# Project details

**Project title**

Enabling the future of low emission transport through the adoption of laser processing

**Research category**

Industrial research

**Estimated timescales**

Project start date :
8-4-2019

Duration in months :
36

**Lead organisation**

THE ASSOCIATION OF INDUSTRIAL LASER USERS

**Partners**

**Challenge summary**

To accelerate the progress towards globally-agreed reductions in greenhouse gas emissions, and improve energy-efficiency through innovative laser material processing and design changes, implemented in the UK transport supply chain (aerospace, automotive, off-highway and rail)

**Scope: Alignment with grand challenges**

The challenge relates to:

- **clean growth**
- **future of mobility**

involving aerospace, automotive, off-highway and rail sectors.

# Application questions

**1. Describe your challenge.**

Climate change is a big threat to our society, with implications on food supply, housing and health. As such, the UK government has set ambitious targets, to comply with the Paris Climate Agreement.

Achieving these time-sensitive targets requires urgent and immediate action to improve the performance of vehicles used for transportation of people and goods throughout the UK. Additionally, there is a significant market opportunity for UK companies through investing in clean growth.

Irrespective of what powers these vehicles, whether fossil fuels, hydrogen or stored electricity, the vehicle structure needs to have lowest practical weight, minimum drag and efficient energy conversion to ensure that fuel-economy is maximised to achieve maximum distance travelled per kW input. Reducing automotive vehicle weight by 35% can result in fuel savings of 20% (http://www.nrcan.gc.ca/node/16755).

Implementation of light-weight structures for aviation, automotive, off-highway etc. is in progress but prohibitively expensive. For example, the use of Titanium in aircraft through conventional machining consumes 20 times more titanium than ends up being used in the finished aircraft. Titanium is expensive with rising cost. Much of that cost can be reduced through new manufacturing methods based on laser technology.

The current reliance on fossil fuel engines for much of UK mobility produces a significant proportion of the greenhouse gas emissions and atmosphere pollutants. A strategy to continuously improve the fuel-efficiency of vehicles is needed. The accelerating trend towards electrification requires new vehicles with greater efficiency to provide extended range, ensuring lower electrical demand in the charging cycle.

Modernisation of manufacturing (to achieve competitiveness with other industrial nations) drives:

- manufacturing processes to achieve maximum productivity with minimum cost
- supply chains to be streamlined to reduce the carbon footprint of vehicle components and sub-systems

Laser manufacturing has the capability to improve the productivity (by replacing conventional joining, cutting and drilling techniques) and to offer innovation to extend what is possible in the light-weighting and fuel efficiency enhancement of vehicles.

Technologies have been proven in research environments on a small scale, but have failed to translate into the market, owing to a lack of large scale trials, with collaboration between the laser technology providers, RTOs and the transport sector supply chain.

Investment by UK government in this challenge will specifically address this deficiency -- enabling rapid adoption of solutions to market, helping the UK achieve the emission targets, and improving productivity in the identified sectors.

This challenge will have been addressed when:

- material scrap is reduced towards zero (laser processing)
- drag has been reduced to the minimum (through surface engineering)
- optimum materials are implemented (composites, non-metals and light-weight alloys)
- engine efficiency is maximised (through new engine design with optimised air and fuel flows)
- manufacturing cost reductions have been achieved

Benefits of this next-generation technology will include:

- lower running costs for vehicles and greater distances between refuelling or charging events
- lower particulate and greenhouse gas emissions to improve the air quality for everyone
- greater employment opportunities in manufacturing through reshoring of the supply chain
- greater competitiveness and market share for UK suppliers

**2. What is the opportunity for productivity growth?**

Addressing the implementation of laser processing in materials, design and production methods to manufacture energy efficient and lower emissions vehicles will improve the productivity of the supply chain for vehicle structure and propulsion systems.

Innovative laser manufacturing of (for example) automotive bodies achieves lower energy consumption (even as high as 90% (https://automotivemanufacturingsolutions.com/technology/remote-control)) and reduced cycle times resulting in lower manufacturing costs and greater productivity per robot, per laser, and per manufacturer. Significant reductions in scrap are also achieved.

The introduction of new and innovative laser sources (with new pulse parameters, new wavelengths, higher frequency and power output) enables both new applications and improvements to the throughput of existing applications.

New materials, including transparent polymers and glasses provide weight-saving and visibility improvements. These can be joined, textured, shaped and machined by laser processes which far exceed the productivity of conventional processes. The laser cutting and joining of composites is a challenge identified by UK designers and manufacturing engineers.

Lasers can be delivered via fibre optic cables allowing processing heads to be easily carried by robots. Consistency, repeatability and the degree of fine control over laser output (and the resulting manufacturing process consistency) deliver results that are suited to high volume manufacturing -- including the quantities typically found in the automotive industry, and the reliability and consistent quality needed to achieve the highest safety standards of the aerospace industry. The combination of robots and lasers allows for efficient digital manufacturing and supports Industry 4.0.

In short, laser processing provides:

- Accuracy, repeatability, efficiency and reliability
- Flexibility for reconfiguration by software (digital manufacturing)
- Ability to minimise lead time and cost wastage on tooling
- Maximum uptime with lowest maintenance

The introduction of these advanced manufacturing solutions delivers clean and efficient manufacturing with low emissions and reduces the demand on the electricity and gas supply.

**3. What is the market opportunity?**

The transportation sector not only supports UK exports, but contributes massively to infrastructure, employment, GDP and growth. The market is highly competitive and the UK needs to achieve a leading position in the global market for fuel-efficient and low emissions vehicle technology, manufactured using efficient production processes. In terms of greenhouse gas emissions, road and air transport are the biggest contributors -- together totalling 27% of the UK total emissions (source UK Greenhouse gas emissions - statistics 1990-2015 (https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2015))

The automotive sector employs 814,000 people in the UK and accounts for 13% of UK total exported goods, 80% of UK-built cars being exported. (source SMMT Motor Industry Facts 2017 (https://www.smmt.co.uk/wp-content/uploads/sites/2/SMMT-Motor-Industry-Facts-2017_2-online.pdf)).

Dissatisfaction among owners of diesel vehicles produces greater growth in electric and more efficient fossil-fuel powered models, driving demand for fuel-efficient design enabled by laser material processes. 2016 saw record levels of new UK registrations (2.6 million). A competitive supply chain could achieve positive growth in employment and exports over the next 3 years in spite of Brexit.

In the aerospace sector, which employs over 110,000 in the UK, passenger demand growth averages 4.2% annually in UK. (UK Gov Aviation Forecasts 2017 (https://www.gov.uk/government/publications/uk-aviation-forecasts-2017)).

Air Transport Movement is rising (2% annually) as well as total number of seats (3% annually). 2050 targets for CO2 emissions, and the UK DfT connectivity strategy demand new engine and airframe innovations to further reduce emissions and improve fuel efficiency. Companies like Airbus, Bombardier and Rolls Royce have used laser processing to achieve some of the required improvements. The highly-competitive supply chain for aerospace engines and airframe is a UK strength with high growth prospects if this challenge is addressed.

Rail transport is of secondary importance in the big picture of emissions, but greater energy efficiency with lower emissions is beneficial here also.

**4. What evidence is there of UK strengths and competitive advantage?**

The UK is equipped with strong laser processing research capabilities in Universities (spread widely, geographically) where primary research is at world class levels and a proven level of expertise exists in solving industrial challenges and developing innovative solutions on a small scale. Investment in government-funded HVM Catapult Centres and RTOs like TWI has produced further capabilities in application development for the new materials, processes and laser sources required by this challenge. Within the UK, there exist groups of researchers (e.g. the ESPRC funded Centre for Innovative Manufacturing in Laser-based Production Processes) with knowledge of laser technology that is closely allied to the supply chain for transportation where lasers are already being used.

The Association of Industrial Laser Users connects manufacturers of laser sources and systems with the researchers working on new technology, materials and applications -- priorities for research and innovation being driven by industrial needs identified in the end user community of laser users.

The UK has an extensive capability for innovation and productivity improvement throughout the transportation sector and the supply chain, which employs over 1 million people in the UK (referenced in Section 3).

Combining the strengths the UK has across the supply chain: in advanced materials, laser processing and transportation sector provides the powerful ingredients necessary to solve this challenge through UK-based innovation.

In spite of the above strengths, the uptake of laser manufacturing is lower than in other countries. This is where ISCF funding can make a difference. For example at AUDI in Germany, the A8 was radically reduced in weight by new materials (composites and alloys) which are joined by laser welding using a remote process that reduced cycle time by over 53% and replaced a traditional laser welding robot solution. UK manufacturers like JLR, Nissan, Ford and Honda need to address similar challenges to provide the fleet of future vehicles, engines and sub-systems which can meet the challenge presented.

UK manufacturers of components for transportation vehicles are already facing requirements to implement new technology in a short timeframe as evidenced by:

- the rapid shift to battery-powered vehicles
- the adoption of new materials (plastics, composites, new alloys)
- implementation of GPS and Artificial Intelligence in vehicle control

The flexibility provided by industrial laser processes allows radically new designs, materials and technologies to be readily implemented.

With or without the possible changes to international trading conditions related to Brexit, the supply chains in Aerospace and Automotive would benefit from a systematic reshoring to enhance international competitiveness. Reshoring parts of the supply chain with laser-enabled world-class UK manufacturers provides further benefits in efficiency and productivity.

Local supply chains:

- reduce carbon footprint
- improve employment
- reduce inventory
- reduce risk
- increase the potential for export, growth and job creation

The McKinsey report "Lightweight, heavy impact" (Feb 2012), shows the trend in deploying lightweight systems across different sectors and highlights especially the automotive sector and in particular the trend towards electric vehicles.

**5. What is the demand from industry?**

The Association of Industrial Laser Users (AILU) has been a pivotal organisation in the connecting of industry with research organisations and mobilising the UK supply chain across all sectors of manufacturing towards the increased uptake of laser manufacturing technology since its establishment in 1995.

AILU has 140 UK industrial member organisations representing approximately:

- 60 End-user organisations using lasers in manufacturing (OEMs and supply-chain)
- 55 Manufacturers of laser sources and systems
- 25 Supporting companies providing goods and services to the UK supply chain

Since 2015, AILU has been working with the EPSRC-funded CIM in Laser-Based Production Processes, research and technology organisations, and industry representatives to formulate a national strategy to increase the adoption of laser material processing across the widest number of industry sectors. During the course of preparing the national strategy, AILU was assisted by over 75 organisations representing UK manufacturing, who participated in workshops and surveys to provide the inputs for the strategy formulation. During a workshop in May 2017, to look at industry demand for laser material processing, and indications of industry funding were estimated at £100m over 5 years (£20m per year not including ISCF matched funding). The national strategy, "Lasers for Productivity: a UK strategy", was launched at Westminster in March 2018, in a meeting sponsored by Joanna Cherry, MP, and attended by leading figures from the UK laser industry.

In the process of putting this bid together, input from end-users across the transport sector has been sought, through AILU's membership-base as well as the wider network of the team who have led this bid. The Appendix details information of key organisations who have been involved in the development of the national strategy, as well as those who have expressed their support for this EOI by letter or in an e-mail. Letters/e-mails of support have been received from:

- A wide range of UK manufacturers in the transport sector, including: Nissan, JCB, Honda, Leonardo, Gestamp, Unipart, and Rolls-Royce.
- UK laser hardware manufacturers, including: SPI, Coherent, Rofin-Sinar, Renishaw and OpTek Systems.
- UK Universities and RTOs, including: Heriot-Watt University, Manchester University, Southampton University, TWI, HVM Catapult Centres (with specific interest from AMRC and NAMRC).

Dr Paul Hilton is a recognised leader in industrial laser processing, with more than 30years experience of innovation leadership in this area, and would be a suitable director for the

technology leadership. He is currently the President of the European Laser Institute, a Member of the Board of Stakeholders of Photonics21, and an ex-President of AILU. The challenge would seek to complement Dr Hilton's expertise with a second Director from Industry, providing leadership on end-use applications for UK manufacturing. Several willing candidates have been identified during the development of this EOI, and could be consulted with in more detail at a later date when more details are known about the position.

**6. Why is ISCF support needed?**

Laser processing impacts the UK economy by £25 billion, through hardware supply and the use of this hardware for manufacturing operations. However, UK manufacturers lag behind in the adoption of laser processing; purchasing fewer than 8% of the high-power laser processing systems bought by German manufacturing, for example. Consequently, UK industry is more likely to use traditional manufacturing techniques, reducing their global competitiveness.

In the transport sector, initiatives to reduce emissions necessitate the adoption of lightweight materials, the production of more energy-efficient powertrains, and development of advanced solutions. Furthermore, the environmental impact of manufacturing operations is increasingly scrutinised. A step change is required by UK manufacturers, to reduce environmental impact and simultaneously increase productivity and their ability to produce more energy efficient transport structures.

Laser-based manufacturing has the potential to provide this step change, as recognised by the funding of the Laser-Based Production Processes CIM and the Future Photonics Hub by EPSRC. These initiatives support the development of next generation solutions, however the mechanism to translate these activities into industry benefit does not currently exist. The UK already has world-leading laser hardware and systems providers (SPI, Renishaw), who export over 85% of their product. Furthermore, the UK also has a number of world-leading Universities (Heriot-Watt, Manchester, Southampton) and RTOs (TWI, HVMc), who develop and translate processing know-how to industry.

Innovation funding is required to provide a pathway between UK manufacturers in the transport sector with this world-leading UK capability. ISCF support will de-risk this activity, and encourage UK primes/OEMs, as well as their supply chains, to evaluate, develop and adopt laser processing. Global competition limits this approach currently, with UK manufacturers competing on short-term price, rather than investing in longer-term capability. ISCF support would enable cross-cutting initiatives to collate and disseminate best practice, ensuring improvement throughout supply chains.

**7. What level of funding is needed?**

Funding of £ 100 million is sought, comprising:

1. £ 40 million from ISCF

2. £ 60 million from industry

**8. Are you happy for us to share your details with potential collaborators?**

Yes