

**EP/M009424/1**

**Ultra Efficient Engines and Fuels**

*Dr Robert Morgan*

*Document produced, 3 Apr 2018*

<b>Award Title</b>	Ultra Efficient Engines and Fuels
<b>Award Reference</b>	EP/M009424/1
<b>Location</b>	University of Brighton
<b>Funding Start Date</b>	2015-02-01
<b>Funding End Date</b>	2018-07-31
<b>Award Abstract</b>	
<b>Lay Summary</b>	This research seeks to address the knowledge gap with the internal combustion engine (ICE) and answer the question 'how far can you go?'. The research considers methods for reducing fuel consumption of the ICE from two directions: first by improving in-c

## Sections

### Publications

#### ***High precision in-cylinder thermometry using laser induced grating spectroscopy***

**Publication date** 2015  
**First Named Author** Ewart, P  
**Secondary Authors** Wilman, C;Williams, B.A.O;Williams, J;Stone, C.R  
**Publication Type** Conference Proceeding / Conference Paper  
**Is Published** Yes  
**Publication ID** 56d02d77406214.99526261

#### ***Identifiers:***

**Data Source** Manual

**ISSN (Print)**

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**ISSN (Linking)**

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#### ***Comparing the effect of different oxygenate components on PN emissions from GDI engines***

**Publication date** 2015  
**First Named Author** Leach, F  
**Secondary Authors** Stone, C.R;Davy, M.H;Richardson, D  
**Publication Type** Conference Proceeding / Conference Paper  
**Is Published** Yes  
**Publication ID** 56d03002db7e35.53997786

#### ***Identifiers:***

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#### ***Aspects of Numerical Modelling of Flash-Boiling Fuel Sprays***

- Submitted on, 13 Mar 2018

Page 3 of 44

<b>Publication date</b>	09 2015
<b>First Named Author</b>	Price C
<b>Secondary Authors</b>	Hamzehloo A, Aleiferis P, Richardson D
<b>Publication Type</b>	Conference Proceeding / Conference Paper
<b>Is Published</b>	Yes
<b>Identifiers:</b>	
<b>PubMed ID</b>	
<b>Digital ID</b>	10.4271/2015-24-2463
<b>ISSN (Print)</b>	
<b>ISSN (Digital)</b>	0148-7191
<b>ISSN (Linking)</b>	

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***Development of a Fast-Acting, Time-Resolved Gas Sampling System for Combustion and Fuels Analysis***

<b>Publication date</b>	04 2016
<b>First Named Author</b>	Talibi M
<b>Secondary Authors</b>	Hellier P, Balachandran R, Ladommatos N
<b>Publication Type</b>	Journal Article / Review
<b>Is Published</b>	Yes
<b>Journal</b>	SAE International Journal of Engines (V: , #: 2, Pg: )
<b>Identifiers:</b>	
<b>PubMed ID</b>	
<b>Digital ID</b>	10.4271/2016-01-0791
<b>ISSN (Print)</b>	19463936
<b>ISSN (Digital)</b>	1946-3944
<b>ISSN (Linking)</b>	19463944

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***Combustion and exhaust emission characteristics, and in-cylinder gas composition, of hydrogen enriched biogas mixtures in a diesel engine***

<b>Publication date</b>	04 2017
<b>First Named Author</b>	Talibi M

**Secondary Authors** Hellier P, Ladommatos N

**Publication Type** Journal Article / Review

**Is Published** Yes

**Journal** Energy (V: , #: , Pg: )

***Identifiers:***

**PubMed ID**

**Digital ID** 10.1016/j.energy.2017.02.070

**ISSN (Print)**

**ISSN (Digital)** 03605442

**ISSN (Linking)**

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***An overview of the effects of fuel molecular structure on the combustion and emissions characteristics of compression ignition engines***

**Publication date** 02 2017

**First Named Author** Hellier P

**Secondary Authors** Talibi M, Eveleigh A, Ladommatos N

**Publication Type** Journal Article / Review

**Is Published** Yes

**Journal** Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering (V: , #: 1, Pg: )

***Identifiers:***

**PubMed ID**

**Digital ID** 10.1177/0954407016687453

**ISSN (Print)** 2041-2991

**ISSN (Digital)** 0954-4070

**ISSN (Linking)**

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***The effect of varying EGR and intake air boost on hydrogen-diesel co-combustion in CI engines***

**Publication date** 03 2017

**First Named Author** Talibi M

<b>Secondary Authors</b>	Hellier P, Ladommatos N
<b>Publication Type</b>	Journal Article / Review
<b>Is Published</b>	Yes
<b>Journal</b>	International Journal of Hydrogen Energy (V: , #: 9, Pg: )
<b>Identifiers:</b>	
<b>PubMed ID</b>	
<b>Digital ID</b>	10.1016/j.ijhydene.2016.11.207
<b>ISSN (Print)</b>	
<b>ISSN (Digital)</b>	03603199
<b>ISSN (Linking)</b>	

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***A comparative study between a Rankine cycle and a novel intra-cycle based waste heat recovery concepts applied to an internal combustion engine***

<b>Publication date</b>	07 2016
<b>First Named Author</b>	Morgan R
<b>Secondary Authors</b>	Dong G, Panesar A, Heikal M
<b>Publication Type</b>	Journal Article / Review
<b>Is Published</b>	Yes
<b>Journal</b>	Applied Energy (V: , #: , Pg: )
<b>Identifiers:</b>	
<b>PubMed ID</b>	
<b>Digital ID</b>	10.1016/j.apenergy.2016.04.026
<b>ISSN (Print)</b>	
<b>ISSN (Digital)</b>	03062619
<b>ISSN (Linking)</b>	

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***Thermodynamic analysis and system design of a novel split cycle engine concept***

<b>Publication date</b>	05 2016
<b>First Named Author</b>	Dong G

**Secondary Authors** Morgan R, Heikal M  
**Publication Type** Journal Article / Review  
**Is Published** Yes  
**Journal** Energy (V: , #: , Pg: )

***Identifiers:***

**PubMed ID**  
**Digital ID** 10.1016/j.energy.2016.02.102  
**ISSN (Print)**  
**ISSN (Digital)** 03605442  
**ISSN (Linking)**

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***The 60% efficiency reciprocating engine: A modular alternative to large scale combined cycle power***

**Publication date** 2016  
**First Named Author** Gurr, A.  
**Secondary Author** A. Atkins & R. Morgan  
**Publication Type** Conference Proceeding / Conference Paper  
**Publication ID** 58bb230850ee56.05665603

***Identifiers:***

**Data Source** Manual  
**ISSN (Print)**  
**ISSN (Digital)**  
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***A novel split cycle internal combustion engine with integral waste heat recovery***

**Publication date** 11 2015  
**First Named Author** Dong G  
**Secondary Authors** Morgan R, Heikal M  
**Publication Type** Journal Article / Review  
**Is Published** Yes

**Journal** Applied Energy (V: , #: , Pg: )

**Identifiers:**

**PubMed ID**

**Digital ID** 10.1016/j.apenergy.2015.02.024

**ISSN (Print)**

**ISSN (Digital)** 03062619

**ISSN (Linking)**

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***AN APPROACH TO MODELING FLASH-BOILING FUEL SPRAYS FOR DIRECT-INJECTION SPARK-IGNITION ENGINES***

**Publication date** 2016

**First Named Author** Price C

**Secondary Authors** Hamzehloo A, Aleiferis P, Richardson D

**Publication Type** Journal Article / Review

**Is Published** Yes

**Journal** Atomization and Sprays (V: , #: 12, Pg: )

**Identifiers:**

**PubMed ID**

**Digital ID** 10.1615/AtomizSpr.2016015807

**ISSN (Print)**

**ISSN (Digital)** 1044-5110

**ISSN (Linking)**

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***Gas dynamics and flow characteristics of highly turbulent under-expanded hydrogen and methane jets under various nozzle pressure ratios and ambient pressures***

**Publication date** 04 2016

**First Named Author** Hamzehloo A

**Secondary Author** Aleiferis P

**Publication Type** Journal Article / Review

**Is Published** Yes



**Journal** International Journal of Hydrogen Energy (V: , #: 15, Pg: )

**Identifiers:**

**PubMed ID**

**Digital ID** 10.1016/j.ijhydene.2016.02.017

**ISSN (Print)**

**ISSN (Digital)** 03603199

**ISSN (Linking)**

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***Numerical modelling of transient under-expanded jets under different ambient thermodynamic conditions with adaptive mesh refinement***

**Publication date** 10 2016

**First Named Author** Hamzehloo A

**Secondary Author** Aleiferis P

**Publication Type** Journal Article / Review

**Is Published** Yes

**Journal** International Journal of Heat and Fluid Flow (V: , #: , Pg: )

**Identifiers:**

**PubMed ID**

**Digital ID** 10.1016/j.ijheatfluidflow.2016.07.015

**ISSN (Print)**

**ISSN (Digital)** 0142727X

**ISSN (Linking)**

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***Evaluations of Scavenge Port Designs for a Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine by 3D CFD Simulations***

**Publication date** 04 2016

**First Named Author** Wang X

**Secondary Authors** Ma J, Zhao H

**Publication Type** Conference Proceeding / Conference Paper

**Is Published** Yes

**Identifiers:**

**PubMed ID**  
**Digital ID** 10.4271/2016-01-1049  
**ISSN (Print)**  
**ISSN (Digital)** 0148-7191  
**ISSN (Linking)**

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***On the transcritical mixing of fuels at diesel engine conditions***

**Publication date** 11 2017  
**First Named Author** Crua C  
**Secondary Authors** Manin J, Pickett L  
**Publication Type** Journal Article / Review  
**Is Published** Yes  
**Journal** Fuel (V: , #: , Pg: )  
**Publication ID** 10.1016/j.fuel.2017.06.091

***Identifiers:***

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**PubMed ID**  
**Digital ID** 10.1016/j.fuel.2017.06.091  
**ISSN (Print)**  
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***Time-resolved gas thermometry by laser-induced grating spectroscopy with a high-repetition rate laser system***

**Publication date** 6 2017  
**First Named Author** Förster F  
**Secondary Authors** Crua C, Davy M, Ewart P  
**Publication Type** Journal Article / Review  
**Is Published** Yes  
**Journal** Experiments in Fluids (V: , #: 7, Pg: )

Publication ID 10.1007/s00348-017-2370-6

**Identifiers:**

Data Source CrossRef

PubMed ID

Digital ID 10.1007/s00348-017-2370-6

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***Analysis of scavenge port designs and exhaust valve profiles on the in-cylinder flow and scavenging performance in a two-stroke boosted uniflow scavenged direct injection gasoline engine***

Publication date 08 2017

First Named Author Wang X

Secondary Authors Ma J, Zhao H

Publication Type Journal Article / Review

Is Published Yes

Journal International Journal of Engine Research (V: , #: , Pg: )

Publication ID 10.1177/1468087417724977

**Identifiers:**

Data Source CrossRef

PubMed ID

Digital ID 10.1177/1468087417724977

ISSN (Print)

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***Investigating the Combustion and Emissions Characteristics of Biomass-Derived Platform Fuels as Gasoline Extenders in a Single Cylinder Spark-Ignition Engine***

Publication date 2017

First Named Author Talibi M

**Secondary Authors** Hellier P, Ladommatos N  
**Publication Type** Journal Article / Review  
**Journal** SAE Technical paper (V: 2017-01-2325, #: , Pg: )  
**Publication ID** 59c918fe565930.40782828  
**Identifiers:**  
**Data Source** Manual  
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***Analysis of the effect of intake plenum design on the scavenging process in a 2-Stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine***

**Publication date** 2017  
**First Named Author** Wang X  
**Secondary Authors** Ma J, Zhao H  
**Publication Type** Conference Proceeding / Conference Paper  
**Publication ID** 59c920f71334c3.27239560  
**Identifiers:**  
**Data Source** Manual  
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***The Recuperated Split Cycle - Experimental Combustion Data from a Single Cylinder Test Rig***

**Publication date** 2017  
**First Named Author** Morgan, R  
**Secondary Authors** Jackson, Heikal, Atkins, Dong  
**Publication Type** Journal Article / Review  
**Journal** SAE Int. J. Engines 10(5):2017 (V: , #: , Pg: )

**Publication ID** 59d245e5d85624.30083555

***Identifiers:***

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***A Late Injection Combustion Strategy Using a Novel Ramped Combustion System***

**Publication date** 2017

**First Named Author** Morgan R

**Secondary Authors** Heikal, Pike-Wilson

**Publication Type** Conference Proceeding / Conference Paper

**Publication ID** 59d24e192780f5.07526215

***Identifiers:***

**Data Source** Manual

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***Multipoint temperature measurements in gas flows using 1-D laser-induced grating scattering***

**Publication date** 11 2016

**First Named Author** Willman C

**Secondary Author** Ewart P

**Publication Type** Journal Article / Review

**Is Published** Yes

**Journal** Experiments in Fluids (#: 12)

**Publication ID** 10.1007/s00348-016-2282-x

***Identifiers:***

**Data Source** CrossRef

Digital ID 10.1007/s00348-016-2282-x

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***Analysis of the effect of bore/stroke ratio and scavenge port angles on the scavenging process in a two-stroke boosted uniflow scavenged direct injection gasoline engine***

Publication date 11 2017  
First Named Author Wang X  
Secondary Authors Ma J, Zhao H  
Publication Type Journal Article / Review  
Is Published Yes  
Journal Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering (V: , #: , Pg: )  
Publication ID 10.1177/0954407017735383

***Identifiers:***

Data Source CrossRef  
PubMed ID  
Digital ID 10.1177/0954407017735383  
ISSN (Print)  
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ISSN (Linking)

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***Analysis of mixture formation process in a two-stroke boosted uniflow scavenged direct injection gasoline engine***

Publication date 10 2017  
First Named Author Wang X  
Secondary Authors Ma J, Zhao H  
Publication Type Journal Article / Review  
Is Published Yes  
Journal International Journal of Engine Research (V: , #: , Pg: )  
Publication ID 10.1177/1468087417736451

***Identifiers:***

Data Source CrossRef

PubMed ID

Digital ID 10.1177/1468087417736451

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***Analysis of the impact of exhaust valve profile on the scavenging and combustion process in a 2-stroke Boosted Uniflow Scavenged Gasoline (BUSDIG) engine***

Publication date 2017

First Named Author Wang X

Secondary Authors Ma J, Zhao H

Publication Type Conference Proceeding / Conference Paper

Publication ID 5a9c638d097422.37920327

***Identifiers:***

Data Source Manual

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***Numerical Simulation of the Gasoline Spray with an Outward-Opening Piezoelectric Injector: A Comparative Study of Different Breakup Models***

Publication date 2018

First Named Author Wang X

Secondary Author Zhao H

Publication Type Conference Proceeding / Conference Paper

Publication ID 5a9c644cb386c9.17277133

***Identifiers:***

Data Source Manual

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***Impact of increasing methyl branches in aromatic hydrocarbons on diesel engine combustion and emissions***

**Publication date** 03 2018  
**First Named Author** Talibi M  
**Secondary Authors** Hellier P, Ladommatos N  
**Publication Type** Journal Article / Review  
**Is Published** Yes  
**Journal** Fuel (V: , #: , Pg: )  
**Publication ID** 10.1016/j.fuel.2017.12.045

***Identifiers:***

**Data Source** CrossRef

**PubMed ID**

**Digital ID** 10.1016/j.fuel.2017.12.045

**ISSN (Print)**

**ISSN (Digital)**

**ISSN (Linking)**

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***Numerical Modelling of Fuel Spray Formation and Collapse from Multi-Hole Injectors under Flash-Boiling Conditions***

**Publication date** 2018  
**First Named Author** Price C  
**Secondary Authors** Hamzehloo A, Aleiferis P.G, Richardson D  
**Publication Type** Journal Article / Review  
**Journal** Fuel (V: , #: , Pg: )  
**Publication ID** 5a9d5de777cf64.39027968

***Identifiers:***

**Data Source**

**ISSN (Print)**

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***Time-resolved gas thermometry by laser-induced grating spectroscopy with a high-repetition rate laser system***

**Publication date** 6 2017

**First Named Author** Förster F

**Secondary Authors** Crua C, Davy M, Ewart P

**Publication Type** Journal Article / Review

**Is Published** Yes

**Journal** Experiments in Fluids (V: , #: 7, Pg: )

**Publication ID** 10.1007/s00348-017-2370-6

**Identifiers:**

**Data Source** CrossRef

**PubMed ID**

**Digital ID** 10.1007/s00348-017-2370-6

**ISSN (Print)**

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**ISSN (Linking)**

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***Quantification of diesel injector dribble using 3D reconstruction from x-ray and DBI imaging***

**Publication date** 09 2017

**First Named Author** Crua C

**Secondary Authors (10)** Sechenyh V, Turner J, Sykes D, Duke D, Swantek A, Matusik K, Kastengren A, Powell C, Viera A, ...

**Publication Type** Conference Proceeding / Conference Paper

**Is Published** Yes

**Publication ID** 10.4995/ILASS2017.2017.4742

**Identifiers:**

**Data Source** CrossRef

**PubMed ID**

**Digital ID** 10.4995/ILASS2017.2017.4742

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## Awards and Recognition

<b>Award Type</b>	Personal invitation as keynote or other named speaker to a conference
<b>Award Name</b>	Future Powertrain Conference 2016
<b>Individual</b>	Robert Morgan
<b>Award Level</b>	National (any country)
<b>Year Awarded</b>	2016
<b>Award Description</b>	Invited Speaker at the Future Powertrain Conference 24th -25th February 2016 , Coventry UK. Presentation entitled; 'The Role of Waste Heat Recovery in Achieving Ultra High Efficiency from the Internal Combustion Engine'. The invitation was in response to (a) Brighton's recent appointment by APC as IC Engine Thermal Efficiency Spoke and (b) the reputation of the Advanced Engineering Centre and Dr Morgan in advanced high efficiency engine research.
<b>Impact of Award</b>	The opportunity to present at this leading national conference enhanced the reputation of the University of Brighton's Advanced Engineering Centre research and published the role of the centre's position as a spoke for the APC.
<b>URL</b>	

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<b>Award Type</b>	Personal invitation as keynote or other named speaker to a conference
<b>Award Name</b>	Linear Power Systems Conference 2015
<b>Individual</b>	Robert Morgan
<b>Award Level</b>	National (any country)
<b>Year Awarded</b>	2015
<b>Award Description</b>	Invited Speaker at the Linear Power Systems Conference 7th & 8th September 2015, Brighton UK. Presentation title 'The role of the free piston engine in achieving ultra high efficiency'. The invitation arose from Dr Morgan's research in high efficiency engines and free piston engines.
<b>Impact of Award</b>	Participation at the conference enhanced the Universities reputation in high efficiency engine research and supported the Universities

successful application to APC for the position of IC Engine Thermal Efficiency spoke.

URL

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<b>Award Type</b>	Poster/abstract prize
<b>Award Name</b>	Highly Commended Prize for Poster Presentation at Future Powertrain Conference 2017
<b>Individual</b>	Wang X
<b>Award Level</b>	National (any country)
<b>Year Awarded</b>	2017
<b>Award Description</b>	Compared to the 4-stroke engine, the compact 2-stroke engine doubles the firing frequency and allows lower indicated mean effective pressure (IMEP) with the same output torque, which is naturally suitable for the application of the down-sizing and down-speeding technology. In this study, a novel 2-stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) engine was proposed and optimized to improve the fuel consumption with aggressive engine down-sizing down-speeding technology.
<b>Impact of Award</b>	Dissemination of the concept of the novel 2-stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) engine.
<b>URL</b>	<a href="https://futurepowertrains.co.uk/">https://futurepowertrains.co.uk/</a>
<b>Digital ID</b>	

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## Collaborations and Partnerships

<b>Collaboration Title</b>	Advanced Propulsion Centre Internal Combustion Engine Thermal Efficiency Spoke
<b>Partner</b>	
<b>Organisation Name [0]</b>	Advanced Propulsion Centre
<b>Contributed Financially [0]</b>	No
<b>In-kind contribution [0]</b>	No
<b>Contributions Made</b>	The APC spoke position was recently awarded. As such, no significant contribution has been made at this time
<b>Partner Contributions</b>	The APC spoke position was recently awarded. As such, no significant contribution has been made at this time
<b>Year Commenced</b>	2015
<b>Year Ended</b>	Still Active
<b>URL</b>	<a href="http://www.apcuk.co.uk/spokes/">http://www.apcuk.co.uk/spokes/</a>
<b>Resultant Outcomes</b>	No specific outcomes at this stage

**Categorisation of impact**  
**Formally Governed**

No impact yet  
Yes

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<b>Collaboration Title</b>	Jaguar Land Rover "Spray Centre"
<b>Partner</b>	
<b>Organisation Name [0]</b>	Jaguar Land Rover
<b>Department [0]</b>	Powertrain research
<b>Contributed Financially [0]</b>	Yes
<b>Contribution Currency [0]</b>	GBP
<b>Contribution Amount [0]</b>	30000
<b>Contributions Made</b>	The Cold Driven Shock Tube facility developed as part of this project forms part of JLR's "Spray centre" concept for internal combustion engine research, intended to generate data for future diesel combustion systems. The companion EPSRC CASE studentship in Diesel CFD modelling of high pressure/high temperature diesel sprays is in conjunction with JLR's Powertrain CFD team, including regular conference calls and bi-monthly reviews, with member of JLR Powertrain Research and Powertrain CFD teams.
<b>Partner Contributions</b>	Provision of EPSRC CASE studentship. Access to fortnightly CFD team meetings (conference call) and feedback from the engineers on this team. Provision of software licences (StarCD and StarCCM ) to run internal combustion engine simulations, and provision of JLR code to post-process CFD results.
<b>Year Commenced</b>	2015
<b>Year Ended</b>	Still Active
<b>URL</b>	
<b>Resultant Outcomes</b>	No publications or specific deliverables to JLR as yet.
<b>Categorisation of impact</b>	Economic
<b>Formally Governed</b>	No

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<b>Collaboration Title</b>	APC funded project through Preparing for the Grand Challenge: "Fast Next Generation Coriolis (NGC)"
<b>Partner</b>	
<b>Organisation Name [0]</b>	University of Oxford

<b>Contributed Financially [0]</b>	No
<b>In-kind contribution [0]</b>	Yes
<b>In-kind contribution currency [0]</b>	GBP
<b>Give an estimate of the in-kind value. [0]</b>	5000
<b>Contributions Made</b>	Designed and sourced the high pressure diesel components, including injector, for the experiments to be carried out under this collaboration.
<b>Partner Contributions</b>	Collaboration with a current APC funded project through Preparing for the Grand Challenge: "Fast Next Generation Coriolis (NGC)", for novel high pressure coriolis flow measurement of diesel injection flow rate. This collaboration provides a system for high pressure diesel delivery to the shock tube experiment and improved measurements for use as more accurate boundary conditions for diesel combustion modellers. The APC project has also paid for a Injector Driver system to be shared, which will allow control of the collaborative experiments.
<b>Year Commenced</b>	2017
<b>Year Ended</b>	Still Active
<b>URL</b>	
<b>Resultant Outcomes</b>	Experiments not yet performed.
<b>Categorisation of impact</b>	No impact yet
<b>Formally Governed</b>	No
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<b>Collaboration Title</b>	Renewal of the Jaguar Land Rover Centre of Excellence in Spark-Ignition Engine Research at Imperial
<b>Partner</b>	
<b>Organisation Name [0]</b>	Jaguar Land Rover
<b>Contributed Financially [0]</b>	Yes
<b>Contribution Currency [0]</b>	GBP British Pound Sterling
<b>Contribution Amount [0]</b>	1500000
<b>In-kind contribution [0]</b>	Yes
<b>In-kind contribution currency [0]</b>	GBP British Pound Sterling
<b>Give an estimate of the in-kind value. [0]</b>	1000000
<b>Contributions Made</b>	The Jaguar Land Rover Centre of Excellence in Spark-Ignition Engine Research was established in 2014 for 3 years initially and run up to the end of

<b>Partner Contributions</b>	2016, i.e. overlapped with this grant for 2 years. The Centre of Excellence was renewed for another 5 years in January 2017 till the end of 2021 at Imperial College. Contributions include extensive experimental and modelling work on future engine combustion systems and fuels using state-of-the-art research engines and advanced simulations. The collaboration with JLR was strengthened by the development of the turbulent spray chamber that is part of this EPSRC grant and also forms part of a 'Spray Centre' subsidiary activity with JLR, Imperial and Oxford. There are regular biweekly teleconferences and bimonthly meetings where there is knowledge transfer with modellers and experimentalists within JLR. Collaboration involves meetings with partners, particularly the University of Oxford that holds the equivalent JLR Centre of Excellence in compression-ignition engines. This activity has included a large meeting at the APC in Warwick where new knowledge was shared over a full day event between the two Universities and the Powertrain research team of JLR in November 2016. Contributions by the other University partners also comes via knowledge transfer through workshops, e.g. a dedicated workshop meeting on fuels in June 2016 (with Imperial, UCL, Brighton, Brunel).
<b>Year Commenced</b>	2017
<b>Year Ended</b>	Still Active
<b>URL</b>	
<b>Resultant Outcomes</b>	Publications have already emerged particularly on the modelling part of the work related to this grant for spray formation at extreme conditions.
<b>Categorisation of impact</b>	Economic
<b>Formally Governed</b>	Yes
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<b>Collaboration Title</b>	Hosting of visiting academic in specialising in internal combustion engine research
<b>Partner</b>	
<b>Organisation Name [0]</b>	Inha Technical College
<b>Department [0]</b>	Add location: automotive engineering

<b>Contributed Financially [0]</b>	department
<b>In-kind contribution [0]</b>	Contractually Confidential
<b>In-kind contribution currency [0]</b>	Yes
<b>Give an estimate of the in-kind value. [0]</b>	GBP
	10000
<b>Contributions Made</b>	Detailed discussions and planning of joint activities with visiting academic on mutually of interest exhaust after-treatment research, use of specialist experimental facilities and provision of desk space at UCL
<b>Partner Contributions</b>	Review and feedback on PhD student preliminary results, characterisation of research engine lean burn operating limits and design of experiments to be undertaken in collaboration with my research team, under my supervision, towards a joint publication.
<b>Year Commenced</b>	2017
<b>Year Ended</b>	Still Active
<b>URL</b>	
<b>Resultant Outcomes</b>	Detailed design of joint experimental study to be completed in the coming months, expected publication of a jointly authored paper.
<b>Categorisation of impact</b>	Cultural
<b>Formally Governed</b>	Yes
<hr/>	
<b>Collaboration Title</b>	Development of Fuels Challenge Network database
<b>Partner</b>	
<b>Organisation Name [0]</b>	University of Brighton
<b>Department [0]</b>	Advanced Engineering Centre
<b>Contributed Financially [0]</b>	Yes
<b>Contribution Currency [0]</b>	GBP
<b>Contribution Amount [0]</b>	4100
<b>In-kind contribution [0]</b>	Yes
<b>Give an estimate of the in-kind value. [0]</b>	5000
<b>Organisation Name [1]</b>	Advanced Propulsion Centre
<b>Contributed Financially [1]</b>	No
<b>In-kind contribution [1]</b>	No
<b>Contributions Made</b>	Initial scoping discussion on fuels challenge network approach during

summer 2017, attendance of APC hosting fuels challenge network scoping workshop, contributing specific expertise on future fuels combustion and emissions characteristics for completion of fuels database.

**Partner Contributions** Project leadership by University of Brighton, developing industry contacts and perspectives, lead of Challenge Networks application. Financial support from the UK Advanced Propulsion Centre in developing the Fuels Challenge Network and funding the development of the fuels database.

**Year Commenced** 2017

**Year Ended** Still Active

**URL**

**Resultant Outcomes** The project has so far has resulted in multiple conference and seminar presentations outlining the approach being taken, including events at the Low Carbon Vehicle show, Royal Institute and Future Powertrains Conference. The project is multidisciplinary, including mechanical engineers, chemical and engineers and process engineers.

**Categorisation of impact** Societal, Policy

**Formally Governed** Yes

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**Collaboration Title** Sandia National Laboratories

**Partner**

**Organisation Name [0]** Sandia Laboratories

**Department [0]** Combustion Research Facility

**Contributed Financially [0]** No

**In-kind contribution [0]** No

**Contributions Made** Expertise in high-resolution microscopic imaging under extreme operating conditions.

**Partner Contributions** Access to constant volume spray chamber and optical equipment.

**Year Commenced** 2014

**Year Ended** Still Active

**URL**

**Resultant Outcomes** Award: - "Research prize - Tanasawa Award (2017)"  
 Publications: -  
<http://dx.doi.org/10.4995/ILASS2017.2017.5065> -  
<http://dx.doi.org/10.1016/j.fuel.2017.06.091> -  
<http://dx.doi.org/10.1016/j.icheatmasstransfer.201>



6.05.032 -

[http://www.ilass.org/2/conferencepapers/93\\_2015.pdf](http://www.ilass.org/2/conferencepapers/93_2015.pdf)  
f - <http://ilasseurope.org/publications/proceedings/>

**Formally Governed**

No

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## Further Funding

<b>Funding Scheme</b>	Cryogenic injector testing
<b>Organisation Name</b>	Ricardo UK Ltd
<b>Type</b>	Research grant (including intramural programme)
<b>Funding Currency</b>	GBP British Pound Sterling
<b>Funding Amount</b>	10000
<b>Consortium Funding Amount</b>	
<b>Reference Number</b>	
<b>Start Month</b>	September
<b>Start Year</b>	2016
<b>End Month</b>	July
<b>End Year</b>	2017

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<b>Funding Scheme</b>	Institutional Support for APC spoke
<b>Organisation Name</b>	EPSRC, via Newcastle, Warwick, Loughborough and Bath universities
<b>Type</b>	Research grant (including intramural programme)
<b>Funding Currency</b>	GBP British Pound Sterling
<b>Funding Amount</b>	60000
<b>Consortium Funding Amount</b>	1000000
<b>Reference Number</b>	
<b>Start Month</b>	September
<b>Start Year</b>	2016
<b>End Month</b>	March
<b>End Year</b>	2017

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<b>Funding Scheme</b>	Step C02
<b>Organisation Name</b>	Innovate UK
<b>Type</b>	Research grant (including intramural programme)
<b>Funding Currency</b>	GBP British Pound Sterling
<b>Funding Amount</b>	399000
<b>Consortium Funding Amount</b>	4838000
<b>Reference Number</b>	
<b>Start Month</b>	April
<b>Start Year</b>	2018
<b>End Month</b>	October

**End Year** 2019  
**Digital ID**

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**Funding Scheme** Institutional Support  
**Organisation Name** ESPRC  
**Type** Research grant (including intramural programme)  
**Funding Currency** GBP British Pound Sterling  
**Funding Amount** 205000  
**Consortium Funding Amount**  
**Reference Number** EP/R512977/1  
**Start Month** September  
**Start Year** 2017  
**End Month** March  
**End Year** 2018  
**Digital ID**

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**Funding Scheme** Department of Energy Network Program  
**Organisation Name** Department of Energy and Climate Change  
**Type** Studentship  
**Funding Currency** GBP British Pound Sterling  
**Funding Amount** 55000  
**Consortium Funding Amount**  
**Reference Number**  
**Start Month** January  
**Start Year** 2018  
**End Month** January  
**End Year** 2022  
**Digital ID**

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## Next Destination

**Label** Dr Guangyu Dong  
**Previous Role** Post Doctoral Researcher  
**Has moved role** Yes  
**Organisation Known** Yes  
**Organisation Name** Tianjin University  
**New Sector**  
**Destination Country**

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**Label** Dr Emily Pike-Wilson  
**Previous Role** Post Doctoral Researcher  
**Has moved role** No  
**Organisation Known** Yes  
**Organisation Name** Maternity leave

**New Sector**  
**Destination Country**

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**Label** Luke Doherty  
**Previous Role** Post Doctoral Researcher  
**Has moved role** Yes  
**Organisation Known** Yes  
**Organisation Name** University of Oxford  
**New Sector**  
**Destination Country**

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**Label** Alasdair Cairns  
**Previous Role** Research Project Leader  
**Has moved role** Yes  
**Organisation Known** Yes  
**Organisation Name** University of Nottingham  
**New Sector**  
**Destination Country**

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**Label** Jun Ma  
**Previous Role** Post Doctoral Researcher  
**Has moved role** Yes  
**Organisation Known** No  
**Organisation Name**  
**New Sector** Company (all private companies including social enterprises, but excluding Hospitals and Universities)  
**Industry sector/discipline the staff member moved to.** Transport  
**Destination Country** China, People's Republic of

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**Label** Ajabofu Augoye  
**Previous Role** Post Doctoral Researcher  
**Has moved role** Yes  
**Organisation Known** Yes  
**Organisation Name** Imperial College London (ICL)  
**New Sector**  
**Destination Country**

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**Label** Dr Midhat Talibi  
**Previous Role** Post Doctoral Researcher  
**Has moved role** Yes  
**Organisation Known** Yes  
**Organisation Name** UCL Mechanical Engineering  
**New Sector**

## Destination Country

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<b>Label</b>	Dr Joseph Camm
<b>Previous Role</b>	Post Doctoral Researcher
<b>Has moved role</b>	Yes
<b>Organisation Known</b>	Yes
<b>Organisation Name</b>	Loughborough University
<b>New Sector</b>	
<b>Destination Country</b>	
<b>Digital ID</b>	

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## Engagement Activities

<b>Activity Title</b>	Science show at the London Shell Eco-Marathon 2016
<b>Activity Type</b>	A talk or presentation or debate
<b>How many people?</b>	51 - 100
<b>Geographical Reach</b>	Regional
<b>Primary Audience</b>	Schools
<b>Other Audience</b>	General public
<b>Activity Years</b>	2016
<b>Result Description</b>	The team from UCL - Dr. Paul Hellier, Dr. Midhat Talibi, Dr. Aaron Eveleigh and 2 PhD students, Ms. Aydek Erman and Mr. Viktor Karcher - demonstrated the sooting tendency and energy content of future fuels from sustainable sources. The fuels were burned in an open flame and soot collected on a filter paper. The flame was also used to drive a Stirling engine, with the engine speed demonstrating the calorific value of the fuel. The aim was to educate the students regarding potential fuels of the future which would be low-polluting but have similar energy content as fossil fuels. The show was well appreciated and kept the audience engaged. A paper for the Journal of Chemical Education is being planned based on this activity.
<b>Most important impact?</b>	Plans made for future related activity
<b>URL</b>	<a href="http://www.shell.com/energy-and-innovation/shell-e-comarathon/europe/news-and-highlights.html">http://www.shell.com/energy-and-innovation/shell-e-comarathon/europe/news-and-highlights.html</a>

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<b>Activity Title</b>	Invited talk - Future fuels for road transport: How can future fuels for IC engines contribute to sustainable road transport? - UnICEG
<b>Activity Type</b>	A talk or presentation or debate

**How many people?** 51 - 100  
**Geographical Reach** National  
**Primary Audience** Industry/Business  
**Other Audience** Professional Practitioners, Postgraduate students  
**Activity Years** 2016  
**Result Description** Invited talk to academic and industry members of UnICEG (Universities Internal Combustion Engine Group) at a special meeting on technologies for the future of IC engines, hosted by University of Brighton, UK Advanced Propulsion Centre (APC) spoke for internal combustion engine thermal efficiency.  
**Most important impact?** Requests about (further) participation or involvement  
**URL** <https://www.brighton.ac.uk/advanced-engineering/ev-ents/index.aspx>

**Activity Title** Rest In Peace - ICE at the Royal Institution, 14/11/2016  
**Activity Type** A talk or presentation or debate  
**How many people?** 51 - 100  
**Geographical Reach** National  
**Primary Audience** Industry/Business  
**Other Audience** Media (as a channel to the public), Policymakers/politicians, Professional Practitioners, Public/other audiences, Industry/Business, Undergraduate students, Other audiences  
**Activity Years** 2016  
**Result Description** The event was jointly arranged by the Advanced Propulsion Centre and EPSRC, to debate the future of the internal combustion engine. Results from the ULTRA project were included in the presentation by Dr Robert Morgan. The event was well attended by industry, academics, policy makers, general public and undergraduate and postgraduate students. The event has led to numerous engagements with industrial and academic parties on the topic and has in part become a reference point to the wider debate of the future role of high efficiency engines in a low carbon transport system.  
**Most important impact?** Requests about (further) participation or involvement  
**URL**

**Activity Title** The future of the car. Cheltham Science Festival. 10/6/2016  
**Activity Type** A talk or presentation or debate

**How many people?** 51 - 100  
**Geographical Reach** National  
**Primary Audience** General public  
**Other Audience** Public/other audiences,Other audiences  
**Activity Years** 2016  
**Result Description** The event was a panel discussion to discuss the future of personal transport in a low carbon network. The aim of the event was to promote discussion on the changing role of the car and the technologies that will play a role in transitioning the transport system to a sustainable low carbon footing. The debate was lively and informative and lead to a number of contacts with the public after the event.  
**Most important impact?** Requests for further information  
**URL**

**Activity Title** APC Spoke Network - panel discussion at the 2016 low carbon vehicle show  
**Activity Type** A talk or presentation or debate  
**How many people?** 11 - 50  
**Geographical Reach** National  
**Primary Audience** Industry/Business  
**Other Audience** Policymakers/politicians,Public/other audiences,Industry/Business,Other audiences  
**Activity Years** 2016  
**Result Description** Panel discussion by the APC spoke leads on their respective technology areas, role of different technologies in the future. The event lead to a number of discussions after the event on ultra efficient ICE, such as those the subject of the project.  
**Most important impact?** Requests for further information  
**URL**

**Activity Title** December UNICEG meeting - Ultra High Efficiency Powertrain 20/12/2016  
**Activity Type** A talk or presentation or debate  
**How many people?** 51 - 100  
**Geographical Reach** National  
**Primary Audience** Professional Practitioners  
**Other Audience** Professional Practitioners,Industry/Business  
**Activity Years** 2016  
**Result Description** The event was one of the three annual UnICEG conferences, focused on Ultra High Efficiency Powertrain. Speakers from the battery, fuel cell, ICE and fuels communities were invited which triggered a lively and productive debate, fostering better engagement between the ICE community

**Most important impact?** and other transport research communities. In particular the role of solid oxide fuel cells and sustainable low carbon fuels were reported of particular interest from the UnICEG membership. Audience reported change in views, opinions or behaviours

**URL**

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**Activity Title** APC / EPSRC Ultra High Efficiency Powertrain Workshop , Brighton, 21/12/2016

**Activity Type** Event, workshop or similar

**How many people?** 51 - 100

**Geographical Reach** National

**Primary Audience** Professional Practitioners

**Other Audience** Professional Practitioners,Industry/Business

**Activity Years** 2016

**Result Description** The APC / EPSRC Ultra High Efficiency Powertrain Workshop was one of the two workshops described in the impact plan for the project. The workshop aimed to debate the make-up of the far right hand end of the automotive council roadmap, ultimately aimed at identifying the grand challenges and role of thermal propulsion technology in a low carbon transport system. The output of the workshop has been fed into the 2017 road-mapping exercise organised by the APC. - Importance of sustainable fuels - The importance of split cycle technology in delivering a very high efficiency thermal propulsion system - A research gap in the understanding of future consumer behaviour in a connected economy and the impact on the requirements of the vehicle propulsion system

**Most important impact?** Plans made for future related activity

**URL**

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**Activity Title** Presentation at the UK Consortium on Turbulent Reacting Flows (UKCTRF)

**Activity Type** A talk or presentation or debate

**How many people?** 51 - 100

**Geographical Reach** International

**Primary Audience** Other audiences

**Other Audience** Industry/Business,Postgraduate students,Study participants or study members,Third sector organisations

**Activity Years** 2017

**Result Description** The latest developments and results on in-nozzle-out fuel spray modelling under flash-boiling

conditions and also supercritical fuel injection modelling were presented at the annual meeting of the UK Consortium on Turbulent Reacting Flows (UKCTRF). The ULTRA project members from Imperial College London joined the aforementioned consortium and will be able to use services provided by ARCHER, the UK national high performance computing facility. Plans made for future related activity [http://www.ukctrf.com/wp-content/uploads/2017/09/PROGRAMME\\_FINAL\\_PDF\\_3.pdf](http://www.ukctrf.com/wp-content/uploads/2017/09/PROGRAMME_FINAL_PDF_3.pdf)

**Most important impact?**  
**URL**

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**Activity Title** Invited Talk - Numerical Modelling of Injection Processes with various Fuels at Extreme Conditions  
**Activity Type** A talk or presentation or debate  
**How many people?** 51 - 100  
**Geographical Reach** National  
**Primary Audience** Industry/Business  
**Other Audience** Postgraduate students  
**Activity Years** 2016  
**Result Description** Dissemination of new predictive/modelling capability of fuel spray formation under challenging thermodynamic conditions related to advanced high-efficiency engines. Modelling capability delivered to industrial sponsor for direct impact on their engine design processes.  
**Most important impact?** Requests about (further) participation or involvement  
**URL**

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**Activity Title** Invited Talk - Superheated and Supercritical Injection, Spray Formation Experiments and Modelling Challenges  
**Activity Type** Event, workshop or similar  
**How many people?** 51 - 100  
**Geographical Reach** International  
**Primary Audience** Industry/Business  
**Other Audience** Postgraduate students  
**Activity Years** 2017  
**Result Description** Engagement with the inaugural meeting/workshop of the Special Interest Group (SIG) on Sprays in Engineering Applications supported by the UK Fluids Network (EPSRC). Multi-disciplinary audience which sparked questions and discussion. Plans for future related activities and new research.  
**Most important impact?** Requests about (further) participation or



**URL** involvement  
<https://www.brighton.ac.uk/advanced-engineering/research-projects/sprays-in-engineering-applications-modelling-and-experimental-studies.aspx>

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**Activity Title** Children's University Graduation Taster Session  
**Activity Type** A talk or presentation or debate  
**How many people?** 101 - 500  
**Geographical Reach** Regional  
**Primary Audience** Schools  
**Other Audience** Schools,Public/other audiences  
**Activity Years** 2016,2017  
**Result Description** A taster lecture on fuel design for cleaner IC engines given to primary school children and their parents during a visit to UCL, and awarding of graduation certificates during subsequent ceremony.  
**Most important impact?** Audience reported change in views, opinions or behaviours

**URL**

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**Activity Title** Thermal Propulsion R&D Challenge Workshop  
**Activity Type** Event, workshop or similar  
**How many people?** 11 - 50  
**Geographical Reach** National  
**Primary Audience** Other audiences  
**Other Audience** Professional Practitioners,Industry/Business  
**Activity Years** 2017  
**Result Description** The automotive council technology roadmaps were refreshed this year and published at the Low Carbon Vehicle show in September (<http://www.apcuk.co.uk/resourcelibrary/propulsion-roadmaps/>). In addition to the roadmaps, a comprehensive set of R&D challenges have been developed which will be released in December. A workshop was organised, hosted by Loughborough University aimed at developing project to address the medium and long-term R&D challenges. The scope of the workshop will be to: • Identify the 'grand challenges' arising from the Thermal Propulsion Roadmap to address the identified R&D challenges, common themes that address multiple areas and cross disciplinary research themes • Prioritize the challenge areas • Develop project and consortium to address the identified grand challenges • Identify possible funding routes and an action plan to develop a set of high quality research proposals

**Most important impact?** Plans made for future related activity  
**URL**  
**Digital ID**

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**Activity Title** Presentation to Special Interest Group in Combustion  
**Activity Type** A talk or presentation or debate  
**How many people?** 11 - 50  
**Geographical Reach** National  
**Primary Audience** Professional Practitioners  
**Other Audience** Professional Practitioners, Postgraduate students  
**Activity Years** 2017  
**Result Description** This was an invited talk to the Special Interests Group in Combustion titled Future Challenges in Internal Combustion Engines. The aim of the talk was to bring together applied research in engines and in particular the results of the 2017 APC roadmapping exercise with the fluids - fundamental combustion research community. The presentation triggered a lively debate on the future R&D challenges and requirements for zero emissions combustion

**Most important impact?** Requests for further information  
**URL**  
**Digital ID**

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**Activity Title** Special Interests Group (SIG) Research Workshop: Numerical Simulation of the Gasoline Spray with an Outward-Opening Piezoelectric Injector  
**Activity Type** A talk or presentation or debate  
**How many people?** 11 - 50  
**Geographical Reach** National  
**Primary Audience** Professional Practitioners  
**Other Audience** Postgraduate students  
**Activity Years** 2017  
**Result Description** An invited presentation on the modelling of the Gasoline Spray with an Outward-Opening Piezoelectric Injector was given on the Special Interests Group (SIG) workshop on Sprays in engineering applications: modelling and experimental studies.

**Most important impact?** Audience reported change in views, opinions or behaviours  
**URL** [https://www.brighton.ac.uk/advanced-engineering/ev\\_ents/index.aspx](https://www.brighton.ac.uk/advanced-engineering/ev_ents/index.aspx)  
**Digital ID**

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**Activity Title** SAE Powertrains Fuels and Lubricants 2017 Beijing technical presentation -

**Activity Type** A talk or presentation or debate

**How many people?** 11 - 50

**Geographical Reach** International

**Primary Audience** Professional Practitioners

**Other Audience** Policymakers/politicians, Industry/Business, Postgraduate students

**Activity Years** 2017

**Result Description** Presentation of technical paper detailing experimental study of novel fuels from lignocellulosic biomass tested in a research engine at SAE (Society of Automotive Engineers) Powertrains, Fuels and Lubricants 2017 conference in Beijing, China, to an international audience of academics specialising in this area and global industry experts from fuels companies (for example Shell, Saudi Aramco) and vehicle manufacturers (for example Ford, General Motors, Toyota).

**Most important impact?** Plans made for future related activity

**URL** <http://saeevents.org/events/sae-2017-international-powertrain-fuels-lubricants-meeting>

**Digital ID**

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**Activity Title** Invited presentation at 6th International Symposium of Jet Propulsion and Power Engineering at Beijing University of Aeronautics and Astronautics 'Effects of alkylbenzene methyl branch addition on compression ignition combustion and emissions'

**Activity Type** A talk or presentation or debate

**How many people?** 51 - 100

**Geographical Reach** International

**Primary Audience** Professional Practitioners

**Other Audience** Industry/Business, Undergraduate students, Postgraduate students

**Activity Years** 2017

**Result Description** Invited presentation at 6th International Symposium of Jet Propulsion and Power Engineering at Beijing University of Aeronautics and Astronautics on the impacts of fuel design from lignocellulosic biomass on diesel combustion and emissions. Audience included a range of international academics with interests in combustion and thermal propulsion, further informal discussions took place as a smaller select group of specially invited presenters during a private dinner following the conference.

**Most important impact?** Requests about (further) participation or involvement

**URL**

**Digital ID**

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**Activity Title** Invited technical presentation and visit at Tianjin University China, National Key Laboratory of Engines

**Activity Type** A talk or presentation or debate

**How many people?** 11 - 50

**Geographical Reach** International

**Primary Audience** Postgraduate students

**Other Audience** Professional Practitioners

**Activity Years** 2017

**Result Description** Invited presentation to Tianjin presentation on 'Effects of alkylbenzene methyl branch addition on compression ignition combustion and emissions'. This visit was a follow-up to a similar invited talk in 2015 to strengthen and continue contacts made during this visit.

**Most important impact?** Plans made for future related activity

**URL**

**Digital ID**

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## Influence on Policy

**Influence Name** Automotive Council UK Technology Roadmaps

**Influence Type** Participation in advisory committee

**Title**

**Cited Publication**

**Healthcare Area**

**Issuing Organisation**

**Year First Realised** 2017

**Geographic Influence** National

**Country** United Kingdom of Great Britain & Northern Ireland (UK)

**Area of policy influence.** Transport

**Describe Other**

**Specific Impacts** No impacts yet

**Impact Description**

**URL**

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## Research Tools and Methods

<b>Material Name</b>	Cold Driven Shock Tube (CDST) facility
<b>Material Type</b>	Improvements to research infrastructure
<b>Description</b>	Creation of World Class facility: Oxford Cold-Driven Shock Tube – brand new facility for fuel spray research and optical diagnostics, capable of generating gas conditions up to 150 bar and 1500 K for several milliseconds. Currently undergoing certification and sign off for CE marking before commissioning begins.
<b>Provided to Others</b>	N/A
<b>Year First Provided</b>	
<b>Impact Description</b>	No experiments performed yet.
<b>URL</b>	

<b>Material Name</b>	Heavy duty research engine
<b>Material Type</b>	Improvements to research infrastructure
<b>Description</b>	New single cylinder deisel research engine with variable compression ratio and variable swril with 3000 bar fuel injection pressure and 250bar maximum firing pressure capability
<b>Provided to Others</b>	No
<b>Year First Provided</b>	
<b>Impact Description</b>	New uneque capability in the UK. Testing of novel hydrogen - diesel combustion system
<b>URL</b>	

<b>Material Name</b>	Turbulent Flow Chamber for Spray and Combustion Optical Diagnostics
<b>Material Type</b>	Improvements to research infrastructure
<b>Description</b>	A new constant volume vessel has been designed and manufactured to allow studies of spray formation and combustion under controlled levels of ambient turbulence and at high-pressure high-temperature conditions, including supercritical points. This is a unique new UK facility to accommodate such conditions and with extensive optical access.
<b>Provided to Others</b>	N/A
<b>Year First Provided</b>	
<b>Impact Description</b>	Being commissioned.
<b>URL</b>	

<b>Material Name</b>	High Speed Laser Induced Grating Spectroscopy
<b>Material Type</b>	Improvements to research infrastructure
<b>Description</b>	High speed LIGS
<b>Provided to Others</b>	Yes
<b>Year First Provided</b>	2017

**Year First Provided**  
**Impact Description**

First demonstration of high speed LIGS enabling application of technique to transient phenomena

**URL**  
**Digital ID**

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## Research Databases and Models

**Material Name**

Database for Evaluations of Scavenge Port Designs for a Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine by 3D CFD Simulations

**Material Type**  
**Description**

Database/Collection of data  
The data used in the following paper is archived:  
Wang, X., Ma, J., and Zhao, H., "Evaluations of Scavenge Port Designs for a Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine by 3D CFD Simulations," SAE Technical Paper 2016-01-1049, 2016, doi:10.4271/2016-01-1049.

**Provided to Others**  
**Year First Provided**  
**Year First Provided**  
**Impact Description**

Yes  
2016

**URL**  
**Digital ID**

The design and impact of the scavenge ports of BUSDIG engine were clarified by CFD simulations.  
<https://doi.org/10.17633/rd.brunel.3116560.v1>  
10.17633/rd.brunel.3116560.v1

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**Material Name**

Database for Analysis of the effect of intake plenum design on the scavenging process in a 2-Stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine

**Material Type**  
**Description**

Database/Collection of data  
The data used in the following paper is archived here:  
Wang, X., Ma, J., and Zhao, H., "Analysis of the effect of intake plenum design on the scavenging process in a 2-Stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine" SAE Technical Paper 2017-01-1031.

**Provided to Others**  
**Year First Provided**  
**Year First Provided**  
**Impact Description**

Yes  
2017

**URL**  
**Digital ID**

The design and evaluation of the intake plenum of the BUSDIG engine were clarified.  
<https://doi.org/10.17633/rd.brunel.4565158.v1>  
10.17633/rd.brunel.4565158.v1

**Material Name** Database for Analysis of Scavenge Port Designs and Exhaust Valve Profiles on the In-cylinder Flow and Scavenging Performance in a 2-Stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine

**Material Type** Database/Collection of data

**Description** The data used in the following paper is archived here: Wang, X., Ma, J., and Zhao, H., "Analysis of Scavenge Port Designs and Exhaust Valve Profiles on the In-cylinder Flow and Scavenging Performance in a 2-Stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine". International Journal of Engine Research.

**Provided to Others** Yes

**Year First Provided** 2017

**Year First Provided**

**Impact Description** The effects of the scavenge ports and exhaust valve profiles on the scavenging process of the BUSDIG engine were identified.

**URL** <https://doi.org/10.17633/rd.brunel.5195731.v1>

**Digital ID** 10.17633/rd.brunel.5195731.v1

**Material Name** Database for Analysis of the impact of exhaust valve profile on the scavenging and combustion process in a 2-stroke Boosted Uniflow Scavenged Gasoline (BUSDIG) engine

**Material Type** Database/Collection of data

**Description** The data used in the following paper is archived here: Wang, X., Ma, J., and Zhao, H., "Analysis of the impact of exhaust valve profile on the scavenging and combustion process in a 2-stroke Boosted Uniflow Scavenged Gasoline (BUSDIG) engine". IMechE Internal Combustion Engines 2017 conference.

**Provided to Others** Yes

**Year First Provided** 2017

**Year First Provided**

**Impact Description** The effect of the negative valve overlap (NVO) strategy on controlling the scavenging and combustion process in BUSDIG engine was clarified.

**URL** <https://doi.org/10.17633/rd.brunel.5371525.v1>

**Digital ID** 10.17633/rd.brunel.5371525.v1

**Material Name** Database for Analysis of the Effect of the Bore/Stroke (B/S) Ratio and Scavenge Port Angles on the Scavenging Process in a 2-Stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine

**Material Type** Database/Collection of data

**Description** The data used in the following paper is archived here:

Wang, X., Ma, J., and Zhao, H., "Analysis of the Effect of the Bore/Stroke (B/S) Ratio and Scavenge Port Angles on the Scavenging Process in a 2-Stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) Engine". Proc. IMechE, Part D: Journal of Automobile Engineering.2017.

**Provided to Others** Yes  
**Year First Provided** 2017  
**Year First Provided**  
**Impact Description** The impact of the bore/stroke ratio and scavenge port design of the BUSDIG engine was clarified.  
**URL** <https://doi.org/10.17633/rd.brunel.5383951.v1>  
**Digital ID** 10.17633/rd.brunel.5383951.v1

**Material Name** Database for Analysis of Mixture Formation Process in a 2-Stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) engine  
**Material Type** Database/Collection of data  
**Description** The data used in the following paper is archived here: Wang, X., Ma, J., and Zhao, H., "Analysis of Mixture Formation Process in a 2-Stroke Boosted Uniflow Scavenged Direct Injection Gasoline (BUSDIG) engine". International Journal of Engine Research. 2017.  
**Provided to Others** Yes  
**Year First Provided** 2017  
**Year First Provided**  
**Impact Description** The impact of different fuel injection strategies on the in-cylinder flow motions and mixture formation in the BUSDIG engine was clarified.  
**URL** <https://doi.org/10.17633/rd.brunel.5414059.v1>  
**Digital ID** 10.17633/rd.brunel.5414059.v1

**Material Name** Database for Numerical Simulation of the Gasoline Spray with an Outward-Opening Piezoelectric Injector: A Comparative Study of Different Breakup Models  
**Material Type** Database/Collection of data  
**Description** The data used in the following paper is archived here: Wang, X. and Zhao, H., "Numerical Simulation of the Gasoline Spray with an Outward-Opening Piezoelectric Injector: A Comparative Study of Different Breakup Models". SAE Technical Paper 2018-01-0272.  
**Provided to Others** Yes  
**Year First Provided** 2018  
**Year First Provided**  
**Impact Description** The effect of different breakup models on the modelling of an outward-opening piezoelectric injector was clarified.  
**URL** <https://doi.org/10.17633/rd.brunel.5830677.v1>



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## Key Findings

### **Key Findings? Discoveries**

Yes

The main objective of the Ultra project was to determine the ultimate efficiency of the internal combustion engine. An ambitious target of 25-33% improvement over engines in production was set. The split cycle engine research at Brighton University has demonstrated using a combination of experiments and modelling techniques a 40% improvement over typical commercial vehicles at the start of the project, or 30% over the best in class commercial of vehicles of 2018. A further objective of the project was to deliver the experimental techniques, facilities and modelling methodologies required to develop future high efficiency engines. The project has delivered a new portable laser based technique for the accurate measurement of temperature inside an engine. A portable Laser Induced Grating Spectroscopy (LIGS) technique was developed at Oxford University and has been successfully used in a number of project partner laboratories, delivering precise measurement of temperature in very challenging environments.

### **Objectives Reasons**

Partially

Experimental, methodological or technical issues, Staffing matters (e.g. skills shortages, recruitment delays, unexpected extended leave or departure of staff), Other resourcing issues (e.g. difficulty/delay in securing key equipment)

### **Expand**

At this point in time, not all the project objectives have been achieved mainly due to delays in supply of key equipment from suppliers and faults in equipment delivered to the partners. The partners remain confident the overall objectives of the project will be achieved within the remaining time on the project.

### **Further Details Taken Forward**

Commercial exploitation - Oxford are in discussion with a partner to commercialise the LIGS technique. The split cycle technology will be commercialised via a new spin out, Dolphin N2 set up by Ricardo. This new company has secured Innovate UK funding and is currently

raising the matching capital to take the technology to market. Academic Exploitation - Oxford are in discussion with numerous parties to utilise the LIGS technique in applications outside the automotive industry.  
Energy

## Interest to sectors

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## Narrative Impact

### Impacts? Findings

Yes

Informing on the future potential of internal combustion engines. A key objective of the project was identifying the potential and hence role of the internal combustion engine as a low carbon transport system probably dominated by vehicles electrified. The system level thinking core to this project, researching the interaction of an advanced thermally integrated powertrain operating on a sustainable fuel has contributed to a shift in thinking by the industry. It has become recognised that the use of 'simple' internal combustion engine will almost certainly decline and will be replaced by advanced 'Thermal Propulsion Systems' with integral energy recover operating on a manufactured, sustainable fuel. The results informed the update of the Auto Council UK technology roadmaps by the Advanced Propulsion in 2018. The roadmaking process involved a number of events including workshop at Brighton University on 31/7/2016, EPSRC ICE Road-mapping workshop at Brighton University on 23/12/2017, EPSRC - APC workshop at Bath University on 31/1/2017 and a APC - EPSRC R&D challenge workshop on the 12 December 2017 hosted by Loughborough. This process will continue through ongoing dialogue with APC by Dr Morgan, as spoke lead for the APC Internal Combustion Engine Thermal Efficiency spoke with APC and the ICE community. The research on the split cycle engine undertaken on this project has provided more supporting data increasing the credibility of the concept and in particular how Thermal Propulsion technology compares with low temperature fuel cells. The outcomes of the research has lead to a new spin out company, Dolphin N2 being set up by Ricardo and further funding by Innovate UK (Step C02).

Development of Advanced Digital Tools The research also aimed to support the development of predictive models of engine combustion systems. The computational studies at UCL and Imperial have been divided into two main streams, flash-boiling sprays and supercritical injection. The first stream is being investigated by spray modelling using Lagrangian Particle Tracking (LPT) with fuels of different degrees of volatility, including iso-octane and n-pentane, under various conditions. A superheated evaporation model and 0-dimensional atomisation model have been implemented by user coding in the STAR-CD. The developed framework was able to predict the spray plume collapse and penetration length of the flashing sprays issued from multi-hole injectors for direct-injection spark-ignition engines with reasonable agreement to in-house experimental data. The coding methodology has been shared with the CFD group of Jaguar Land Rover for knowledge. The research on hydrogen – diesel combustion at Brighton has supported the assessment of a new combustion model in the Ricardo VECTIS CFD code. The research has assessed the capability of the code and demonstrated new approaches to using CFD to develop understanding of advanced combustion systems. Research on the compression ignition processes of hydrogen using CFD and kinetic modelling has shown the need for new models to accurately capture this process. This has informed the direction of the collaboration between Brighton, Oxford and UCL.

Development of New Experimental Tools The final thread of the project is the development of diagnostic tools to aid the development of fundamental understanding of in cylinder processes and provide validation datasets for computational models. Temperature measurements using Laser Induced Grating Scattering, LIGS, in Brighton's high pressure spray facility have provided data on the temperature evolution for both the compression and expansion cycle at different inlet temperatures and pressures. A further development has improved the temporal resolution of the LIGS technique allowing measurements up to 10kHz (paper in preparation). The high-precision temperature measurements in the Brighton facility were

carried out with a specially designed portable system for LIGS. The technology of this device has been licensed and is currently under development in association with Dantec Dynamics. It is planned to have a version commercially available in 2018. This instrument will provide the technology for high-precision thermometry in a wide range of applications in academic, government and industrial laboratories worldwide.

**Date Materialised**

2016

**Type of Impact**

Economic

**Sectors used**

Energy, Manufacturing, including Industrial Biotechnology, Transport

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Secondments, placements and internships to or from other organisations

**Secondments**

No