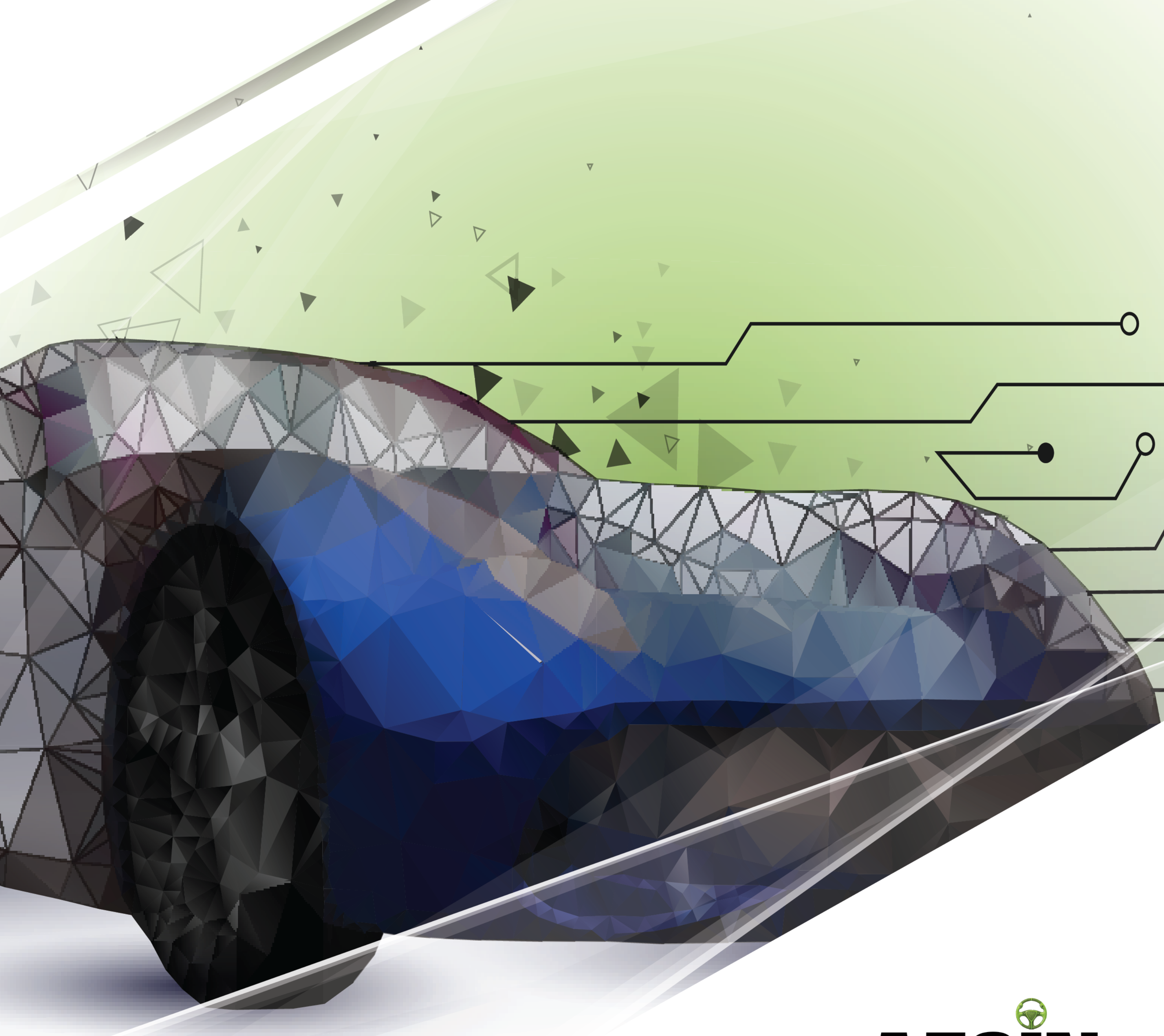
UK
AUTOMOTIVE ELECTRONICS CAPABILITY REPORT

JULY 2018



TechWorks

AESIN
AUTOMOTIVE ELECTRONICS INNOVATION

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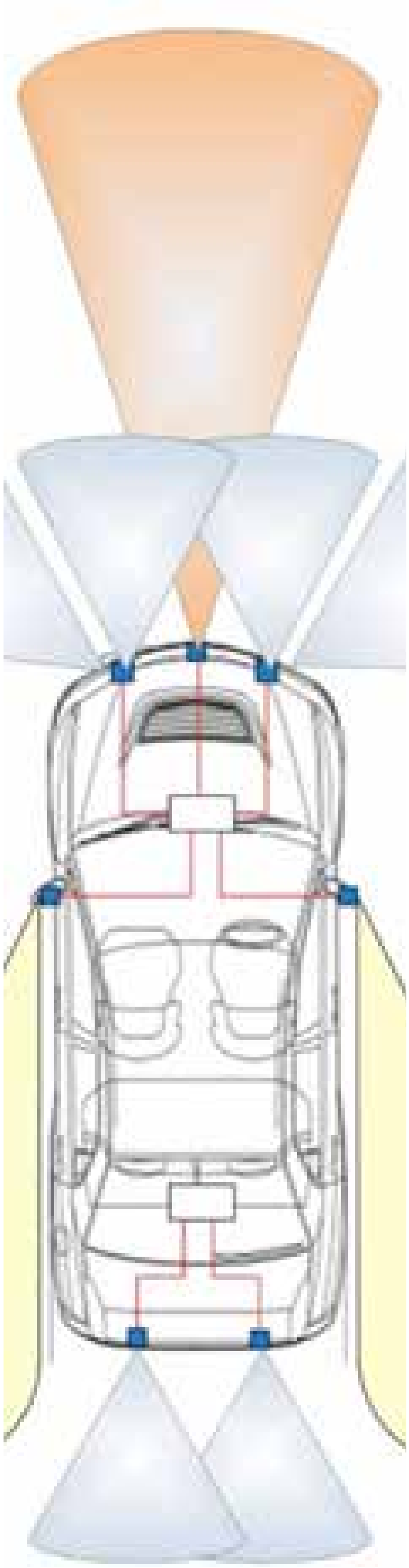


1 SUMMARY

The Automotive Industry is going through unprecedented change, with an explosion in features & functions growing at a rate we have never seen before. This is driving a huge demand for in-vehicle Automotive Electronics both in the Small Signal and Power Electronics domains.

This report and the attached spreadsheet, containing companies that are currently operating or expected to want to enter this space, give a good understanding of how well placed the UK is to seize on this opportunity and exploit the growth in the Automotive Electronics sector.

Innovate UK now has a unique database of UK companies that are strong in this sector and can be targeted to exploit the future growth opportunities as well as opening up further opportunities for companies that want to enter the sector.

The contents of this report were collected and compiled by AESIN members A Banks and R Green. The inputs of A McGibbon, Compound Semiconductor Catapult, and that of the AESIN membership have been much appreciated.

This research is based on the knowledge and analysis of the authorship and AESIN members: no liability can be accepted as a result of any actions taken as a result of it.

2 INTRODUCTION

The aim of this report is to provide an overview of the UK activity involved in Automotive Electronics. This overview will assist Innovate UK in its understanding of the spectrum of skill sets within UK and can assist in its definition and deployment of industry competitions related to the sector. It is clear that the automotive industry is going through rapid changes today, and that electronics technology is the most significant enabler for driving these changes towards smarter and safer vehicles.

In contrast to the rather stable composition of automotive supply chain companies of the past, one of the characteristics of the changes ahead will be the emergence of new entrants to the automotive sector. Companies with a history in for example Aerospace, Robotics, Fin Tech, Industrial Software, now have a focus on Automotive Electronics, as well as a plethora of Start-Up companies focussing on Connected and Autonomous Vehicles CAVs.

Although the scope of this report covers all of the "potential" companies with skill sets appropriate to the automotive sector, the aim is to record examples of where this is already happening. In this way, it may be judged as to what extent product development potential can be expanded through further collaboration.

The report includes in-vehicle electronics, and will exclude transport infrastructure electronics which is situated outside the vehicle. In-vehicle electronics consists of two main categories: Power electronics and small signal electronics. Power is primarily concerned with the switching and management of high currents, while small signal deals with information signals or data manipulation.

The report will serve the twofold purpose:

1. To inform Innovate UK on the number, product/service focus and size of businesses within the automotive electronics space, and;

2. To provide a public resource to the automotive and electronics sector to enable relationship building, provision of services between organisations in the supply chain and greater collaboration.

3 THE AUTOMOTIVE ELECTRONICS ENVIRONMENT

The growth of electronics in passenger vehicles has been increasing over recent years with each new model of a particular brand containing typically 30% more electronics than its previous model. This has facilitated OEMs to differentiate in a competitive market environment, and has enabled enhanced comfort and safety features together with an increasing spectrum of infotainment options. This steady evolution of complexity is about to change dramatically: with the advent of efficient battery technology, cloud connectivity, and AI techniques, then the in-vehicle electronics processing power will increase by some orders of magnitude in a relatively short timeframe - a data explosion.

There are four key trends in automotive technology borne out of the new disrupting electronics capabilities:

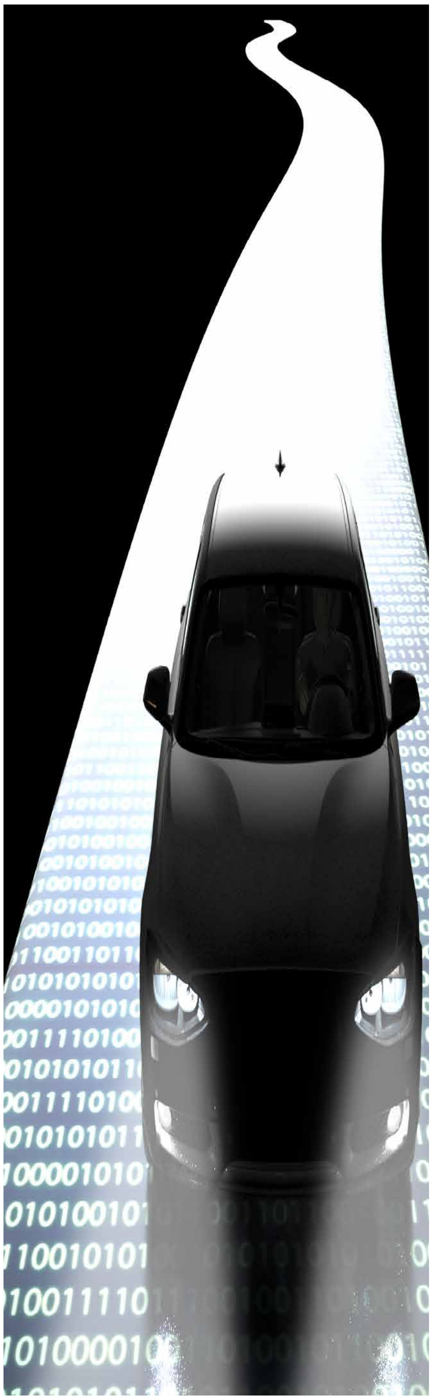
- **Vehicle electrification**
- **Vehicle connectivity (V2X)**
- **Autonomous drive capability (SAE-defined levels 1-5)**
- **Shared mobility services (MaaS)**

The potential benefits of these trends, including increased safety, reduced congestion, reduced emissions, and improved traveller experience, have been well-documented and will not be elaborated on here.

The race is now on within the automotive sector to bring together these new capabilities – capabilities that may have been driven by other market sectors such as Aerospace or Fin Tech. As the industry goes through these disruptions, then brand new partnerships between companies can be expected in order to bring about the innovations required.

Power Electronics

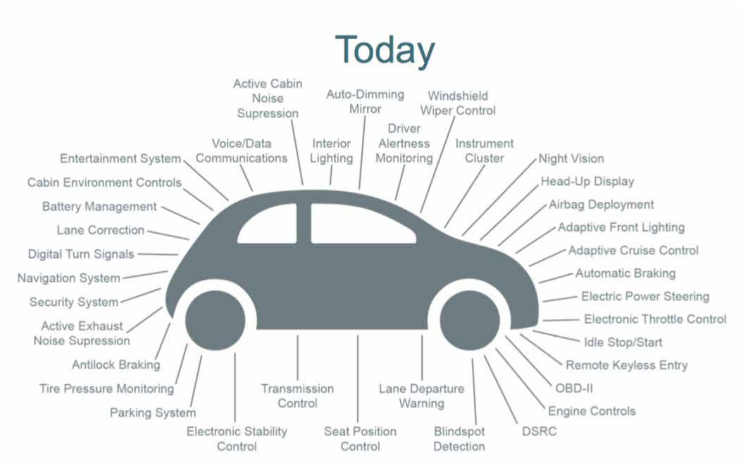
Vehicle electrification is being enabled by enhanced battery storage capabilities and also by power electronics to manage and deploy the energy usage within the vehicle. Automotive manufacturers have typically introduced battery-powered vehicles by designing battery and associated electronics into the space available within an existing chassis. The new generation of EV's are now being designed around the battery system itself such that the battery efficacy can be maximised.



Small–Signal Electronics and Data-Processing

The use of Electronic Control Units (ECU's) began to expand during 1970's with each ECU performing a specific function such as controlling fuel injection or engine emissions. A typical new vehicle at that time might have had 5 ECU's. Up until recently, the design philosophy has been to add a new feature to a vehicle by adding a new ECU. This has resulted in a proliferation of ECU's within the vehicle and vehicles typically containing between 100 and 150 ECU's on board today. The introduction of standard bus protocols (eg CAN) and application interfaces (eg Autosar) has helped to create a robust environment for designers within the increasingly complex scenario.

The proliferation of ECU's has created problems of space, weight, cost, power consumption and the need for more rigorous data transfer methodologies.

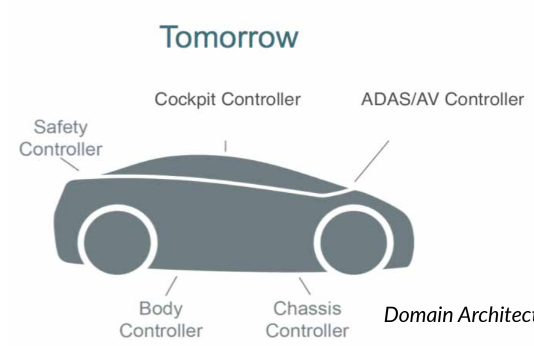


ECU proliferation *(courtesy Visteon)*

Future vehicles are being designed within a Domain Architecture with each Domain handling all appropriate functions to that Domain under a powerful centralised processor unit. Each Domain has different characteristics, and interfaces between Domains can be securely controlled.

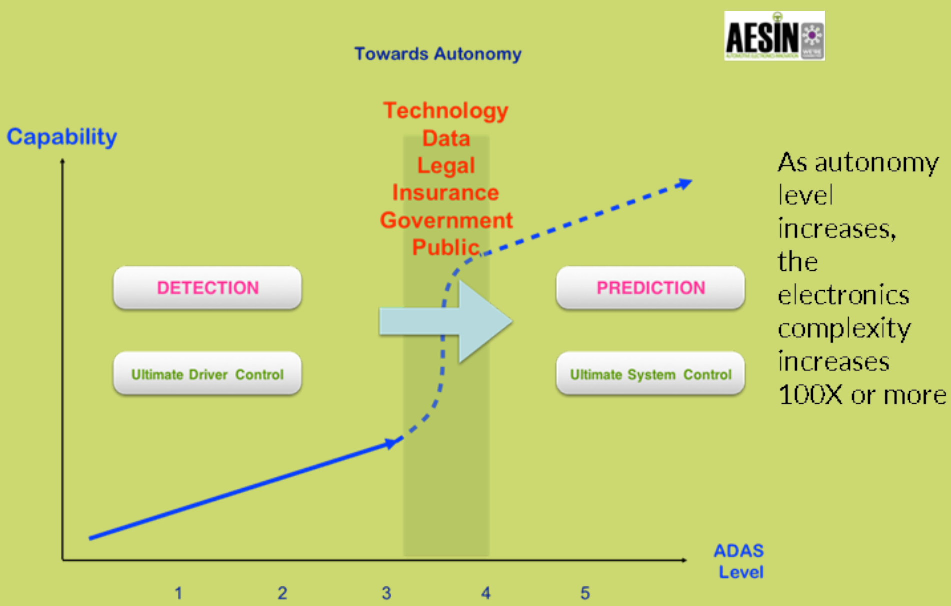
The total amount of processing capability in the vehicle will continue to increase while the intention of the industry is to minimize, or optimize, the total number of ECU's in a vehicle. This means that each ECU will contain much more processing capability and also that, for example, sensors will become "smarter" i.e. data processing functionality will be included on board the sensor module.
It should also be noted that this increase of data processing, together with more display content and connectivity, will all lead to an increase in power consumption for the ECU representing a further challenge to designers already managing a tight power demand budget.

The use of a robust Ethernet standard is widely seen as most appropriate for the very high data rates foreseen for example within a Sensor Fusion implementation for ADAS or Autonomous Drive capability.



Domain Architecture (courtesy Visteon)

But the complexity is about to increase dramatically further. The increasing levels of connectivity and advanced driver assistance systems (ADAS) present in new vehicles are already being appreciated by the car-purchasing public. As the move to autonomous drive capability (SAE Levels 4 and 5) continues then we can foresee an exponential increase in the complexity of the electronic systems required. A set of sensors combined with increasing computing power enables real-time decision-making and actuation of a vehicle's steering and/or acceleration/deceleration. In addition to the increasing complexity of this design, there are many other new issues arising regarding, for example, regulation, certification, safety, and digital resilience and survivability - all to be resolved in order to provide Government and public acceptance of autonomous driving.

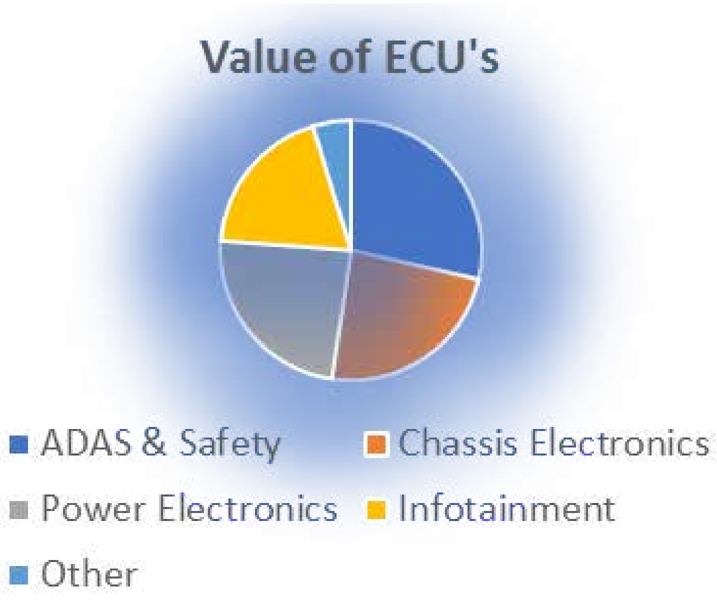


4 THE CHALLENGES THAT CREATE THE OPPORTUNITIES

The worldwide auto electronics market is forecast to be $280 Bn in 2020. Most industry analysts agree that the automotive electronics market will grow at a CAGR of between 6%-8% from 2017 – 2024. By 2024 the market will be worth almost $400 Bn.

The ECU (Electronic Control Unit) value alone of a vehicle is forecast to be 35% of the vehicle cost by 2020 and this is set to increase to 50% of the vehicle cost by 2030 (source: Statista).

An ECU contains data processing unit(s), and also embedded software.

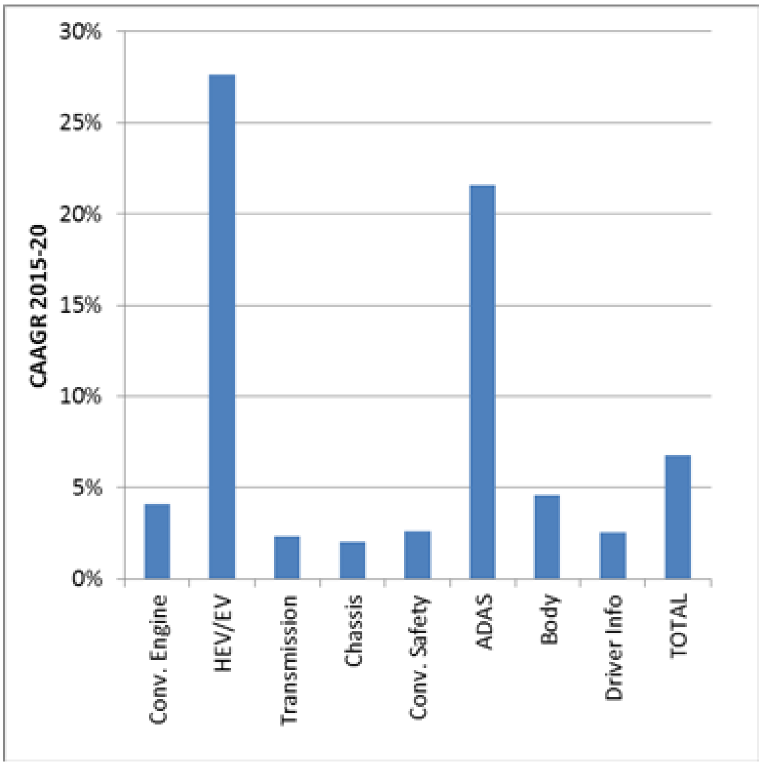


Worldwide ECU Market breakdown
(Source Statista)

With faster processors and more complex implementations comes an increase in software complexity. In 2010 a typical vehicle contained approx. 10 Million lines of software code: today that is over 150 Million lines of code. Software, embedded in the ECU hardware, represents approximately 10% of vehicle content cost: this is forecast to grow to 30% by 2030 (source: McKinsey). In this way, software will become a more valuable part of the ECU, and of the vehicle itself.

As the functionality of the vehicle increases the value of electronics in the vehicle will increase. Manufacturers will always be trying to reduce cost by optimising architectural efficiency, designing multi-functional ECU's, and exploiting Moore's law of semiconductor efficiency (silicon transistor density doubling every 18 months or so) to the full, as well as reacting to the increasing competition in this space.

The two fastest growth market segments in automotive electronics are in Electric Powertrain and ADAS implementations, both showing growth rates in excess of 20% CAGR.

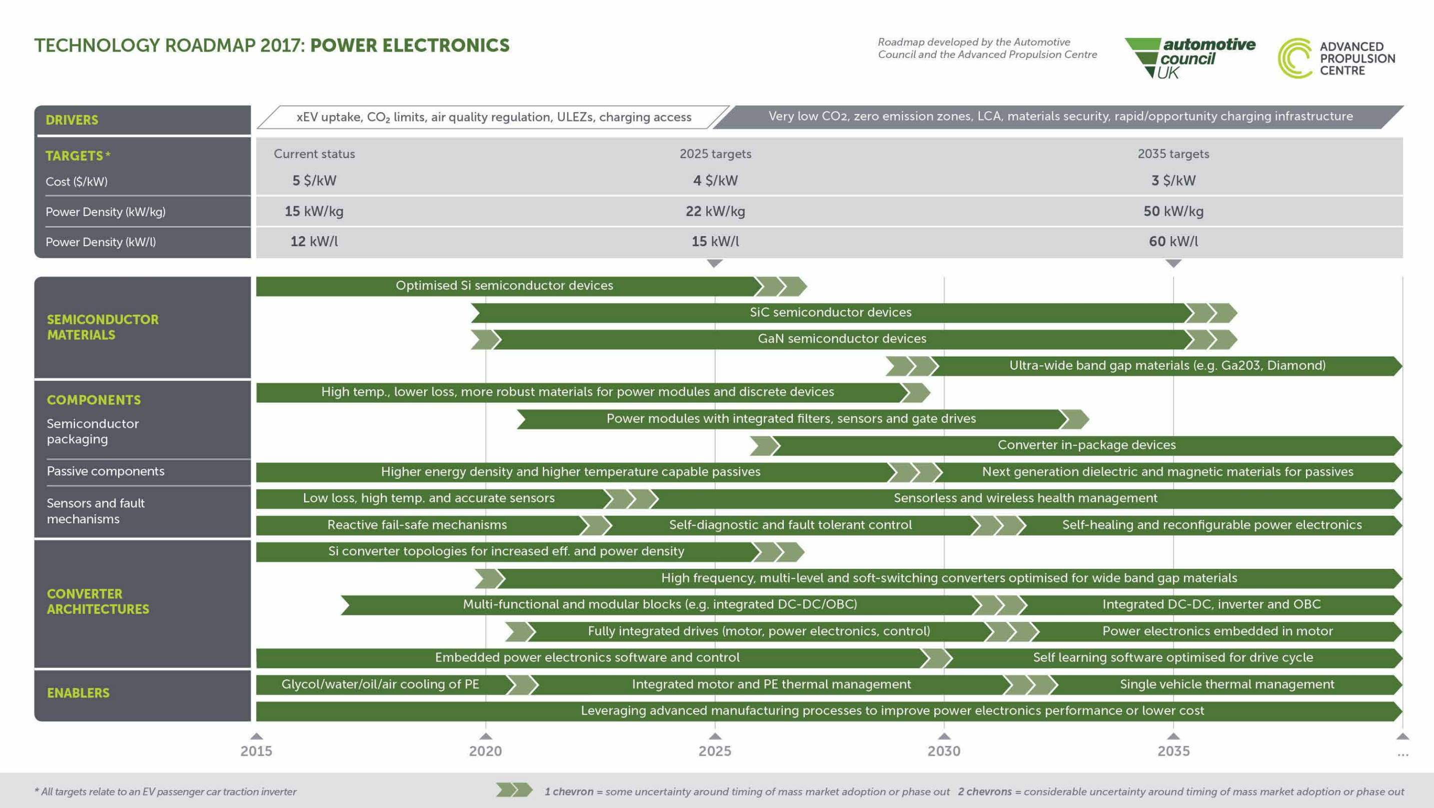


Growth rates in Auto Electronics :
Source Strategy Analytics

Power Electronics

The electric powertrain is a key driver for power electronics, which includes the on-board energy management system together with the battery- charging system. The challenge to produce more power while using less weight and space is producing innovation in SiC- based drive systems with targets of approx 500kW power performance.

The chart below shows the Automotive Council Roadmap for power electronics.



Full details of Power Electronics Roadmap available at:
www.apcuk.co.uk/technology-roadmaps/

The need for rapid charging of EVs has led to fast switching SiC or GaN technologies being used to operate at up to 30kW. Such solutions are also relevant to the Grid-side power management of Vehicle-to-Grid (V2G) implementation.

AESIN, through its Workstream “More Electric Powertrain” chaired by Ricardo’s Global Technical Expert Dr Will Drury, is leading the innovation debate on automotive power electronics with the OEM’s, Tier 1’s and the rest of the Automotive supply chain: the aim is to unite the Power Electronics and Automotive communities to provide thought leadership to facilitate the growth of power electronics and the associated supply chain in the UK. This has also recently been endorsed by the UK Automotive Council with the appointment of Alan Banks (AESIN chairman) to lead an industry growth plan in this sector.

The biggest electrification driver is cost and only through increased volume can the cost targets be met. Furthermore, without general consensus this will never be achieved because everyone will start to develop their own variants. This is particularly worrying for the UK as the decline of Internal Combustion Engine development will need to be replaced with a new industry consisting of Automotive Power Electronics and Electrification.

The overall goal must be to ensure that the UK is best placed to be at the forefront of technology developments within this sector. Through collaboration across the industry and through the engagement across sectors.

Small Signal Electronics

The Automotive Council technology roadmap gives a consensus estimate of how computing requirements will change short- and long-term.

AVs will need to have this increase in real-time processing power on board for the core autonomous driving function. (see Autocouncil Roadmap for CAV Development: https://www.automotivecouncil.co.uk/technology-group-2/automotive-technology-roadmaps/).
Cloud processing off-board may be used for additional information/services eg identifying a free car parking space etc.

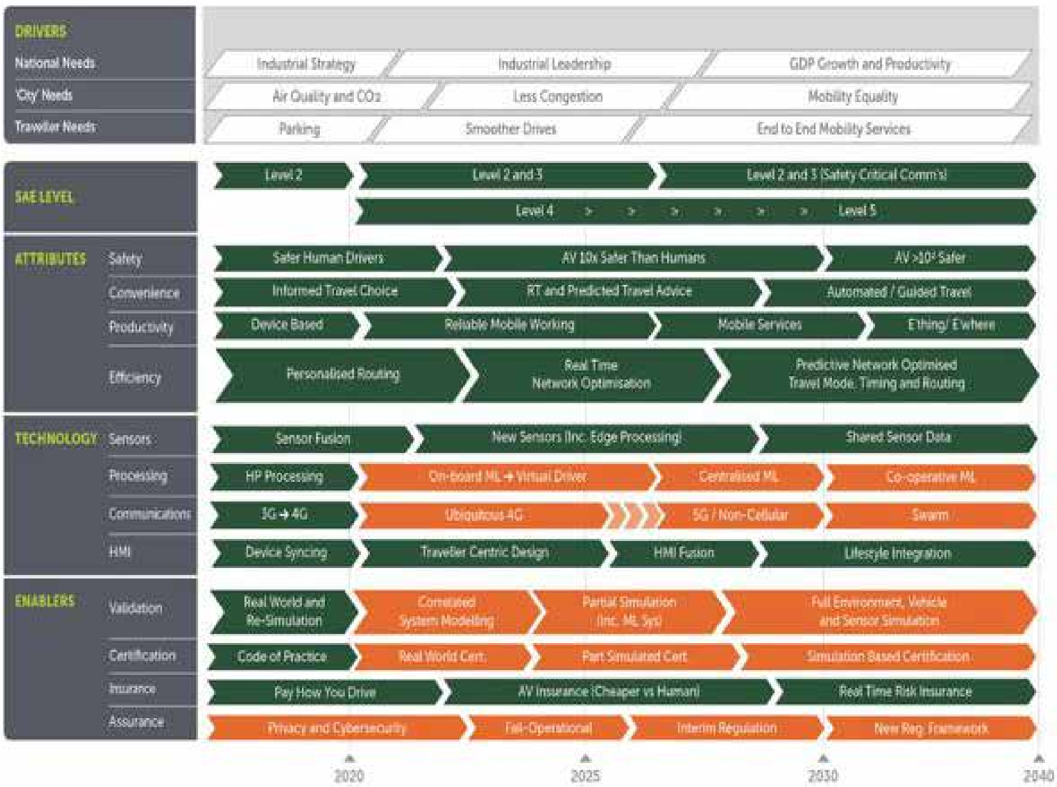
In the longer term, vehicle architecture may well be defined as part of a system-of-systems model (each vehicle interacting within a bigger system of infrastructure/cloud services/traffic system): the balance between computing power on board, and that off-board (in the cloud), is still to be determined and represents a great challenge to the wider industry going forward. The use of such a system architecture will be key to managing complex systems, as well as managing the issues of (functional) safety and security.

	Short Term	Medium Term	Long Term
Compute Power	10^{14}	10^{18}	10^{21}
Software Complexity	10x	1000x	10^{6}x
On board power demand	<200 w	1-4 kW	<1 kW
Hardware life cycle	5-7 years	~2 years	<1 year *

[3]

There will be a need for developing new methodologies and new standards for data processing and cyber-security, as well as new regulations for safety assurance, and vehicle /personal insurance. New business models will be defined supporting new services associated with vehicle transport.

The Automotive Council has recently published a detailed roadmap of the developments of Connected and Autonomous Vehicles which highlights the critical elements for success (displayed in orange in the summary table below).



Full details of CAV Development Roadmap available at:
www.automotivecouncil.co.uk/technology-group-2/automotive-technology-roadmaps/

Challenges

The major challenges can be categorised into various themes. Each of these has a distinct set of challenges in itself.

1. Sensing
The configuration of appropriate sensors (eg camera, radar, lidar, ultrasound) that can effectively create a "picture" of the environment of the vehicle. Sensor innovation is developing rapidly alongside the architectural considerations of managing the resulting high data rates to the central processor.

2. Machine Control (AI)
The use of AI in order to analyse all available input data and to decide upon and implement the movement of the car. This processing is the core of the Sensor Fusion Engine.

3. Connectivity
The transmission and reception of data (technical/commercial) between vehicle and roadside transceivers or cloud sources.

4. Validation and Verification
The testing, including virtual testing and simulation, of vehicle or vehicle systems to adequately account for all potential use cases.

5. Safety and Standards
The definition of standards and safety methodologies in order to ensure integrity of vehicle design, and to provide public confidence in vehicle operation.

6. Security
The provision of digital resilience with respect to the integrity of all data within a vehicle system. This includes resilience to external cyber attack.

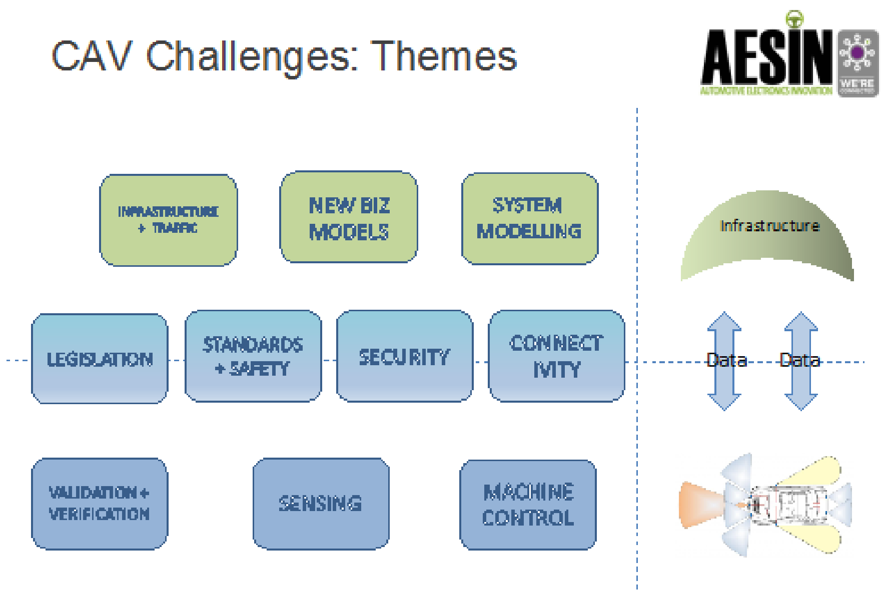
7. Legislation
The provision of regulation that allows safe deployment of autonomous vehicles that in turn provides public confidence in vehicle operation.

8. Infrastructure
Ex-vehicle electronics (roadside or central cloud-based) which communicate with the vehicle creating new technical and business services.

9. New Business Models
New services will result by taking advantage of CAV data. This will inevitably require agreements between service providers, data providers and benefactors.

10. System Modelling
A CAV traffic system can be considered a system-of-systems with data flows within and outside of each vehicle. The development of System Modelling techniques can be useful to create better understanding between partners co-operating within such new complex scenarios.

11. Human-Machine-Interface
As the focus on the needs of a CAV occupant increases in importance, then ergonomic HMI technology will become more relevant and sophisticated, together with health/well-being monitoring technologies



5 UK CAPABILITY OVERVIEW

The Capability Table contains 601 companies operating in UK.
There are 270 companies (44.4% of total) involved with power electronics.
There are 219 companies (36.4% of total) performing R+D in UK.

Supply Chain Classification: The breakdown is as follows:

- 30 OEM companies
- 80 Tier 1 companies
- 40 Tier 2 companies
- 56 Tier N companies
- 18 companies working on Infrastructure (3.0 %)

Automotive Electronics Involvement: breakdown as follows:
(Infrastructure companies removed from percentage calculations)

- 199 companies (34.1%) are already working in in-vehicle Automotive Electronics
- 99 companies (17.0%) will LIKELY become involved in future in-vehicle Automotive Electronics
- 215 companies (36.9%) will POSSIBLY become involved in future in-vehicle Automotive Electronics
- 70 companies (12.0%) are UNLIKELY to become involved in future in-vehicle Automotive Electronics

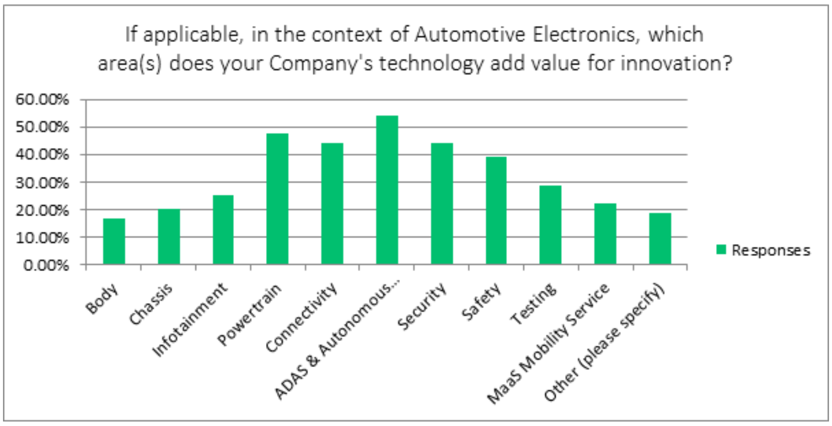
Therefore 513 companies (88.0%) ***are*** or are ***likely to*** or ***possibly will*** become involved in future Automotive Electronics.

It should be noted that the description and allocation of the terms "LIKELY, POSSIBLY" etc are the best opinion of the authorship at the present time, and may not represent everyone's view.

Questionnaire

A questionnaire was sent to AESIN members with the aim of gaining feedback on UK capability. 73 companies replied to a Questionnaire.

- 39% of respondents are UK SME or start-up companies.
- 58% of respondents are working in automotive industry today.
- 83% of (non-automotive) respondents confirmed that they were "Likely to" or "Possibly" start work in automotive electronics in the near future.
- 44% of respondents employed 1-10 engineers, and 45% of respondents employed 1-10 automotive engineers.



The most popular application area that respondents are working on is ADAS+AV (54%), followed by Powertrain (47%), Security (44%) and Connectivity (44%).

6 APPENDIX A: CAPABILITY TABLE [1]

A UK Automotive Electronics Capability Table has been drawn up listing companies and organisations operating in UK that are, or have a possibility to be, working on future in-vehicle applications. This provides insight into the UK spectrum of companies and organisations working on power electronics and/or small signal electronics. It is possible to obtain a copy of the Capability Table file by contacting AESIN (FAO Paul Jarvie) at admin@aesin.org.uk

Nomenclature used:

- ORGANISATION (Column B):
  : Hyperlink used for easy access to Corporate website

- TYPE of Company (Column C):

: Large UK	- HQ in UK, headcount > 250
: SME	- HQ in UK, headcount between 50 - 250
: Small	- HQ in UK, headcount < 50
: Multinational Large in UK	- HQ overseas, UK headcount > 250
: Multinational Medium in UK	- HQ overseas, UK headcount between 50-250
: Multinational Small in UK	- HQ overseas, UK headcount < 50

- LOCATION (Column D):
  : Main location(s) in UK, not necessarily all.

- DESCRIPTION OF FOCUS (Column E):
  : Short description of main focus area of company

- SUPPLY CHAIN POSITION (Column F):
  : Classification, where possible, of position within traditional automotive supply chain.
  In cases where position is Tier 3 , 4 or more, then the designation Tier N is used.

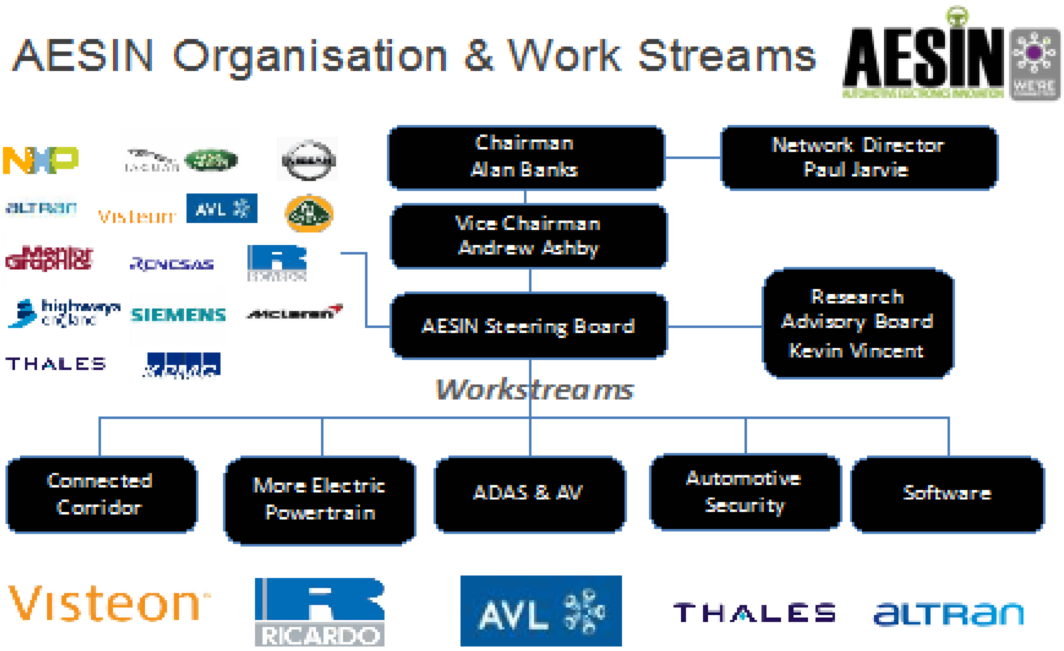
  - POWER ELECTRONICS (Column H)
  : In the indicator YES/NO allows easy filtering to select those companies who have power electronics capability. These companies ("YES") may well have other (small-signal) capabilities as well.

- UK - BASED R+D (Column I)
  : the indicator YES/NO allows filtering to select companies performing R+D within UK

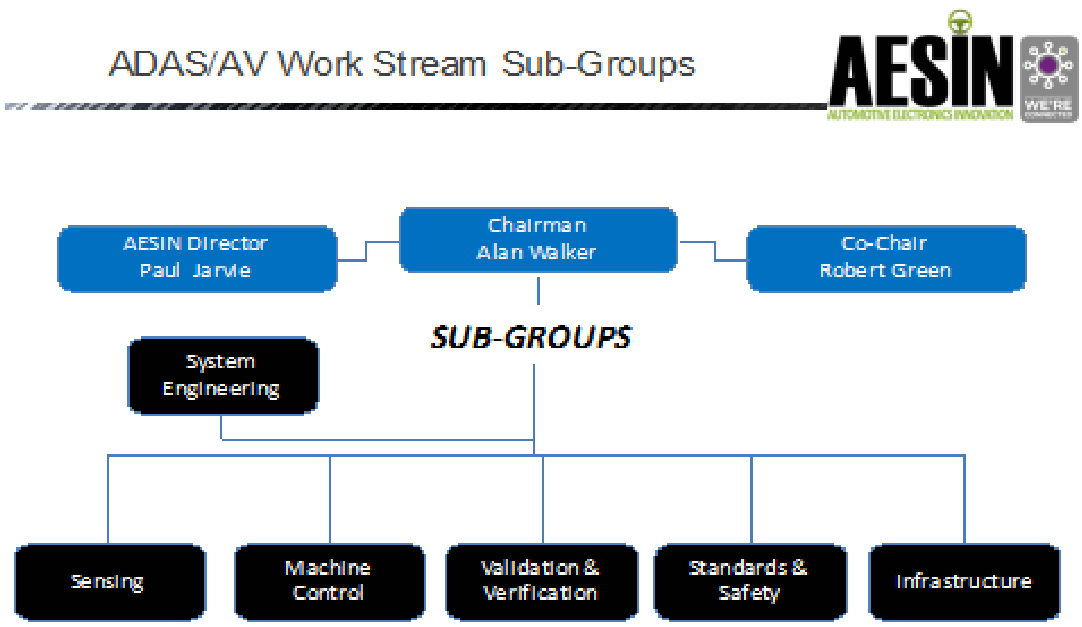
1 *See separate file for data content*

APPENDIX B: AESIN WORKSTREAM STRUCTURE

A key aim of AESIN is to facilitate collaboration between organisations based in UK, enhancing the knowledge and business base in UK. Collaborations are facilitated through a Workstream structure managed by the AESIN Steering Board: each Workstream is dedicated to a particular strategic innovation area, and is organised by a lead and/or Workstream Steering Group.



In the case of ADAS and AV Workstream the activities are focussed through a number of sub-groups which focus on the key themes of innovation.



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