Project details

Project title

Eyes of the Autonomous Future

Research category

Industrial research

Estimated timescales

Project start date :
6-4-2019

Duration in months :
36

Lead organisation

PHOTONICS LEADERSHIP LIMITED

Partners

Challenge summary

Eyes of the Autonomous future: Enabling rapid, safe deployment of autonomous vehicles, from cars, to planes, by leveraging 150 years of UK knowledge to develop, manufacture and test affordable embedded sensors for safe, dependable multi-dimensional detection of a vehicle's surroundings.

Scope: Alignment with grand challenges

Future Mobility: Robust, affordable real-time sensing is vital for future autonomous mobility- without eyes the driverless vehicle is blind.

Application questions

1. Describe your challenge.

Reducing road deaths, decreasing stress on transport infrastructure and increasing productivity all need autonomous vehicles which requires solving the challenge of how vehicles see their surroundings in all conditions and building trust in these systems. The future of autonomy depends on detecting the position, distance and speed of surrounding objects to feed decision making AI algorithms.

Visible cameras are excellent at locating objects in daylight, but struggle in poor weather and measuring to the required accuracy at 200m range. Infrared cameras and microwave sensors help in fog and low light, quantum sensors offer future potential for high sensitivity, but distance and speed require active Light-based Detection and Ranging (LIDAR). All future autonomous cars, planes, boats or trains will require multiple imaging, LIDAR and sensor technologies (Economist 2018). The challenge is making these 100% dependable, integrated into the vehicle, manufacturable in volume, fail-safe and affordable for mass-adoption.

The millions of miles being driven by driverless cars is establishing the potential of AVs. These trials bolt detection systems costing \>£80,000 onto existing vehicles. LIDAR equipment makes up most of this cost (Economist 2018) and is primarily available from just a single manufacturer (Velodyne) using supply constrained 16-year-old technology (Oxbotica). This has inspired multiple pre-market start-ups (Luminar, Quanergy, LEddarTech, Oryx Vision, Ouster etc) requiring urgent intervention to ensure the UK is not left behind. End consumers and vehicle manufacturers need confidence that systems are safe, secure and quality assured, requiring innovation in comparing sensors and evaluating how they 'see' the unexpected, before integration into vehicles.

Availability of robust qualified detection hardware in volume is the biggest challenge to the future of autonomous mobility.

Government intervention is required to bring the currently separate supply chains together in a coordinated approach to deliver a new generation of fit-for-purpose solutions. Action now will give the UK capability to stay ahead, leading the AV revolution and leveraging wider UK AI, battery and transport systems expertise.

Success will be evident from:-

1. Use of UK produced sensors in autonomous vehicle trials in the UK and abroad.
2. Pilot production of sensor sets in volumes of 1000's seeding UK production to support manufacture of AV fleets.
3. Comparison of sensor performance from test-beds independent of the vehicle.
4. Recommendations for the regulation, safety and security standards required from AV sensors.

Impact will be the UK becoming a global leader in Autonomous Vehicles including sensors. Society will benefit from increasing consumer confidence in AVs, accelerating their adoption, reducing commuting and transport deaths. Treasury will benefit from lower expenditure on infrastructure, reduced lost productivity from congestion and increased income from AVs sensing manufacturing. Automotive and aerospace industries will benefit from access to local UK solutions accelerating development of UK AVs giving them early access to one of the most disruptive, highest-growth, markets of the 21st century.

Unsolved the UK will be dependent on solutions developed elsewhere. At worst lack of access will constrain the UK's autonomous industry and jeopardise consumer confidence restricting adoption and the productivity benefits autonomous mobility can provide.

2. What is the opportunity for productivity growth?

In 2017, 1.25m people were killed on roads globally, with 1710 people killed and 24,130 seriously injured in the UK [UK Gov]. Aside from the individual consequences, the economic cost in lost productivity is estimated at ~£15Bn in UK alone [2012 UK Gov]. Autonomous cars promise a solution that also reduces the £13bn annual cost to the UK from congestion (Inrix), as well as enabling personalised transport as a service, offering major productivity growth. Reducing car ownership will also reduce infrastructure costs and enable more productive urban planning (Economist 2018).

Whilst such figures are driving huge interest in driverless cars, the productivity benefits extend beyond automotive. With passenger air traffic forecast to grow at 4.7%/year to 2036 (Statica), the airline industry needs to accommodate more planes into the same space. 5mins of aircraft time on the ground costs an average airline $35m annually (Aviation pros 2017) with airline delays costing the US economy alone $33bn a year. Robust AV sensing embedded in planes can safely increase plane packing density, raising ground handling productivity and reducing highly polluting on-ground aviation fuel burn. In the air LIDAR complement Radar with the ability to detect smaller hazards such as drones that present an increasing safety risk to civilian aircraft.

All autonomous systems, operating in variable environments, need to construct accurate real-time views of their surroundings. Access to reliable, low costs AV sensor sets will support wider productivity enhancement across all autonomous applications where machines must work in tandem with people. Having solutions available in the UK, with capability to prove how they respond in new environments, will also accelerate productivity of the £218m UK automation/robotic industry, supporting the robotics and autonomy sector and accelerating their ability to provide even broader productivity gains to the UK.

3. What is the market opportunity?

1.7million cars were made in UK in 2016, with 1.3 million ($40Bn) exported (SMMT). A target cost of £80 per sensor and 5 sensors per car yields a UK market of ~£680m. With ~95million vehicles manufactured globally each year, and an AV penetration estimate of 50% the potential long-term opportunity in automotive alone is ~£20bn. This compares to the $43.3bn 2025 forecast for advanced driver assistance systems (Transparency Market research) and the $35bn in 2030 market for autonomous vehicles sensors forecast by Yole. As an additional upside, the Economist (3/2018) notes the move to transport as a service will reduced private car ownership requiring more cars to manufactured annually as high utilisation/milleage rates mean AV vehicles will be replaced more frequently.

The total global LIDAR market is forecast to be $5.2bn by 2022 growing at 25.8% per year driven by penetration into autonomous vehicles (Markets and Markets) rising to $44bn by 2050 (Tematys 2018). The airborne LIDAR sector was worth $971m in 2016 and is forecast to grow 17.3% annually to 2.5bn by 2022 (Markets and Markets), giving a ~50:50 split between air and land applications.

Underpinning AV sensors and LIDAR are the compound semiconductor materials used to emit and detect light. This is an area of exceptional UK strength (e.g. IQE, Oclaro, Plessey, CST Global) supported with the Compound Semiconductor Applications Catapult. The supply of compound semiconductor-based photonics into the transport sector is growing rapidly with double digit growth expected to continue reaching $3-4billion by 2022 (Knowledge Sourcing Intelligence 2017).

Additional opportunities will be present in the wider autonomous robotics market experiencing double digit grow and forecast to reach $11Bn by 2024 (Tractica 2017). Higher-value, lower-volume sectors also build on existing UK strengths and present opportunities in sub-sea and aerial vehicles for both civilian and military purposes.

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

The UK invented detecting distance with light with the Admiralty awarding Barr and Stroud an optical range finder contract in 1891. The UK has continued to lead in situational awareness for Defence and Security developing substantial knowledge and intellectual property ripe for deployment in the wider applications. Military rangefinders and fog penetrating cameras are innovated and manufactured in Glasgow, Edinburgh, St Asaph and Belfast and exported globally (Thales, Leonardo, Raptor Photonics etc). New SMEs are emerging focused on high volume AV sensing e.g. Photon Vision.

Industrial expertise in robust, efficient sensing systems is supported by world leading research in advanced lasers at the eye-safe wavelengths essential for LIDAR at the Universities of Cardiff, Glasgow, Heriot-Watt, Imperial College, Sheffield, Southampton, St Andrews, Strathclyde and UCL. The UK also hosts leading capability in next generation of infrared materials capable of being harnessed into weather penetrating cameras (Uni Cardiff, Sheffield, Glasgow, UCL, Lancaster, Heriot-Watt) and high sensitivity LIDAR detectors. Advances in high sensitivity detectors are also emerging from the UK's Quantum program (QuantiC & Quantum Technology Hub for Sensors and Metrology) and companies such as ST Microelectronics and Photon Force.

Addressing the AV sensing challenge also requires volume manufacturing solutions. To this end the UK hosts world-leading experts in integrated photonics circuit, miniaturising optics into volume manufacturable wafer scale platforms (Oclaro, Rockley Photonics, IQE, CST Global, and Universities of Southampton, Sheffield, Glasgow, Cardiff). These techniques are already being applied to components deployed in data communications and are ready to be applied to AV sensors. Often through pilot line projects, companies (IQE, Oclaro, Seagate, STMicroelectronics and Yelo) have also shown the ability to scale-up UK production to multi-million consumer volumes (e.g. in facial recognition sensors, communications and data storage).

Essential integration expertise is present within many of the above companies and at the Compound Semiconductor Applications Catapult (Cardiff), CENSIS (Glasgow), Fraunhofer Centre for Applied Photonics (Glasgow), the Future Photonics Hub (Southampton), EPIC centre (Torbay).

Simulation and safety testing is also a UK strength with simulator manufacture and operation (Warwick / HVM Catapult Drive in Automotive Simulator, Thales, Leonardo, TUV SUD, Rockwell Collins, Spirent Communications) and the UK capability in defence simulation fostered by DSTL directly relevant to AVs.

The significant domestic Automotive and Aerospace manufacturing industries and their associated development centres (e.g. Jaguar Land Rover, BAE Systems, Airbus) and dedicated autonomous vehicle start-ups (Oxbotica, Arrival) are providing significant market-pull in the UK. Visibility of demand is further fostered via the Transport Systems Catapult with access to the currently disparate supply chains through the Automotive Council, Automotive electronics system innovation network (AESIN), the Photonics Leadership Group (PLG) amongst many others. The opportunity in autonomous vehicle sensor is recognised in all the above companies. Demand is reflected in the setting up of a sensing sub-group in AESIN under ADAS & autonomous vehicles work-stream; identification of sensor as a key element of the Automotive Council roadmap for the intelligent connected vehicle; and identification of the area as one of the grand challenges for photonics by the PLG.

5. What is the demand from industry?

Five key UK stakeholder groups are motivated to see this challenge addressed, represented by the wide cross-section of organisations who have indicated their support in annex 1.

End manufacturers: include those developing autonomous or part autonomous vehicles, including driverless or driver-assist cars, lorries, trains, drones, aircraft, ships, underwater and other vehicles. Those expressing strong support include BAE systems, Oxbotica, Thales and AESIN representing the Automotive Council and automotive suppliers broadly.

Industrial innovators who excel at complex system integration and test: including those with experience in situational awareness, IR and LIDAR including Thales, Leonardo, BAE systems who are seeking to maximise the benefits of their RandD investment into broader markets.

Key Suppliers: including those developing the underpinning materials e.g. IQE, CST Global, Artemis Optical, Gooch and Housego, Amerthyst

University Innovators: of materials, sensors and integrated photonics including Universities of Southampton, Glasgow, Strathclyde, Sheffield, Bristol, Aston and the National Automotive Innovation Centre at Warwick.

Research organisations including: Compound Semiconductor Applications and high value manufacturing Catapults, Fraunhofer Centre of Applied Photonics and CENSIS, Huawei Technologies R&D UK and AMRC

Currently there is strong but siloed coordination between academic and industrial organisations. Coordination is present between academia and industry in each of: the Photonics Leadership Group, the Aerospace Technology Institute and within the automotive supply chain through the Automotive Council and AESIN. Whilst the relevant company and academic groups are active in at least one of these organisations few are in two and almost none in all 3. Bringing all 3 sectors together to focus on this challenge is critical to ensure progress is made within the timescales necessary to ensure the opportunity is secured for the UK. To support this a co-directorship for the challenge is proposed one director from AESIN and one from the PLG.

The automotive and aerospace sectors have a strong track record, particularly in the UK of both innovating and of adopting new technologies with an Open Innovation model. Companies are adept at delivering complex systems and familiar with the processes by which technology moves through maturity, validation and critically in the creation and adoption of new standards. The UK position will be greatly enhanced by coordinated efforts to drive and establish appropriate ISO and other industry standards including reliability and safety standards.

The willingness and high perception of the rewards to be gained from AV sensors, particular LIDAR, is evidenced by LIDAR start-ups raising over $461m in funding in the last 12-18months (CB insights). The importance of autonomous vehicles is also clearly seen in the UK's Government support of level 4 vehicles trials in ISCF wave 1-investment that will be support by this challenge and which would otherwise have to purchase \>£2m sensor from outside the UK just for initial road trials. UK Industry willingness and resources to co-invest in this challenge is evidenced by the annex of 34 supporters whose combined investment in the last 5 years and forecast investment for the next 5 years in areas relevant to this challenge exceeds £408millon.

6. Why is ISCF support needed?

Future autonomous vehicles will have four elements: the physical vehicle, the power train/ electric motor, a decision making 'brain' and a sensor system.

Driverless trials have been 'driven' by software companies or vehicle manufacturers, not by sensor developers or the tier 1-2 component suppliers, resulting in autonomous trials using old single source technology. Automotive manufacturers are now moving from 'if' to 'when' they manufacture AVs, triggering them to request deployable AVs sensors from their suppliers. Not previously engaged, those suppliers are not connected to innovators in sensing hardware, which is very different from current generation driver assist systems.

Those who have innovated detection technology are often defence suppliers whose high-value, low-volume products do not support the costs of adaptation to wafer-scale, mass manufacturing. Although, many civil aerospace, security and low-cost defence applications would benefit from the reuse of solutions developed for higher volume applications.

Meanwhile those innovating mass manufacturable integrated photonics have to-date focused on the communications markets. Whilst the underpinning technologies are very similar, the lack of connection to volume automotive tier 1 suppliers, means they have not focused on innovation for AV sensors.

To be ready for the mass deployment of AV forecast for <5 years the automotive industry needs a viable AV sensor supply chain ready in 3 years' time. This requires immediate action to connect the current separate supply chains and bring scale and integration to UK LIDAR, IR and other sensors technology. This program will uniquely focus on developing affordable volume manufacturable technology, proving volume feasibility and supporting SME scale-up with pilot manufacturing lines. Additionally, addressing issues of out-of-vehicle qualification to enable rapid adoption of multiple generations of innovation, whilst building industry, consumer and regulator confidence.

7. What level of funding is needed?

Support of £88million over 3 years is required, paired with \>£59m from industry. This will support innovation in next generation AV sensor components, integrated systems and pilot lines demonstrating their volume manufacturability. In parallel, test-bed simulators will be realised for independent analysis of AV sensors to support regulatory recommendations.

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

Yes