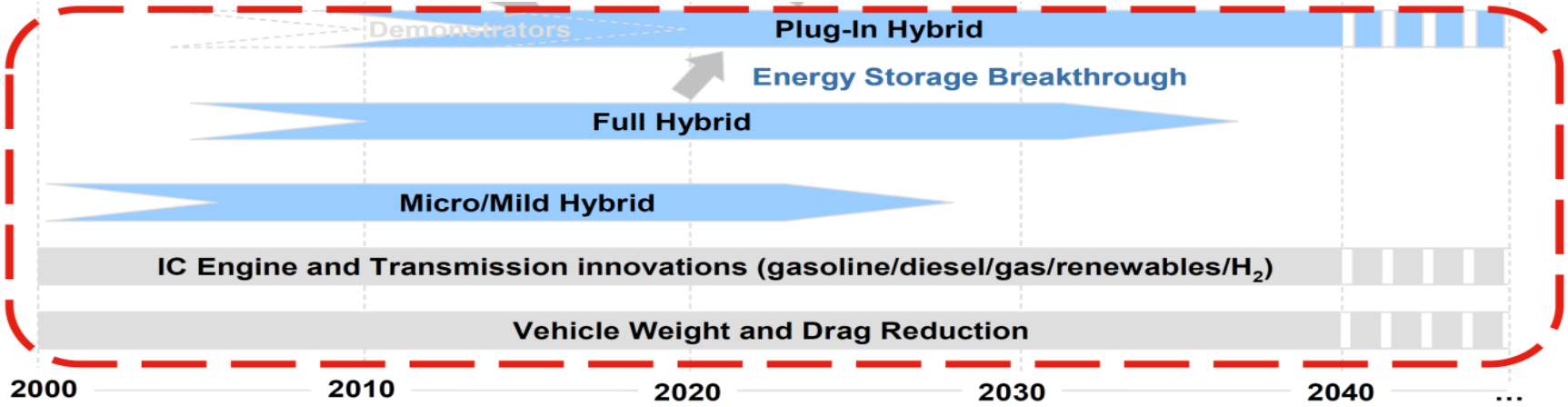
- Global shift to ultra-low emission propulsion systems with some leading low carbon technologies developing in the UK
- Creation and industrialisation of innovations developed in Universities, motorsport and SMEs
- Increasing capacity and breadth of supply chain capabilities to meet demand

Optimizing the balance ICE : EV

Advanced high efficiency Internal Combustion Engines key feature of roadmap & UK focus area

automotive council UK





Town & Country Hybrid vehicle

EV '**Town**' driving <35mph; HEV '**Country'** driving >35 mph

5kWh battery; 15 miles AER => 126mpg ; 52g/km CO_2

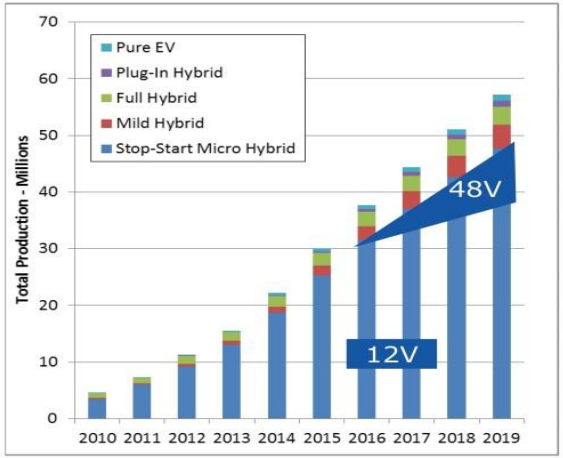
1. European Green Cars Initiative FP7 project - to develop engine prototypes (£2m)
2. TSB IDP9 project to demonstrate plug-in hybrid powertrain in Vauxhall Adam (£3.5m)
3. One of only six products accepted into the Proving Factory – 20k units pa (£3.5m)

Innovation – Libralato engine

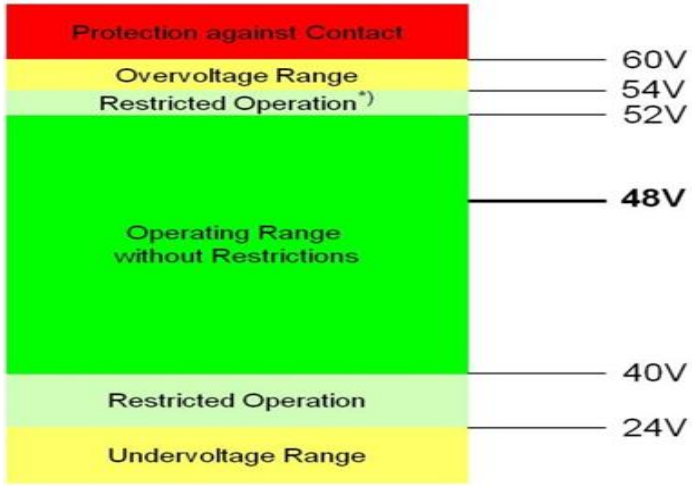
1. One stroke rotary Atkinson cycle
2. Unrivalled efficiency of >40%
3. 100% increased power to weight ratio
4. 30% manufacturing cost reduction - $16.5/kW
5. Euro 6 emissions standards compliant
6. European patent granted 2013

Simulation Results (Gasoline):		
BSFC = 169.7 g/kWh	Brake power = 25.1 kW	Brake efficiency = **46.1 %**
Pmax= 88.34 bar	Brake torque = 160.0 Nm	bmep = 3.9 bar
Engine Speed = 1500.0 rpm	Displacement = 2.57 dm^3	

Innovation - 48V urban EV system

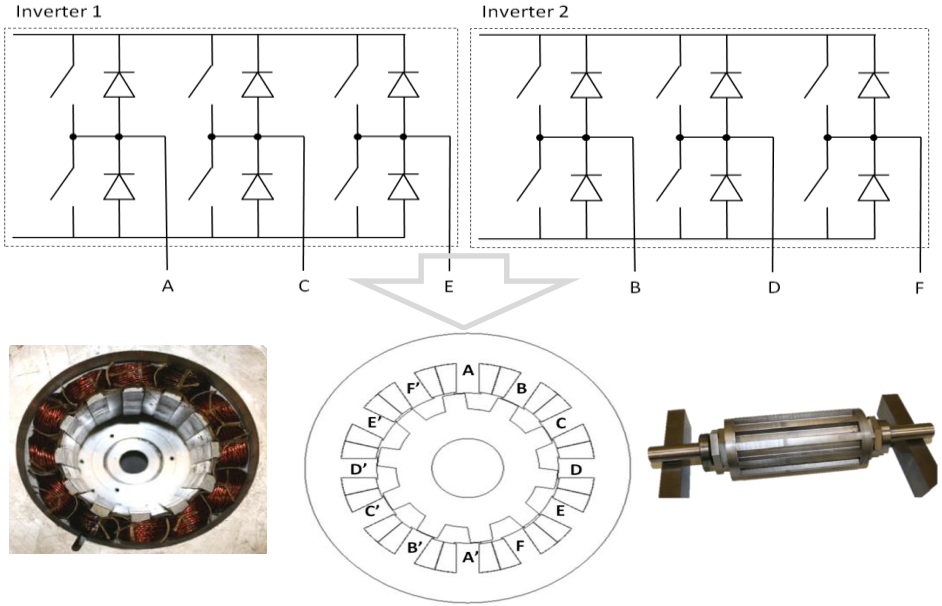


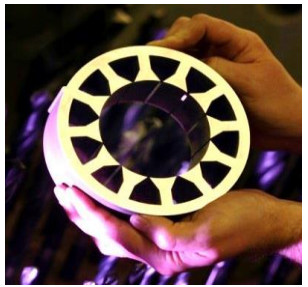
Source: STRATEGY ANALYTICS
With Infineon 48V system projection



1. 48V traditionally limited to ~10kW motor power; dual 48V inverter / motor provides the 22kW required for full EV ‘town’ use
2. 48V systems are non-lethal on contact: massively reduces the safety case (ref: ISO 26262 & German OEM LV148)
3. 48V battery supply removes High Voltage insulation cost / weight / space

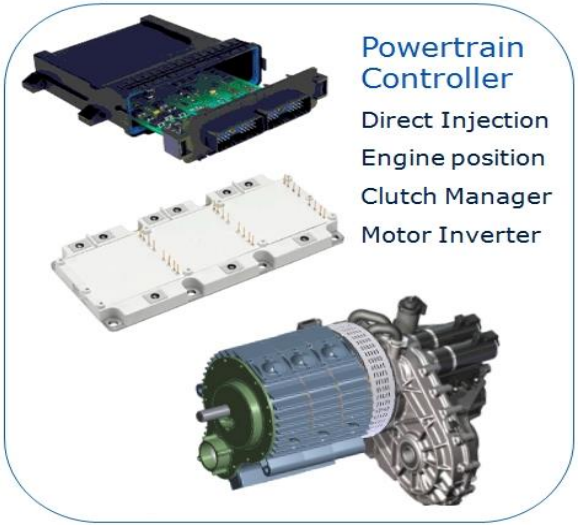
Innovation - 6-phase Switched Reluctance Motor





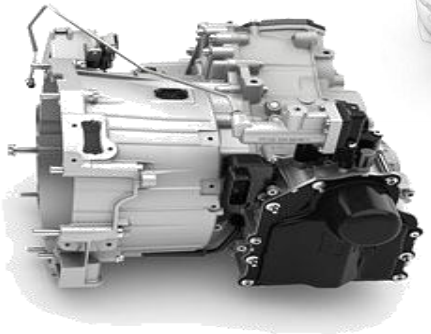
1. No ‘rare earth’ metals; 50% cost reduction vs permanent magnet machines.
2. No ‘exotic’ power devices required (regular FETs rather than high voltage IGbTs)
3. Two inverters driven synchronously from the Powertrain ECU to provide 22kW power with minimal noise / vibration

Innovation – Aurix™ Power electronics



1. Control platform based on new tri-core AURIX™ processors, developed through EU Artemis projects; applied on vehicle for the first time.
2. Control system requires just 2 ECUs; now achievable commercially due to a price drop in these very high performance microcontrollers.
3. Following ISO26262 functional safety techniques to ensure optimum safety case

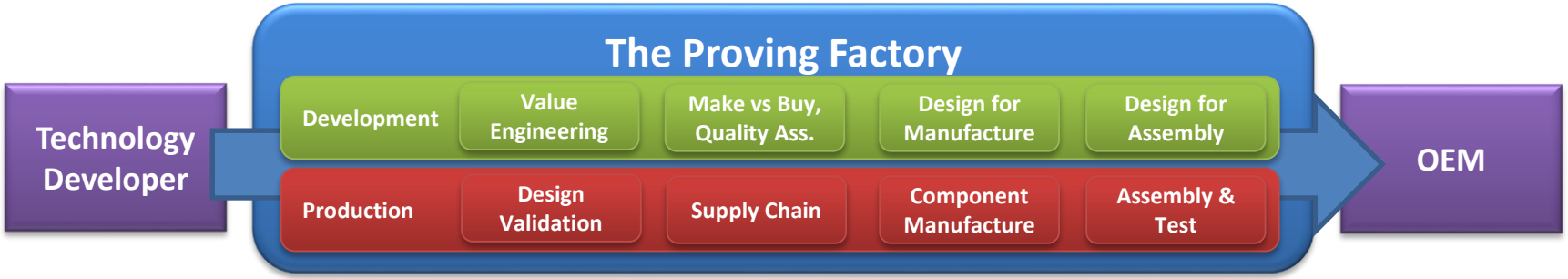
USPs – efficiency, low cost, package, safety



- £1.8k marginal cost = £6.5k less than the next best (e.g. VW Twin Up 2017)
- 48V (non-lethal) versus 300V (lethal) electric systems
- OEMs cannot fit the whole plug-in hybrid powertrain into a small car engine bay

The Proving Factory

'bridging the valley of death'



TRL7	MRL5
• Multiple prototypes have been demonstrated in an operational, on-vehicle environment. • The technology performs as required. • Limit testing and ultimate performance characteristics are now determined. • The technology is suitable to be incorporated into specific vehicle platform development programmes.	• Capability exists to produce prototype components in a production relevant environment. • Critical technologies and components have been identified. • Prototype materials, tooling and test equipment, as well as personnel skills have been demonstrated with components in a production relevant environment. • FMEA and DFMA have been initiated.

Engaged with first potential customers

- Vauxhall/ GM
- Mahindra & Mahindra
- SAIC (MG)

Mahindra Rise.

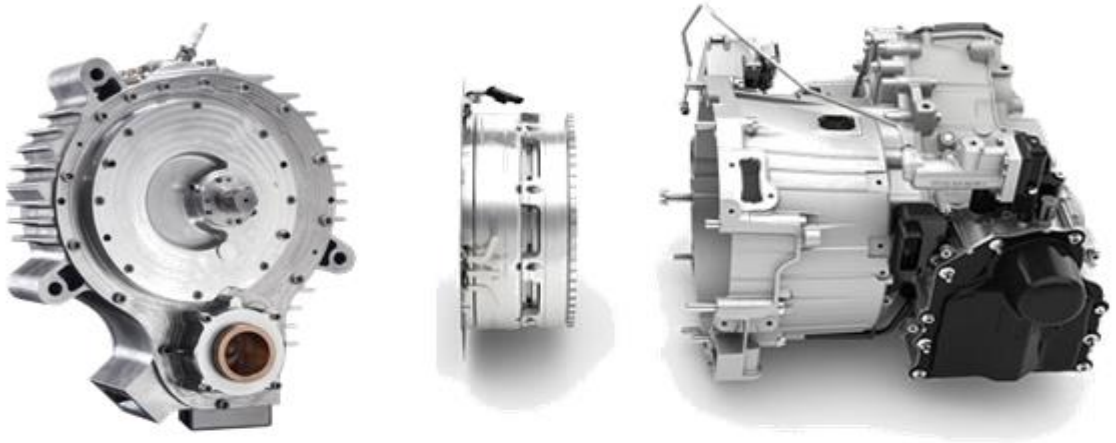
Mahindra REVA

SAIC MOTOR 上海汽车

UK Technical Centre Limited

DEUTZ®

UK ULEV leadership



“The transition [to ultra low emission vehicles] represents a once in a lifetime industrial opportunity for the UK automotive sector,
if it successfully positions itself in the vanguard of this new technology
– delivering jobs and growth for decades to come…”

Dan Aris – Managing Director
dan.aris@libralato.co.uk

Driving the Future Today, OLEV Sep 2013

Technology Strategy Board
Driving Innovation

Epicam Ltd

Tony Dye

EPICAM Ltd
Engine Research Consultants

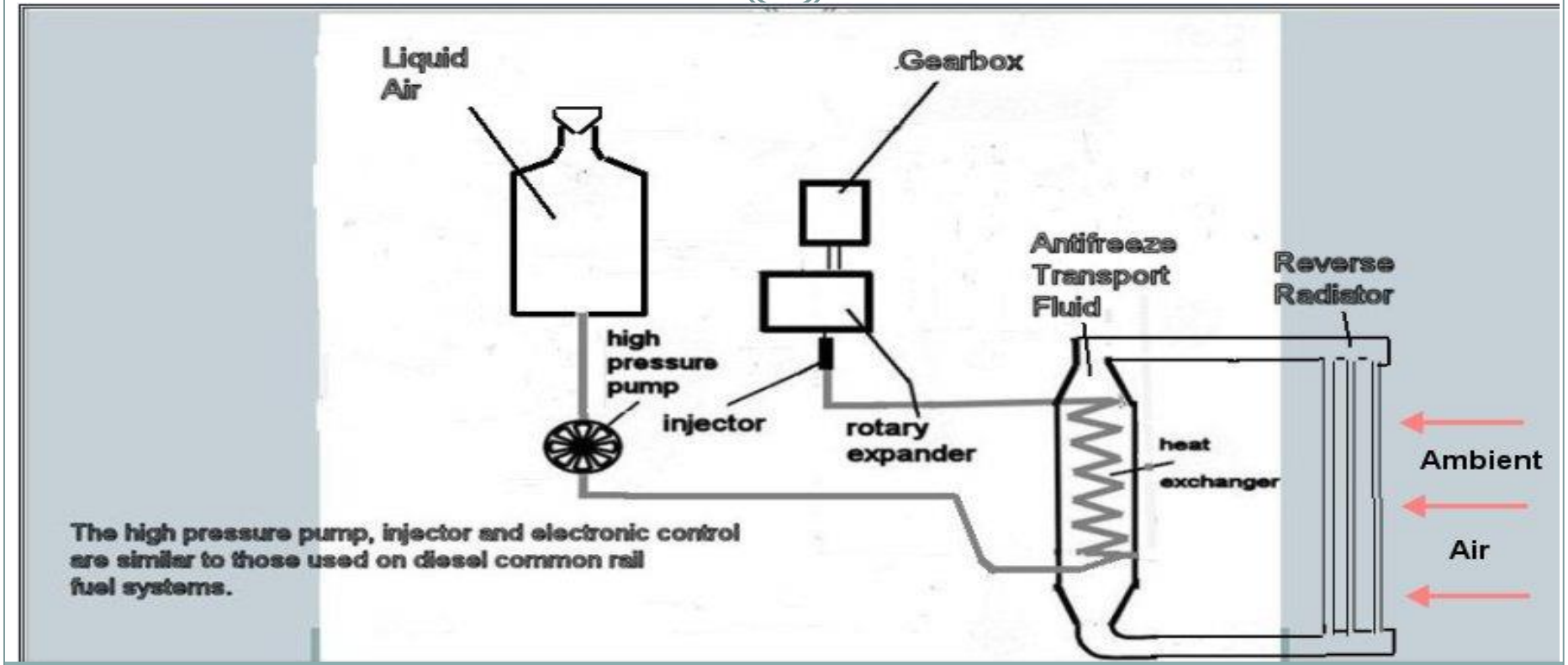
EPIQAIR - The Liquid Air Engine

CLEAN COOL ENERGY FROM LIQUID AIR

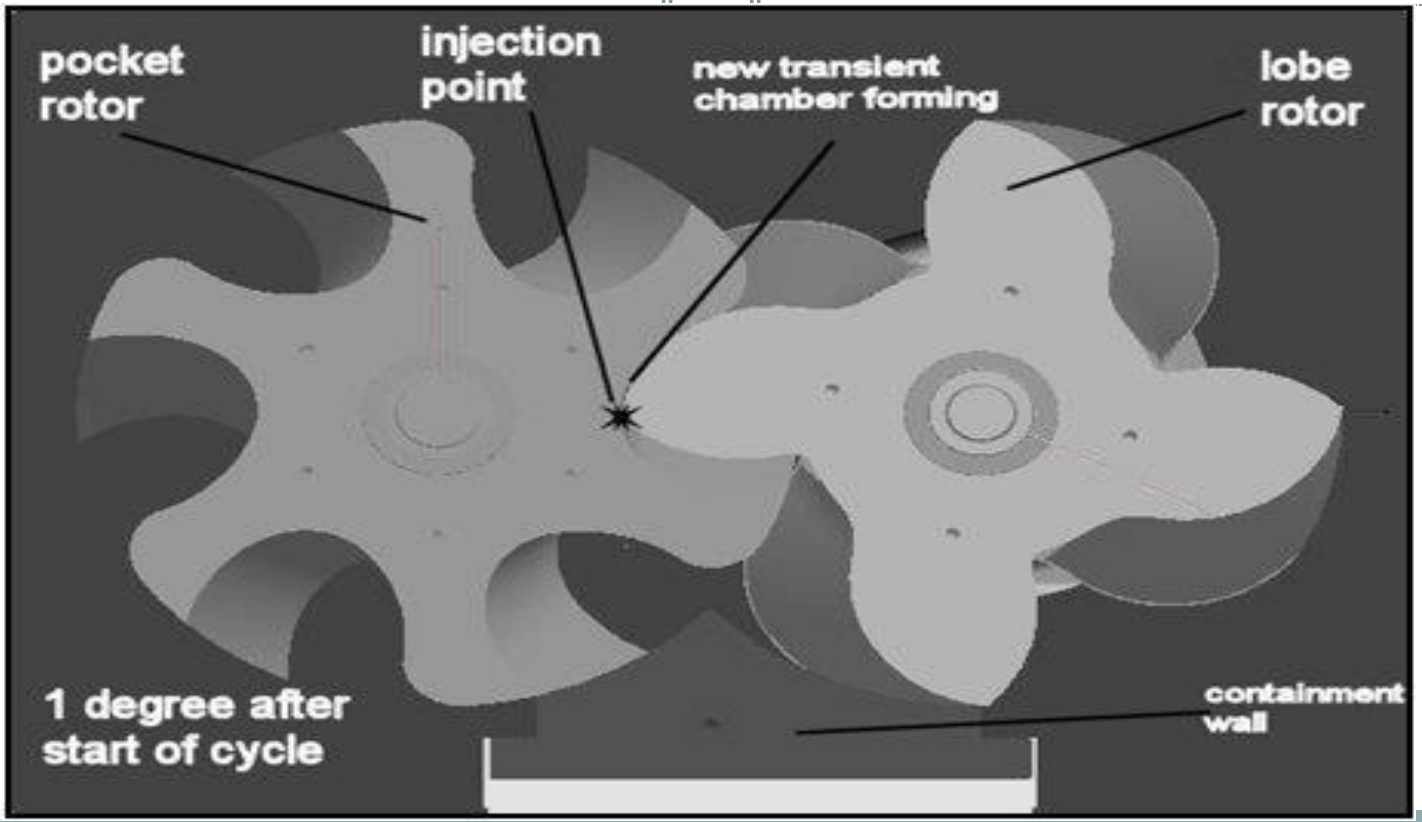
A COST-EFFECTIVE HIGH PERFORMANCE SOLUTION
TO PROVIDE ZERO CARBON POWER

TONY DYE

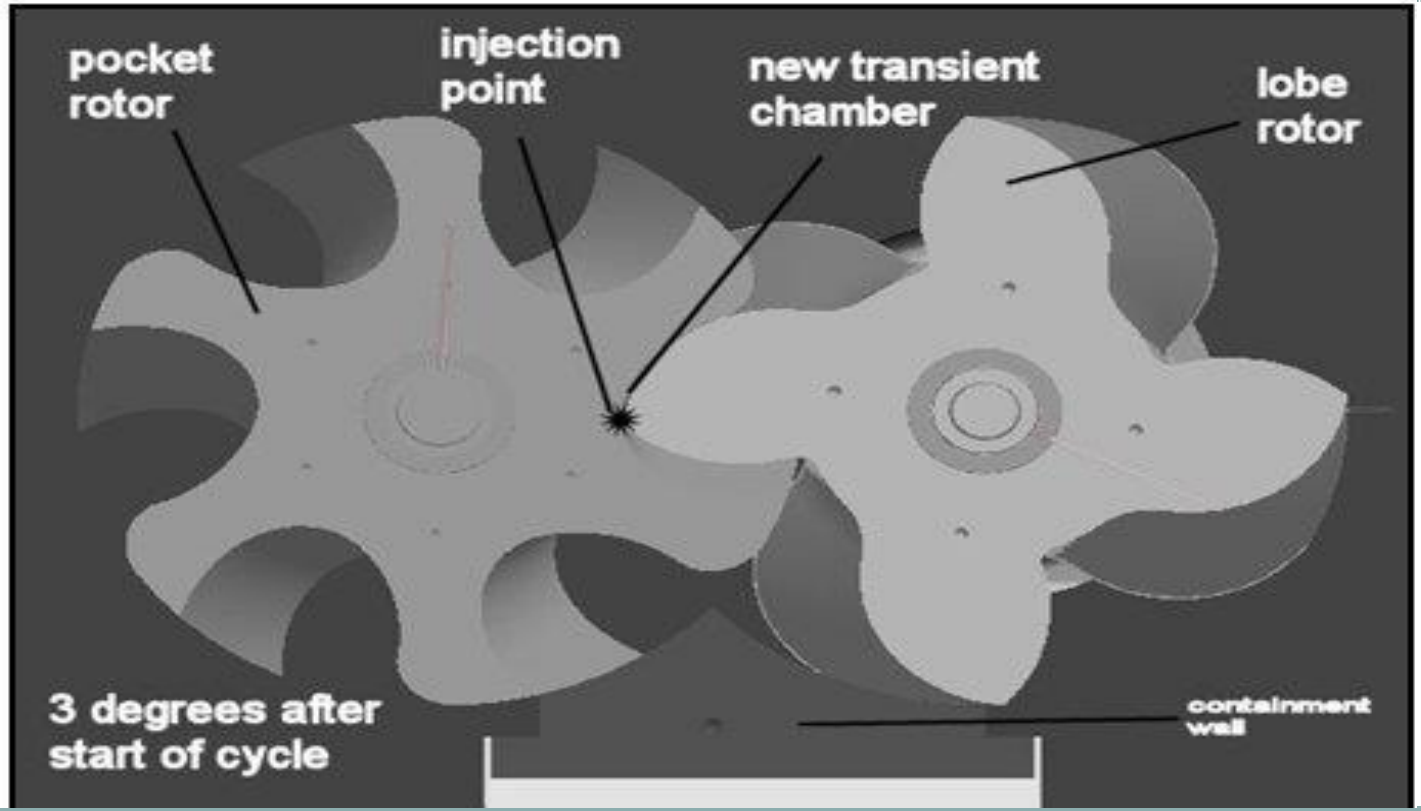
EpiQair Engine Schematic layout



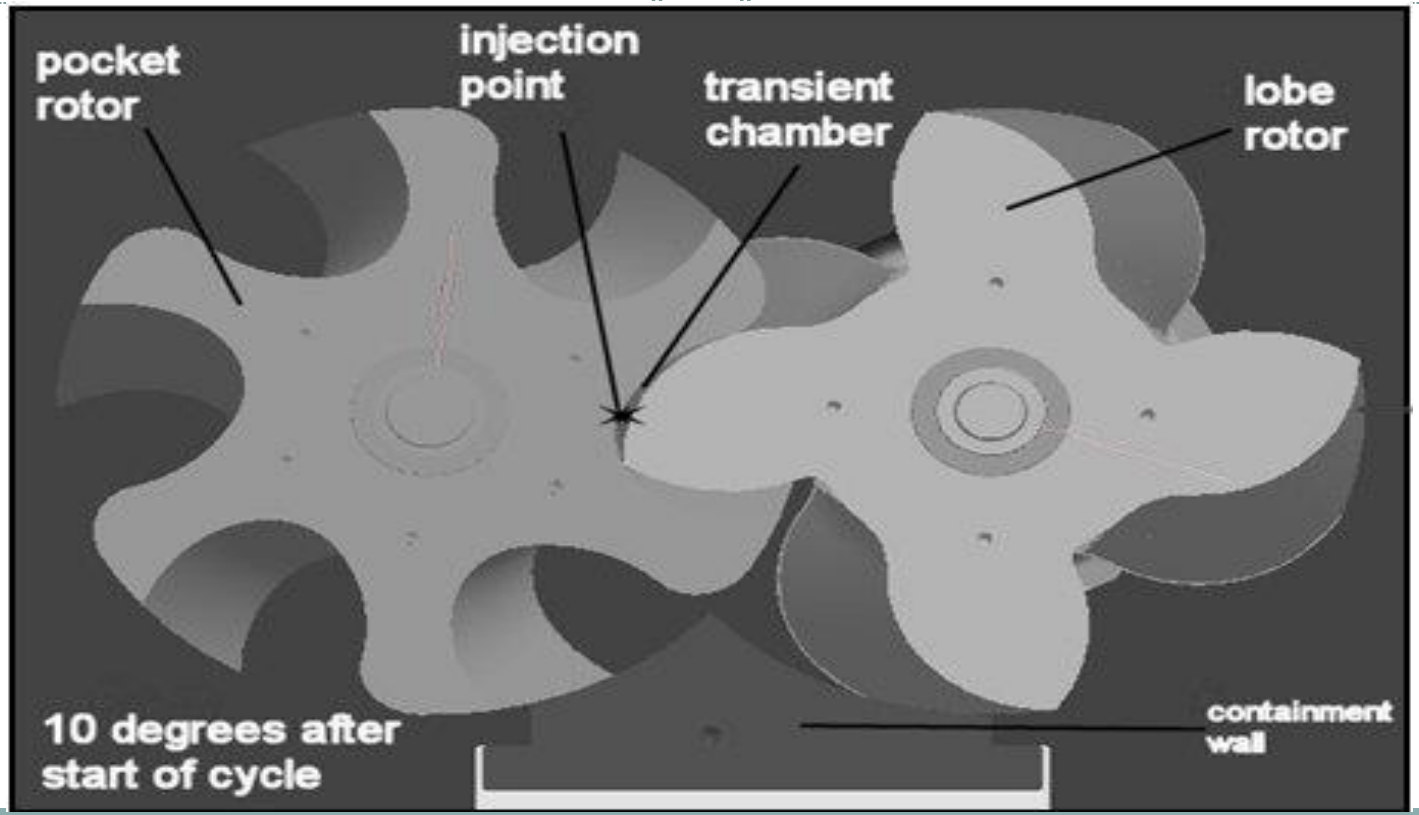
Rotary displacement Expander Stage 1



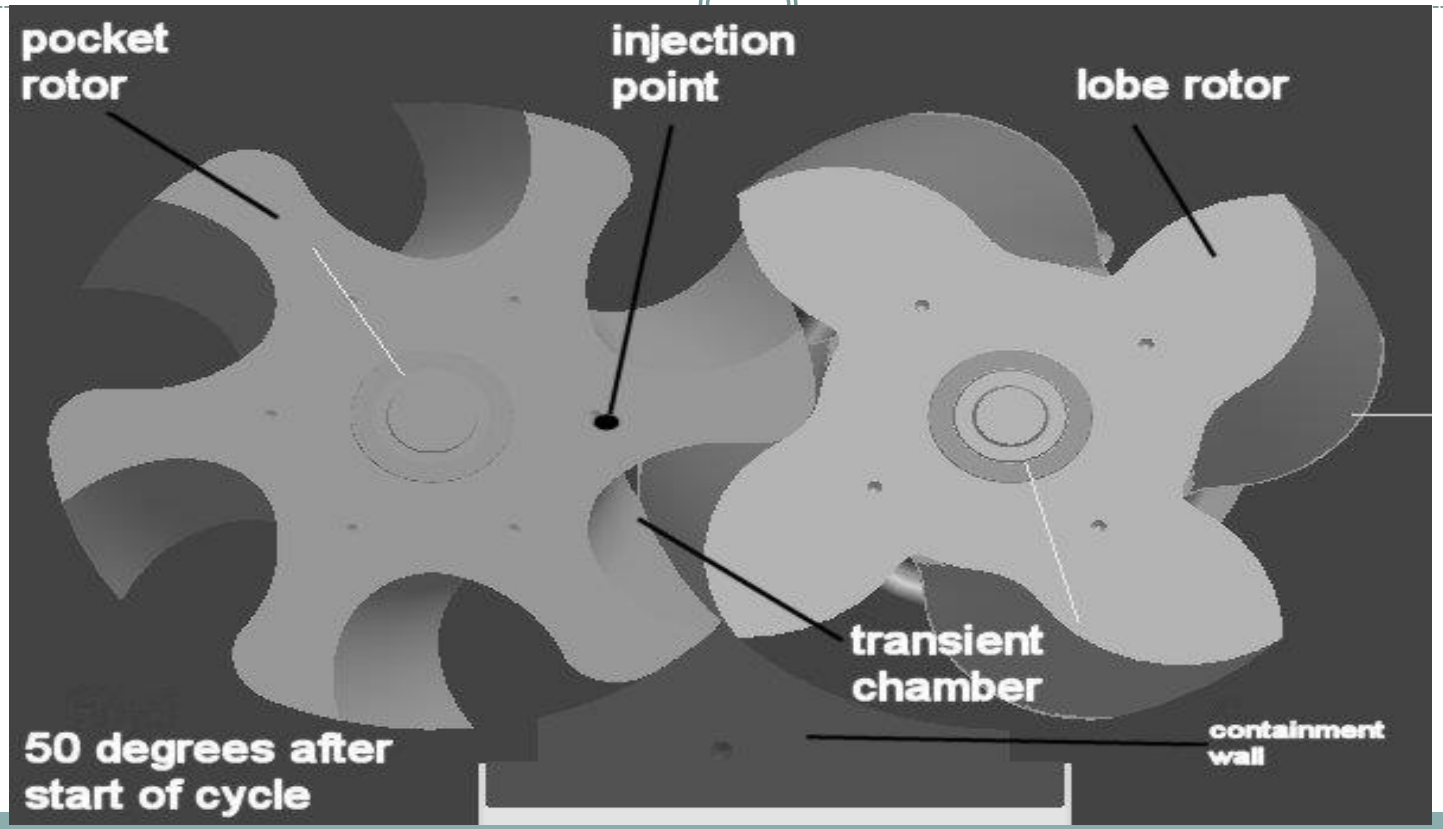
Rotary displacement Expander – Stage 2



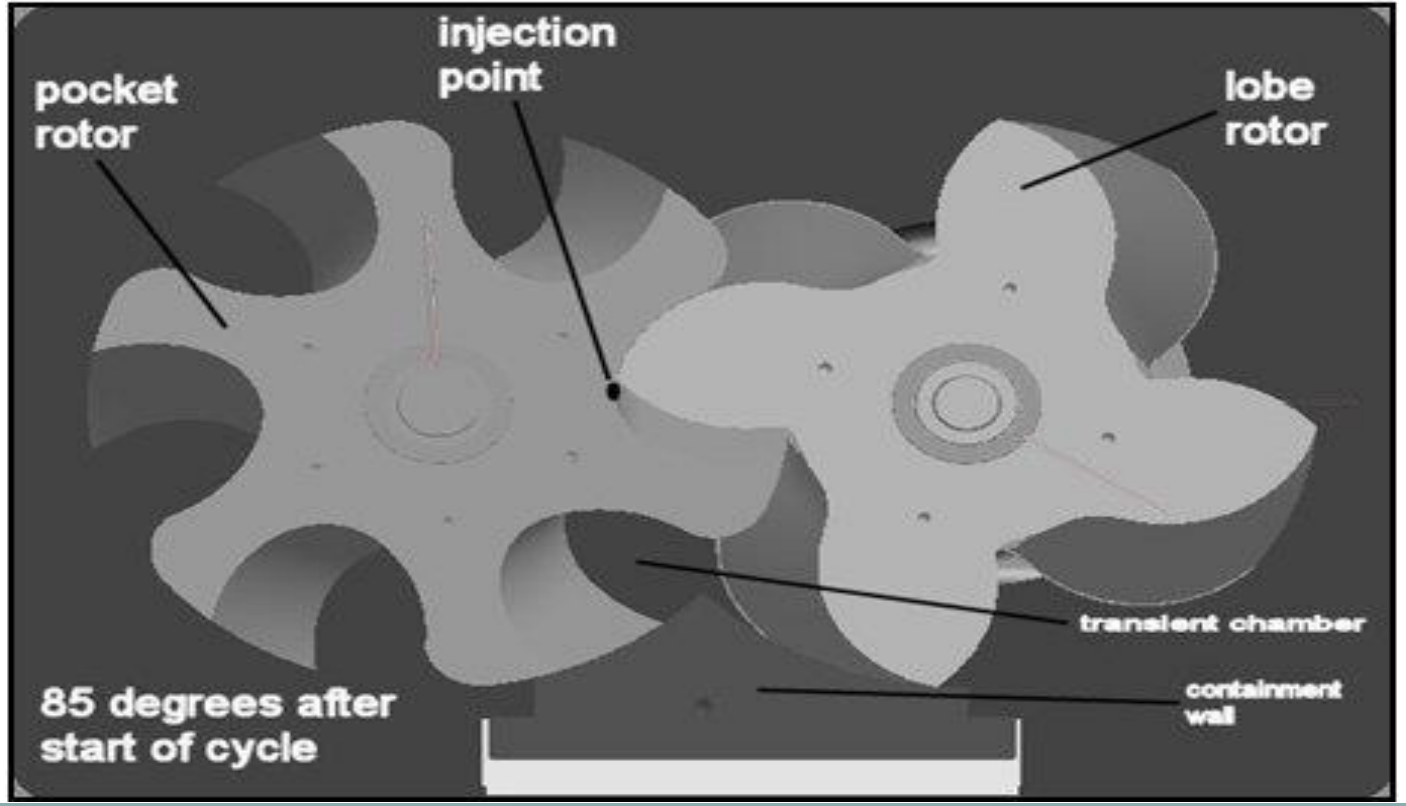
Rotary displacement Expander Stage 3



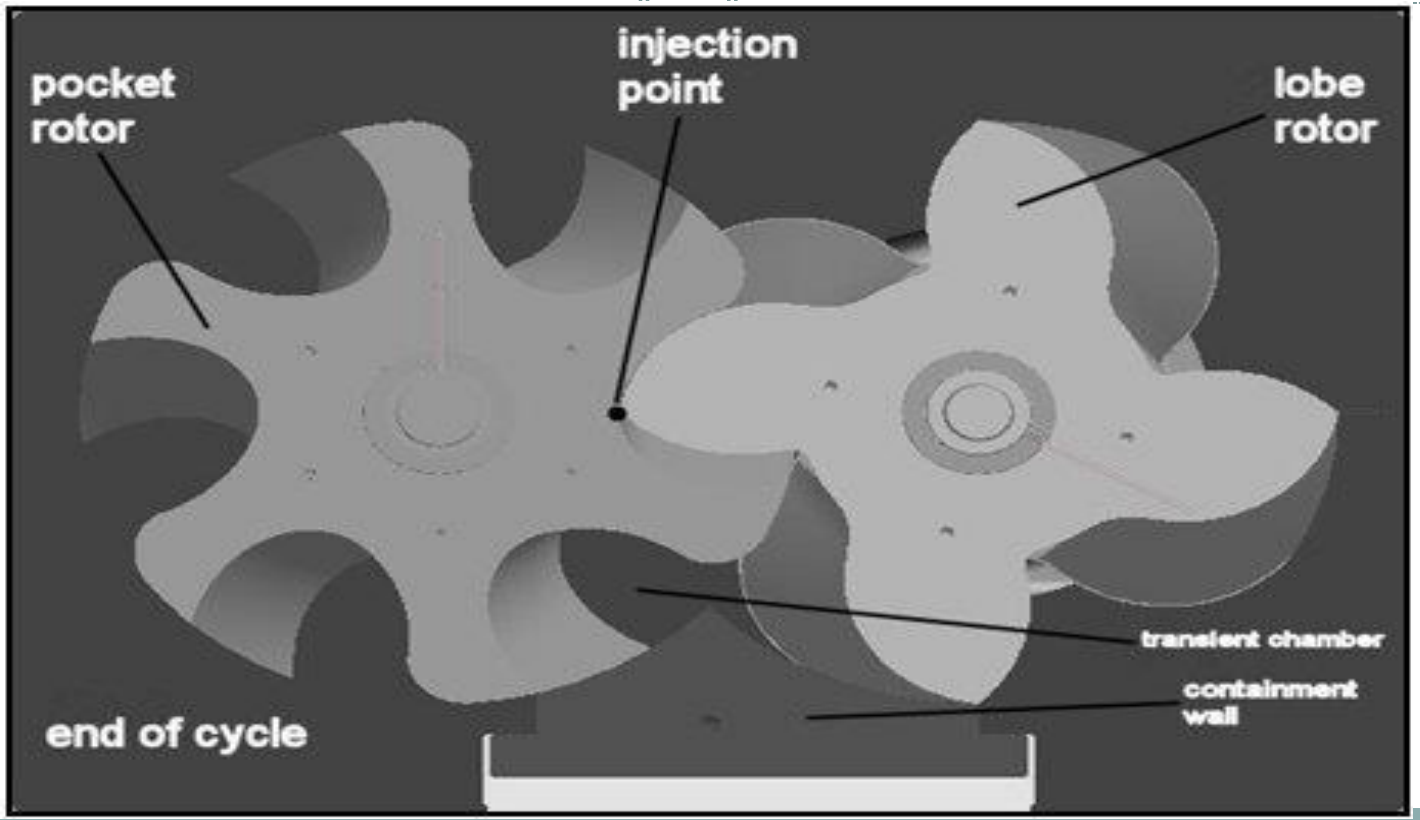
Rotary displacement Expander Stage 4



Rotary displacement Expander Stage 5

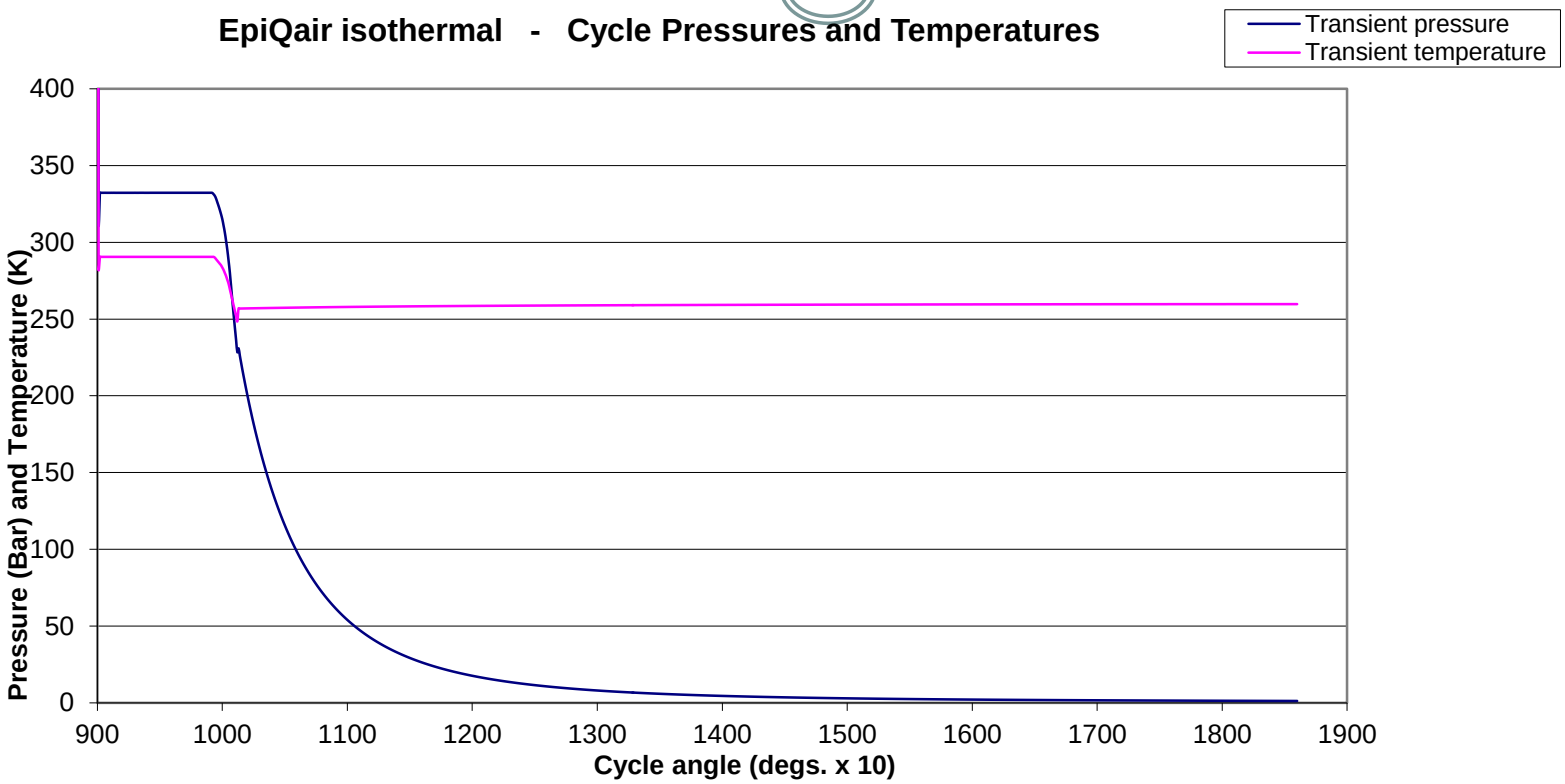


Rotary displacement Expander Stage 6

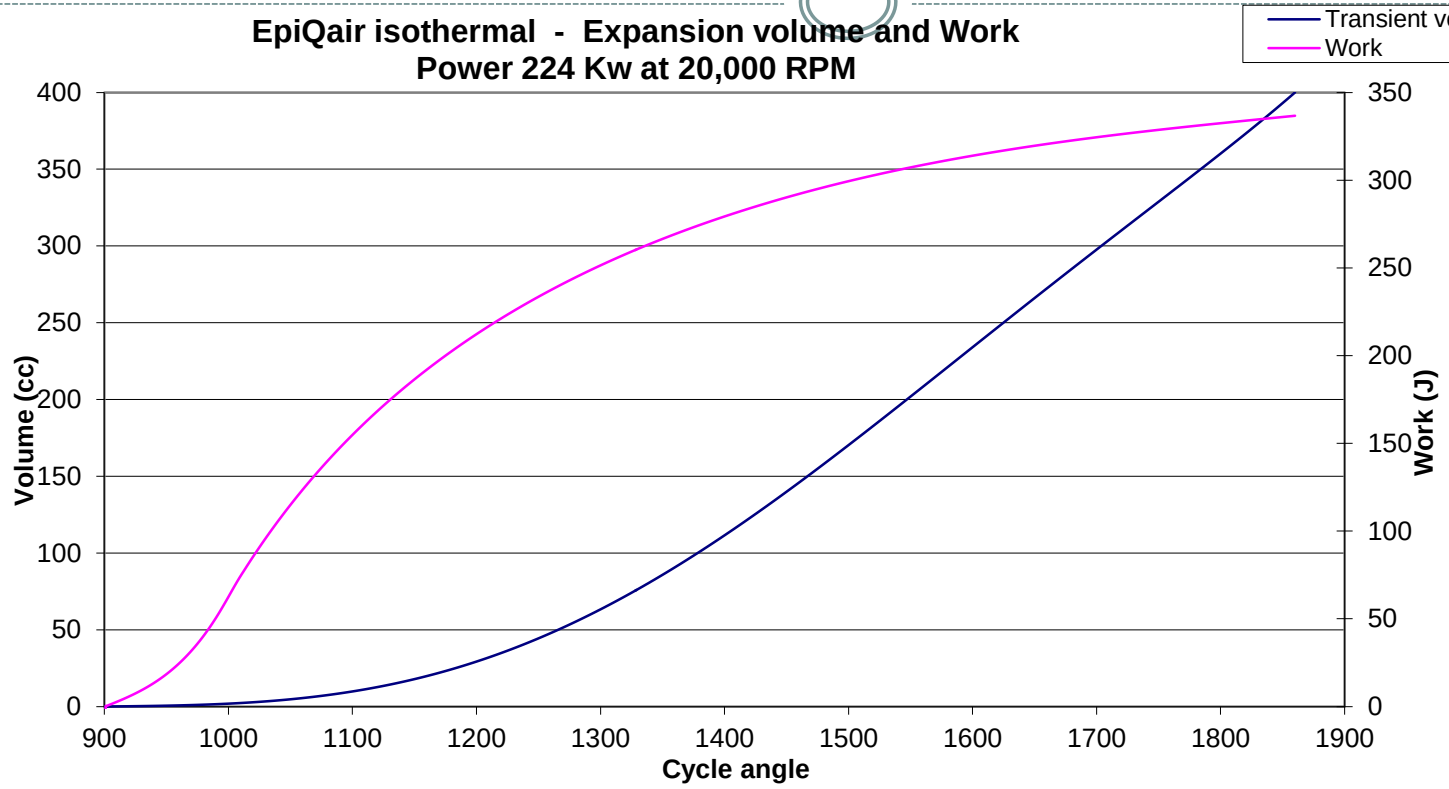


Cycle Pressures and Temperatures

Power = 224 Kw. at 20,000 RPM

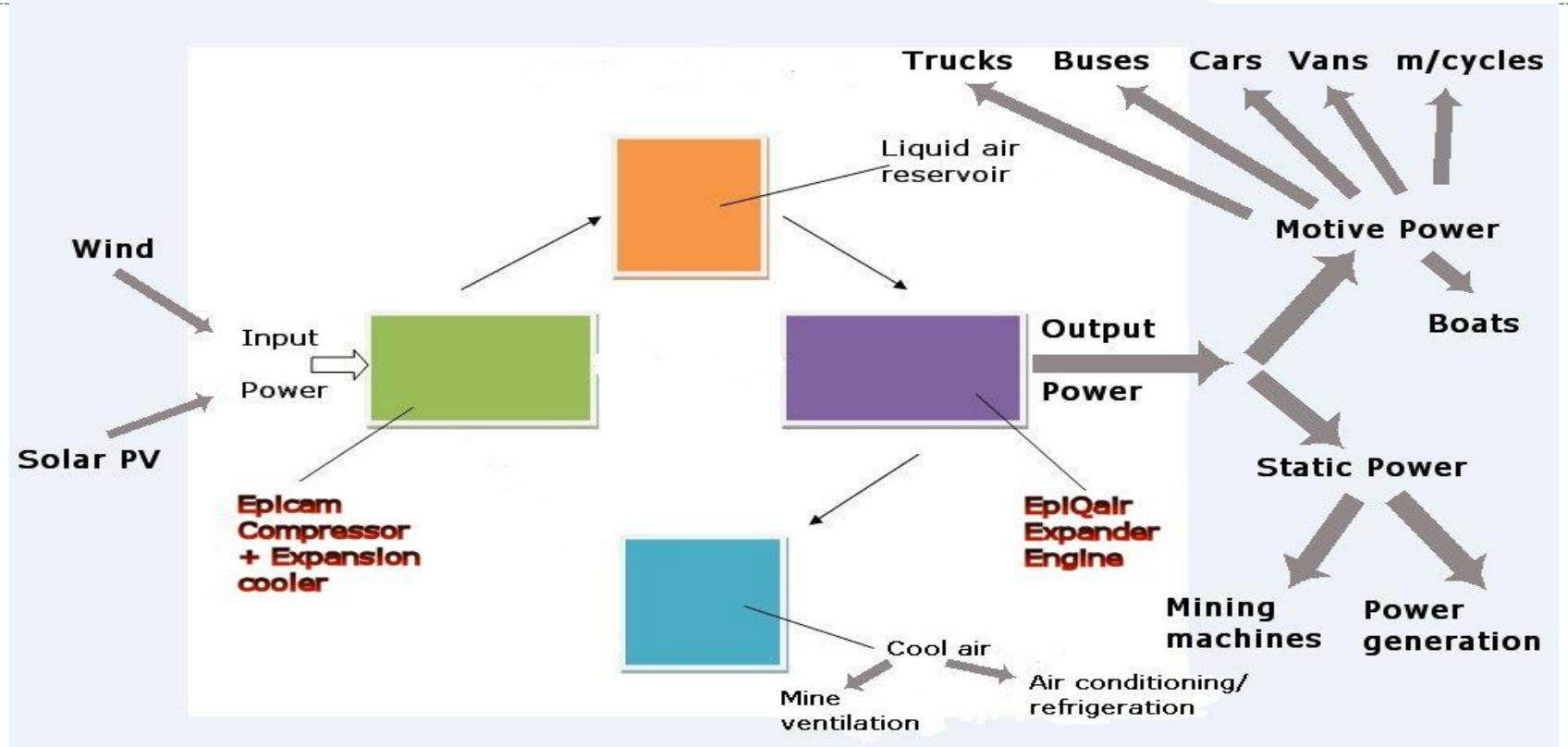


Cycle Expansion Volume and Work



EpiQair Engine Applications

EPICAM Ltd
Engine Research Consultants



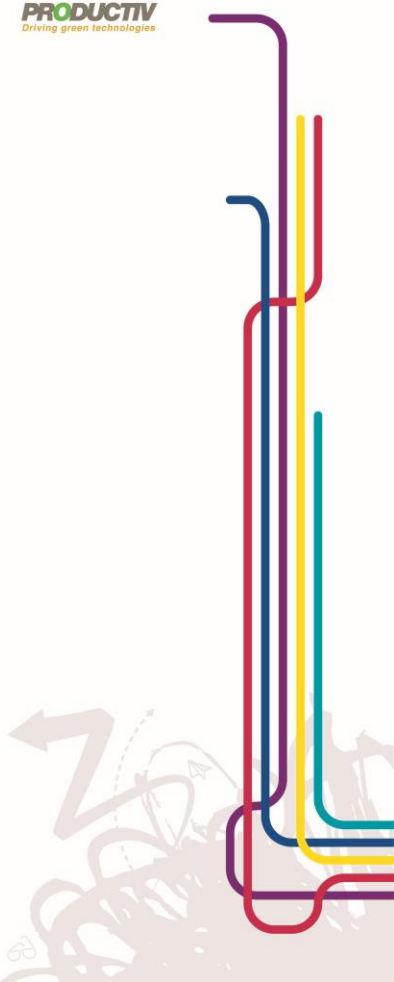
EpiQair engine – the effective solution for carbon-free power

THANK YOU FOR WATCHING

Technology Strategy Board
Driving Innovation

Evolute

Adrian Leavitt



Evolution in Driveline Technology

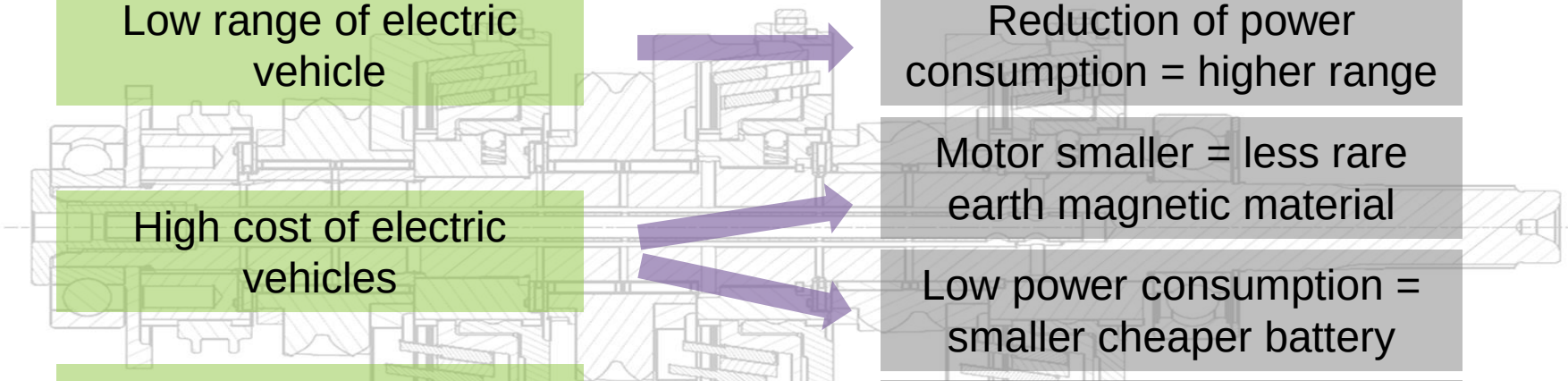
Dr Adrian Leavitt
Project Manager

10-15% Higher Range in Electric Vehicles

Barrier / Solutions

What makes this technology unique?

BARRIERS	SOLUTIONS
Low range of electric vehicle	Reduction of power consumption = higher range
High cost of electric vehicles	Motor smaller = less rare earth magnetic material
	Low power consumption = smaller cheaper battery
High energy consumption of “powershifts”	No energy consumed between gear shifts
Low appeal of current electric vehicles	Target new premium segment (e.g. BMW i3)



Technology

Benefits of the MSYS Transmission

High efficiency multi-speed

- Reduces motor energy consumption
- Enables return on existing EV investment
- Low cost contribution to meeting EC fleet CO_2 target

Patents pending powershift technology

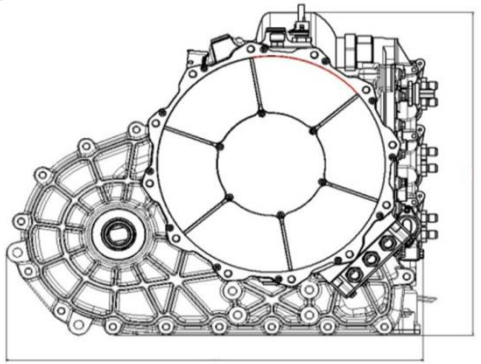
- Smooth and fast gear shift
- Portfolio of technologies going through international applications
- Potential application outside EV

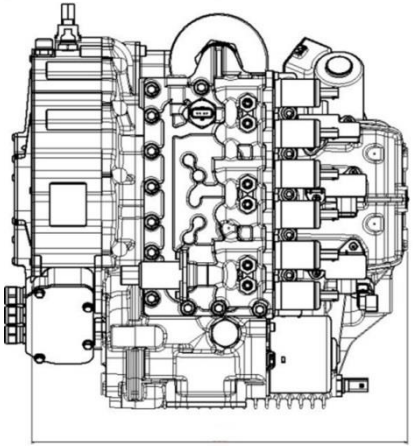
Low weight and size

- 40% weight reduction compared to single speed powertrain

Existing technology used in a new way

- Allows use of existing supply chain
- Low development risk





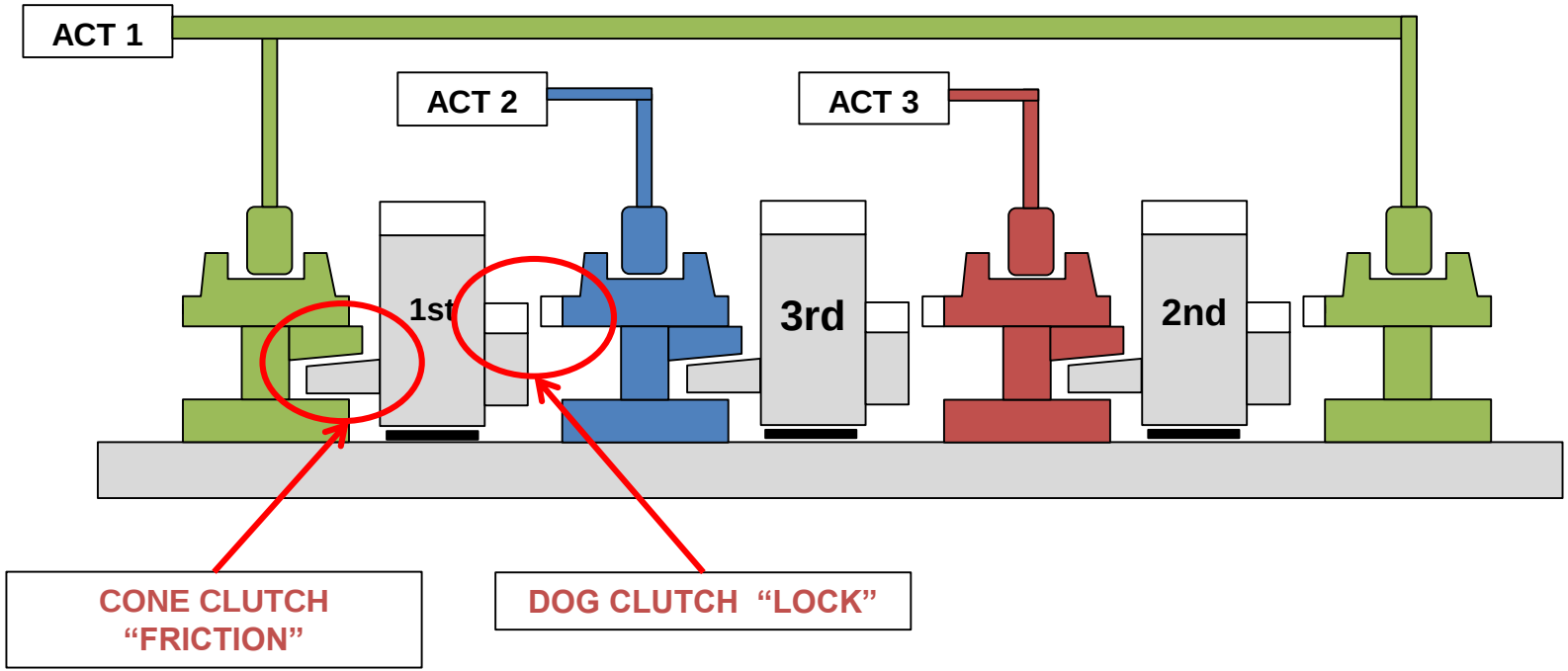
Review of available technologies

- Friction: smooth torque control
- Mechanical lock: reduced energy requirements

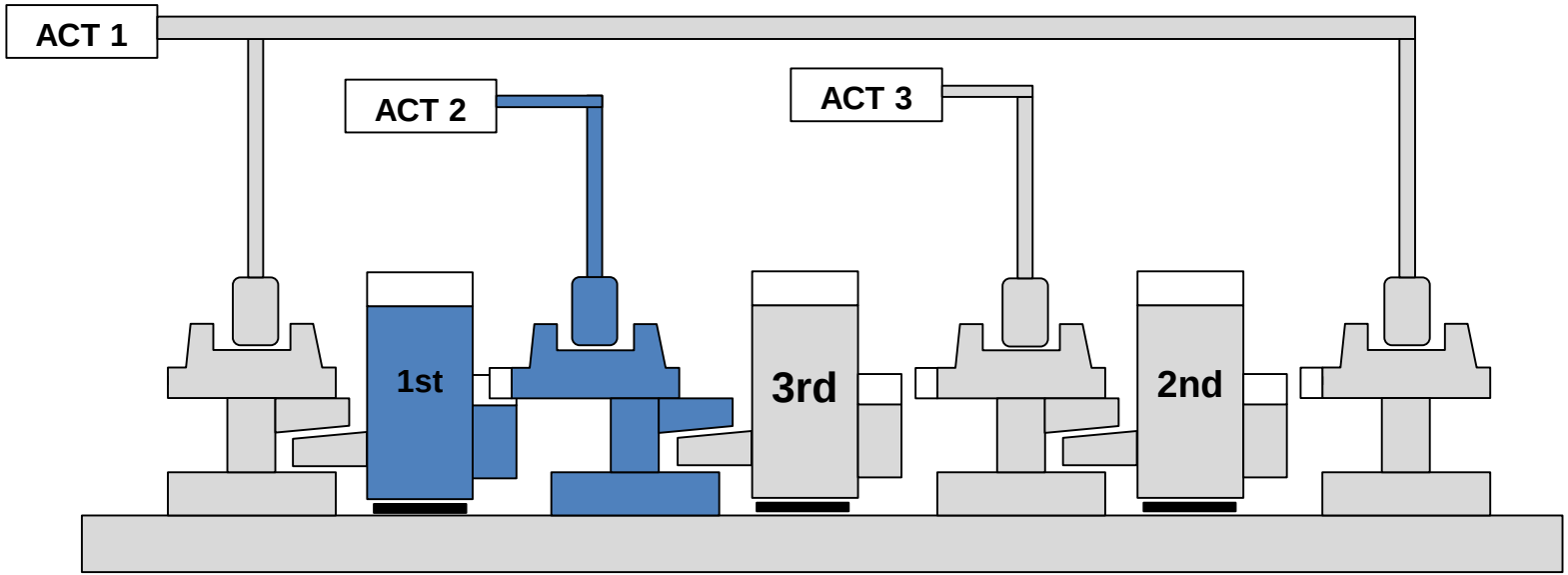
	Power Shift	Drag	In Gear Energy	Cost
Clutches/brakes	✓	✘	✘	✘
Synchronisers	✘	✓	✓	✓
Dog Clutches	✘	✓	✓	✓
One way clutches	?	✓	✓	✓
Const. Load Synch. *	?	✓	✓	✓
MSYS	✓	✓	✓	✓

**** DSD - CTI 2009: "Next Steps In Automated Manual Transmission Technology"***

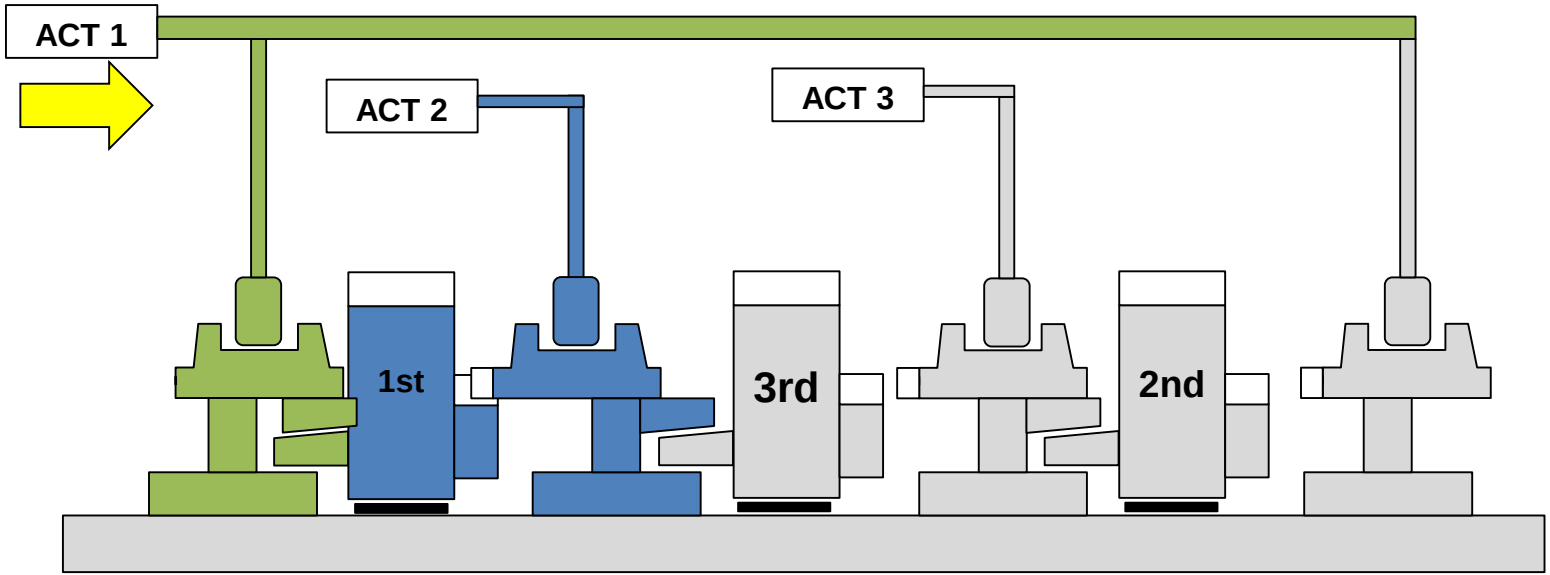
Separation of synchroniser functions



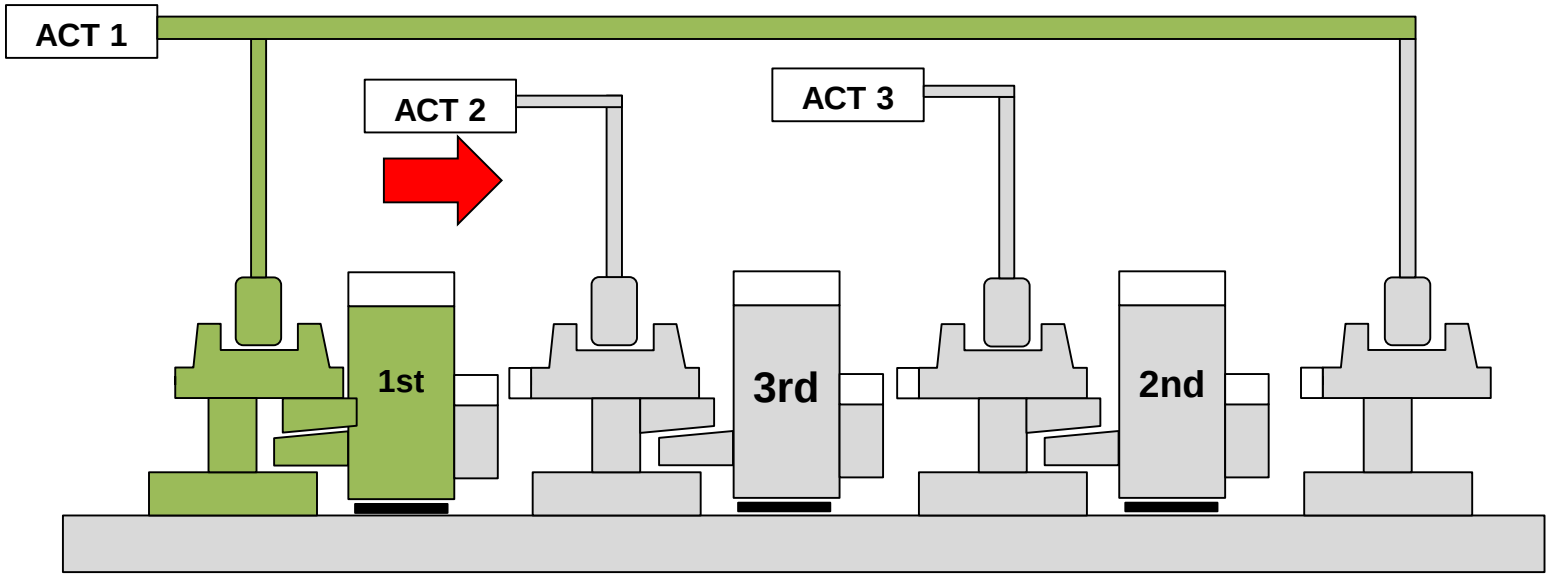
STEP 1: 1st Gear DOG Engaged



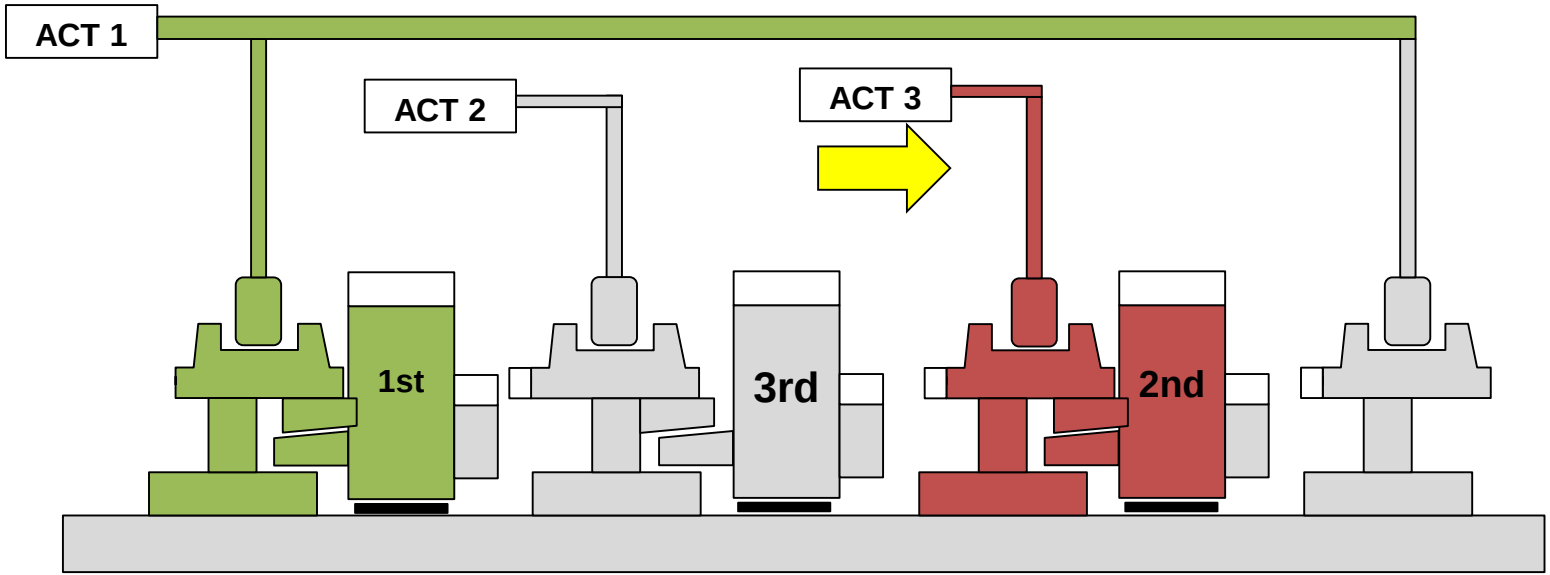
STEP 2: Apply Cone Clutch



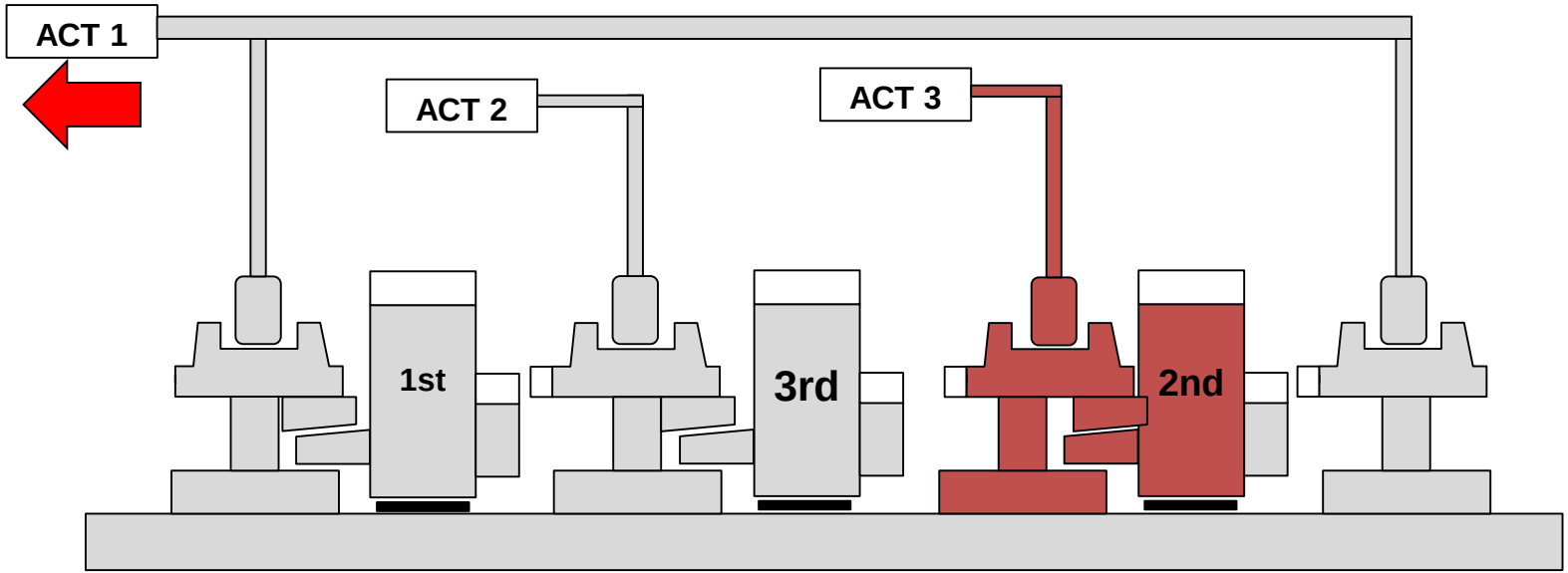
STEP 3: Release 1st Gear Dog – Drive on Cone Clutch



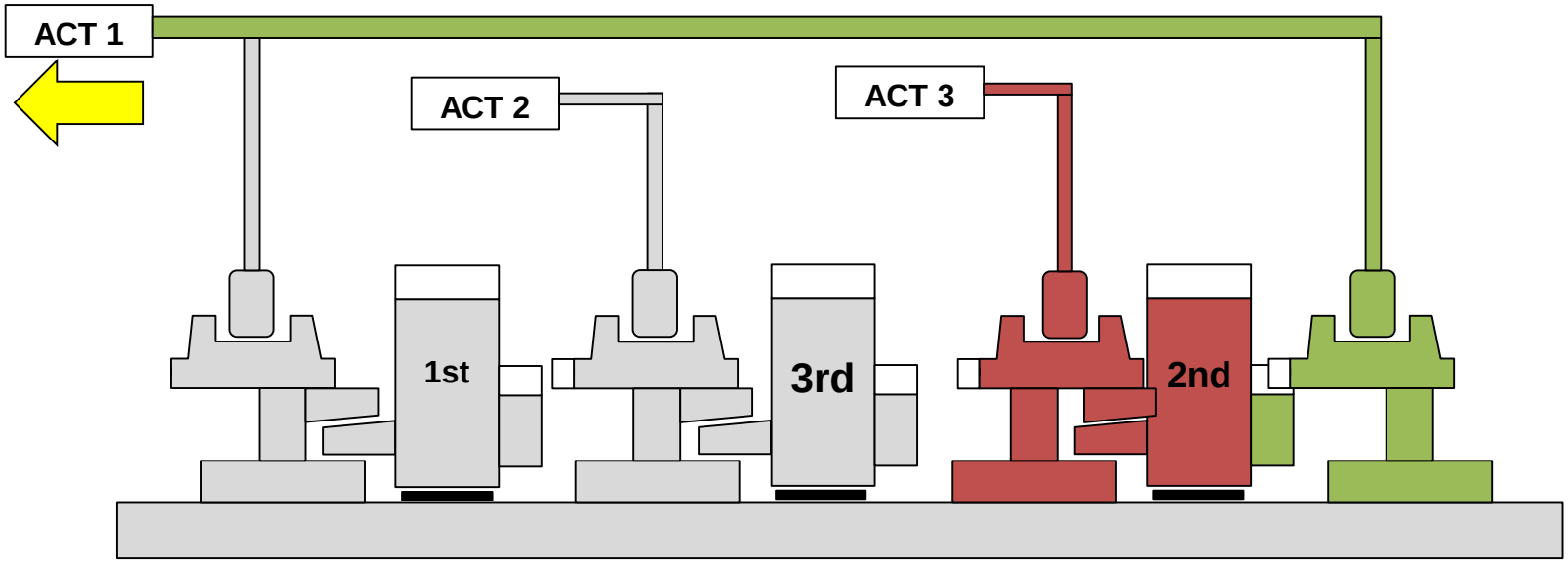
STEP 4: Perform Clutch-to-Clutch torque transfer



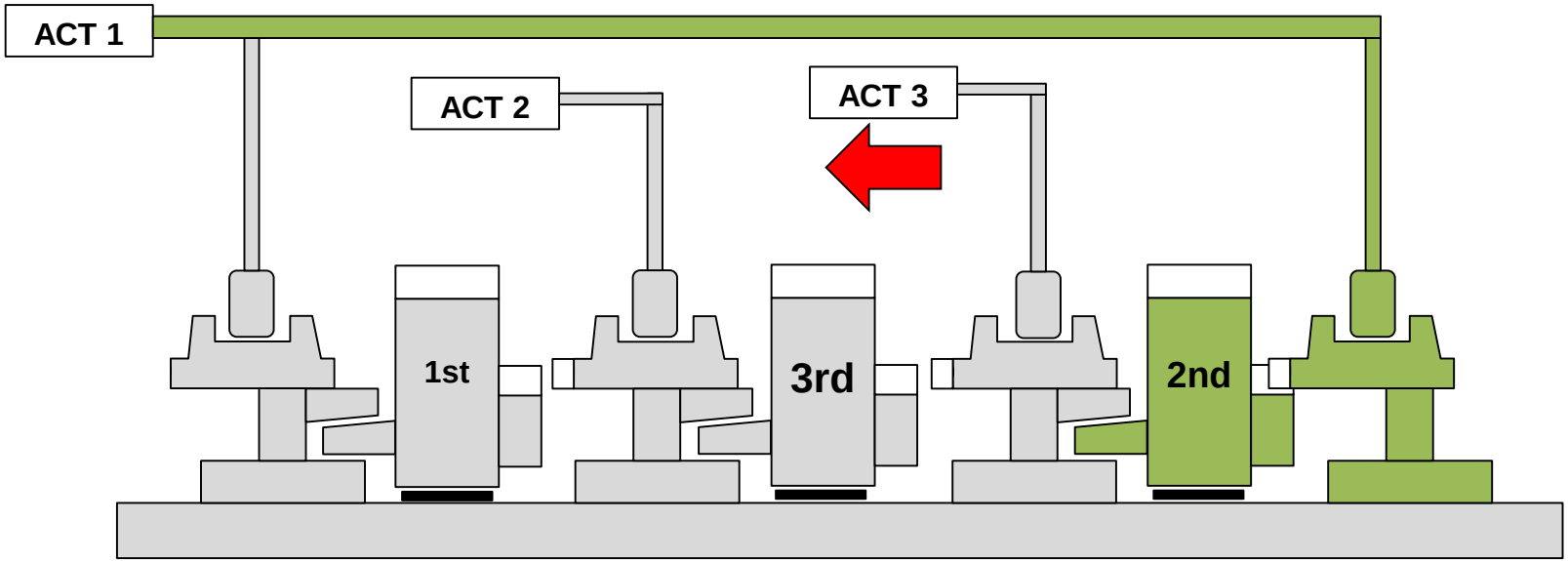
STEP 5: Adjust input speed to new gear & release 1st Gear Clutch



STEP 6: Engage 2nd Gear Dog

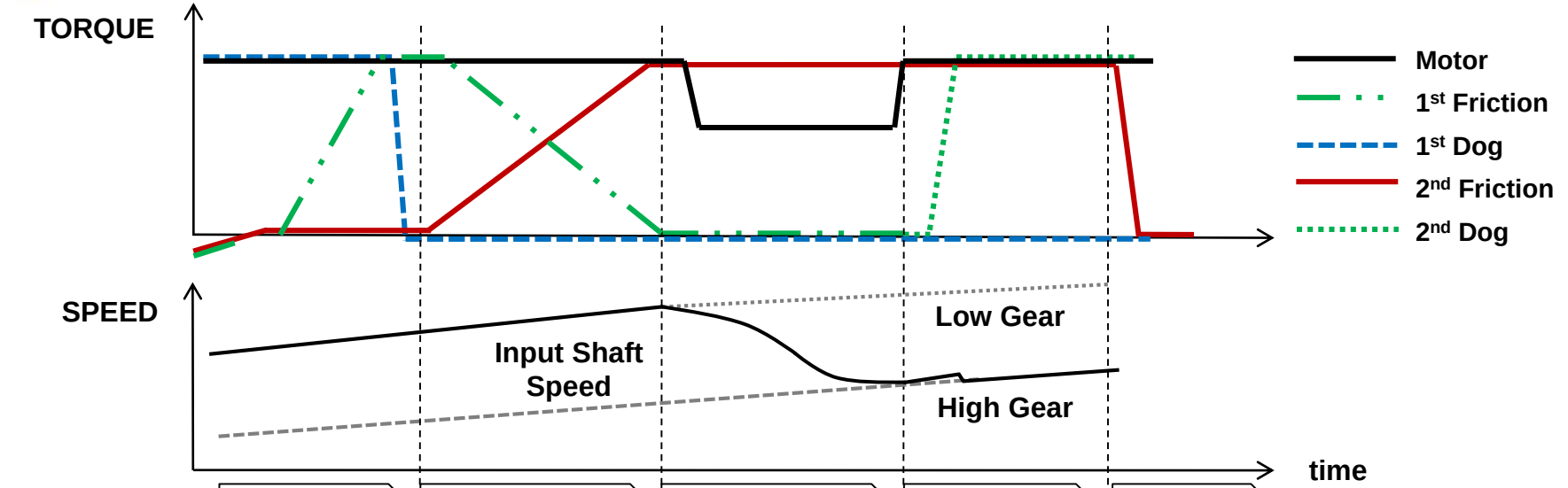


STEP 7: Release 2nd Gear Clutch



Shift Control

MSYS generic power shift



	Prepare	Torque Phase	Speed Phase	Eng.	Off
ACT 1	1st CONE	1st CONE	---	2nd DOG	OFF
ACT 2	1st DOG	---	---	---	OFF
ACT 3	2nd CONE	2nd CONE	2nd CONE	2nd CONE	OFF

Commercial

Where are we today?

Currently in prototype testing phase

Concept demonstrator vehicle available to drive Q2 2014.

Interest from 2 European premium segment vehicle manufacturers

Tier 1 volume manufacturing interest from with UK and Europe

New interest from 3 further vehicle manufacturers

Concept

2011

Prototype Design

2012

Build & Test

2013

Vehicle Demo

2014

Thank you for your attention

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