EARPA Position Paper

Task Force Electronic & Communication Systems (ECS)

The Role of Electronics and Communication Systems in European Road Transport and ICT

September 2018

About EARPA

Founded in 2002, EARPA is the association of automotive R&D organisations. It brings together the most prominent independent R&D providers in the automotive sector throughout Europe. At present its membership numbers 53, ranging from large and small commercial organisations to national institutes and universities.

The EARPA Task Force Electronic and Communication Systems (TF ECS) was launched in 2011. The Task Force discusses the RTD needs for new uses and a better performance of specific electronic and communication systems for automotive applications. It will deliver benefits to safety, environment and mobility.

This position paper presents a synthesis of the Task Force members' view on the relevance of RTD on automotive electronics and communication systems, a description of the role of the Task Force, suggestions for future research priorities and supported roadmaps and how these automotive technologies will impact our society.

Introduction to Electronic and Communication Systems in European Road Transport and ICT

Electronics has become a vector for the development of environmental friendly, safe and versatile vehicles. Nowadays, electronic components constitute a third of the total development costs of a new vehicle and that electronic components represent more than 30% of the total cost of a passenger car. 90% of all new functionalities in a vehicle are provided by electronics and this trend is likely to increase.

Additionally, the setup of communication capabilities between the vehicles and the infrastructure will enable new mobility services and increased safety: the vehicle will gradually become another (moving) node of the global network of the Internet of Things (IoT).

Future mobility will shift into a complex ecosystem of connected, cooperative, (increasingly) automated vehicles offering different services to very different types of end users.

Nowadays, the implementation of the technology is not homogeneous among all vehicles. Modern cars can reach up to 50 ECUs and the trend is that that this number will be higher: current buses and E/E architectures need to be improved to enable connected and automated driving functions due to its bandwidth, latency and security requirements. The verification and validation of these architectures is a complex topic that needs to be addressed by the industry and academia.

The challenge is even greater as vehicles are no longer isolated but are becoming part of complex systems: Electric Vehicles are linked to e.g. smart grids; Connected & Cooperative vehicles are linked to each other and/or the infrastructure; Highly Automated Driving vehicles will integrate the previous and add another layer of complexity.

The electrified, (highly) automated and connected vehicle will generate a huge amount of data that will increase our knowledge of mobility while fuelling promising tools and technologies like transportation Big Data and Artificial Intelligence (AI). More standardisation activities are needed on information exchange on various levels (data formats, protocols, message sets, security and more). New upcoming access technologies (i.e. 5G) will boost up connectivity with greater bandwidths and lower latencies. This amount of information will be exploited through big data analysis techniques and therefore must be protected and secured (i.e. making use of blockchain) as their potential to fuel promising tool and techniques (e.g. Artificial Intelligence) is huge.

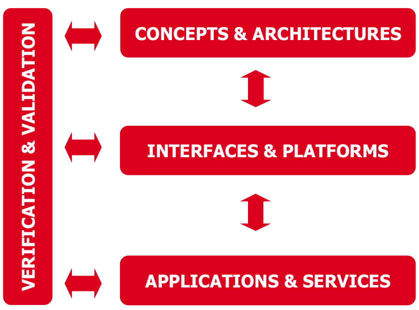
The main objective of the TF ECS is to address these challenges by defining relevant research priorities and implementing successful research activities. Specific objectives include:

- To research and develop methods and tools to integrate new functionalities in the vehicles and the infrastructure in which it is integrated
- To research and develop methods and tools for ensuring that new functionalities fulfil the needs of safety, security, reliability and work load
- To support deployment and standardisation of platforms, communication protocols, validation techniques and criteria
- To implement bridging activities, which demonstrate the possibility of transferring knowledge and functionalities gained in other research activities

The EARPA TF ECS ambition is to catalyse that Europe will be the frontrunner in the technical and organizational innovation towards safe in-vehicle enabled sustainable mobility for all based in new advanced electronics and communications systems. This will be achieved by optimal co-operation in the triple helix of academia, industry and government.

Expertise and role in the development of Electronic and Communication systems

The TF ECS is structured matching how hardware and software components integrating a whole system are typically arranged.



This structure corresponds to a whole system. EARPA is the organisation for R&D entities, which include universities, research centres and industrial partners, which do not manufacture any product. Thus, even if this structure addresses a whole system, the partners of the Task Force have identified their capabilities and limitations.

Within this structure, the following fields of activity are defined:

- **Concepts and Architectures**

  The Connected and Automated Driving (CAD) vehicle will require a complete new architecture , which goes far beyond existing ADAS ready ones. With the vehicle being in control, i.e. not the driver, even more attention needs to be paid to functional safety in the development stages (e.g. ISO 26262, SOTIF). TF members can bring relevant support in technology transfer: an important objective is to identify architectures, which are already in use in other fields (e.g. aviation) and which could be applied for automotive use. Special attention to the new multi-cores strategies and the influence on the existing and new architectures proposed (e.g. AUTOSAR), mainly oriented to improve both time and (functional) safety constraints.

  Additionally, a relevant commitment of the Task Force members is to participate in the standardization process of new architectures, including security and privacy aspects.

- **Interfaces and Platforms**

  The driver's and road user role is evolving in the context of connectivity and automation. Efficiency, safety, security remain priorities. New sustainable mobility concepts require a seamless integration of CAD in the existing transport infrastructure in order to establish future improvements This involves both interfaces among users and vehicles, electronics and platforms for data management.

  Communication will support an array of innovations in this area. By establishing safe, secure interfaces and platforms (for e.g. traffic management) the Task Force will facilitate the adoption of cooperative mobility. This will allow that drivers (and/or vehicles) have access to all the necessary information to take better, informed decisions or may follow automatically traffic management decisions that are compulsory for more efficient and safe traffic flow.

  Several wireless communications technologies are being introduced for automotive purposes. The TF members act through a two-fold approach: on one side, support the deployment in the transportation field of these transmission technologies while integrating new technologies (e.g. lifi, 5G, etc..) and on the other side foster innovation with new services especially by SMEs.

  The development of technologies, tools and standards will enable the deployment of new automotive services. This is a field of activity where the Task Force members can provide strong support, with renowned R&D capabilities for the implementation of these interfaces and platforms.

- **Applications and Services**

  New transport and mobility concepts will be enabled by a number of vehicle automation and communication functions that are most likely to occur in the short/medium-term future. On the basis of those it would be possible to identify more specific research topics that correspond to actual forthcoming needs arising from the societal needs: improve efficiency, safety and reduce the environmental impact of the transport system.

  In the field of C-ITS, going beyond Day-1 applications towards services enhancing the drivers and passengers experience and comfort through connected services and automation of the driving experience. These applications and services will catalyse a shift from traditionally road-side equipment enabled traffic management towards in-car systems enabled advanced mobility, in a co-operative approach with increasing in-car systems involvement, a so called in-car centric approach. Other applications are focussed on the combination of connected and automated driving, like truck platooning, highway pilot or last-mile rapid personal rapid transit systems.

  New applications and services is an area where members of this Task Force can provide relevant input. They can support industry in the definition of new apps and services and identify future requirements applicable to other areas.

- **Design and implementation**

  The ever-increasing complexity of new vehicle technologies calls for improved design paradigms and evolved implementation paths throughout all the value chain: from materials producers, to components manufacturers and vehicle integrators, from certification and regulation to public expectation management. More and more, well-established automotive design and testing methods are underpinned by Model Based Design and Hardware-in-the-loop simulation, all the way to Big Data and AI.

  The members of this Task Force can provide a breadth of expertise and knowhow during the design and implementation phases of current and new automotive technologies.

- **Verification and Validation (V&V)**

  This is also the natural field of action of the members of the TF ECS. Verification and validation activities are typical activities, which are subcontracted to research centres or engineering companies, and this is the core field of activity of many of the members of this Task Force. Partners can bring expertise in these fields and are involved in the development of new concepts, techniques and procedures for verification and validation purposes of ECS and system-of-systems that take into account new enabling technologies and tools (e.g. Artificial Intelligence, Big Data, OTAs). This new technologies and tools, although promising, also introduce uncertainties in the V&V process. Functional Safety and Cybersecurity have to be considered also as it is a requirement for the next generation vehicles. Harmonization at European level should be fostered from a technical point of view in order to maximize the smooth and safe deployment of new vehicles, application and services.

Key research needs
Concerning the topic of ECS, EARPA stresses the importance of further research and development on the following elements:

1. ***Adaptive services and tools for dynamic management of automotive control systems***
2. ***New enabling technologies and concepts for Connected and Automated driving***
3. ***Techniques for the development, integration and testing of the upcoming generation of vehicle electronics***

Research priorities in the field of Electronics and Communications

According to their capabilities, the members of the Task Force have identified the following priorities:

1. Adaptive services and tools for dynamic management of automotive control systems

The successful adoption of cooperative telematics applications requires adaptive middleware (services and tools) to facilitate application management (customization, configuration, assurance, and diagnostics).

Automotive control systems rely on multiple (dozens, and sometimes hundreds of) independent software components that communicate, locally or remotely via a network (e.g. CAN, FlexRay, Ethernet). They must adhere to strict real-time performance constraints and gracefully handle error conditions; their behaviour must remain reliable under all conditions and they are often reused in various circumstances.

While the real-time, robustness and reliability constraints remain a major concern for controlling automotive systems, one of the strategic challenges today is to manage the interactions between the fast growing number of components (with and without real-time constraints). This is extremely complicated because of (1) the strict assurance levels that must be guaranteed with respect to real-time performance/resource constraints, robustness and reliability, (2) the wide variety of configurations that must be enforced throughout the distributed embedded control system, and (3) the need for software (re)deployment to update, upgrade, or extend functionality during the system's lifetime.

Key research activities:

- To address (evolving) requirements and expectations of multiple application (service) providers (OEMs, Tier-1 service providers, communication operators);
- To design and develop services for:
    - diagnostics and monitoring, e.g. collecting data samples and assessing system behaviour by recognizing generic patterns and applying associated metrics
    - distributed service provisioning, e.g. enforcing system behaviour by remote deployment of components and monitoring probes;
- To design and develop configuration tool chains that are able to:
    - specify and collect application goals concerning structural (composition) as well as behavioural aspects (real-time requirements, quality guarantees); the application's functional and non-functional specification, as well as the different configurations are captured by models
    - resolve these independent goals into a coherent application composition that can be deployed onto a network of embedded control systems
    - validate adaptive system behaviour and forward system feedback into the configuration tool chain;
- To open a gateway to connected/cooperative systems including vehicle to vehicle (V2V), vehicle to infrastructure (V2I) and others (i.e. vehicle to pedestrian)
- To define, specify and implement a standard for a Co-operative Mobility Device platform and its communication protocols (e.g. 802.11p, 2/3G, LTE, 5G, etc.) and interfaces in co-operation with OEM's and standardization bodies

2. *Enabling technologies and concepts for Connected and Automated driving*

Future vehicles will be more and more equipped with automated driving functions. While the driver is still responsible and in control today, SAE Level 3 will deploy overtaking systems, in which the e.g. imperfect, young or aged, distracted driver is partly or fully overruled by the automated vehicle. SAE Level 4 systems will hugely increase this automation and should be able to cope with a growing number of driving situation without the driver intervention.

Automated driving could help to reduce the amount of accidents and the impact thereof, to increase the throughput on highways and in the end it could allow the driver to spend his or her time differently from being responsible to drive the vehicle from A to B. Besides legal, liability and human driver aspects, many technical issues need to be solved regarding reliability and robustness of control, actuation systems, sensor and positioning devices. Typical applications / use cases (as identified in ERTRAC roadmap) are truck platooning, highway pilot, automated valet parking and urban automated transport of goods and people.

Key research activities are:

- Control units: Real Time Operating systems (multi core solutions) need to be defined, specified and implemented, which must be capable of processing enormous amounts of data and signals, supported by fault-tolerant and graceful degradation techniques. Units must be cost effective, while meeting reliability, accuracy and security requirements.
- Sensor systems: automotive sensors present a trade-off between number (and type) of devices and the level of awareness of the vehicle. At vehicle level the challenge on environment monitoring (e.g. obstacle detection, movement prediction…) remains a priority with a need of increased accuracy, reliability and coverage while minimising production costs. At smart city level (an Internet of Things environment with smart infrastructure and smart vehicles) information might be provided by trustworthy data providers or other vehicles. The continuous development of Artificial Intelligence techniques in the field of data fusion will support transportation need (in terms of safety, security…).
- Positioning: the specific use case determines the requirements (e.g. accuracy and update rate) of the positioning system. E.g. parking (low speed) is different from safety pull over at a highway. Different Global Navigation Satellite Systems (GNSS) are available such as GPS, GLONASS, EGNOS and RTK GPS in a mature state, and the final deployment of Galileo ready to be a reality, each of them with their own specific characteristics and costs. Again, accuracy and reliability must be increased, while a decrease of costs of high performance GNSS is needed. The use of GNSS positioning for connected and automated vehicles will also require of research in terms of authentication, integrity and security (i.e. anti-spoofing) in order to become a reliable source of information for these vehicles. Hybrid augmentation (enhanced positioning through the use of satellite information together with other sensors as camera or lidar) has the potential to enable high accuracy positioning and leverage the electronics horizon for ADAS and AD systems. New augmentation or positioning techniques (i.e. SLAM) are key for the development of CAV services without direct line of sight with satellites.
- Cybersecurity must be addressed from the design stages in order to maximize security and minimize the impact of attacks to the vehicle in terms of safety and privacy.
- New mobility concepts: Automated driving may support advanced mobility services as car or ride sharing enhancing road public/private transport capillarity and enabling new business models (e.g. new car ownership schemes).
- New methodologies and tools that enable higher levels of automation must be mastered in order to avoid uncertainties or risks and leverage its benefits. AI, deep learning or Big Data must be correctly developed and integrated in ECS but also robustly verified and validated before road deployment.
- With the advent of new, more complex and highly-integrated automated driving features and systems, the confidence on the reliability of the whole system built upon the accumulation of millions of driving miles is no longer sustainable, nor even feasible. New approaches like driving thousands of smart miles, both in real-world and in simulation, are deemed as a must in order to timely get up to acceptable levels of confidence on these new technologies.

3. Techniques for the development, integration and testing of the upcoming generation of vehicle electronics

The goal of the automotive industry is to achieve 100% reliability of electronic components, although in reality this is never achieved. Durability of these components are also directly related to reliability and, as more and more electronic components depend on each other (in terms of connectivity), it becomes imperative that better techniques are devised for verification and validation at component and vehicle level.

As the automotive industry increasingly relies on electronic systems, these systems become responsible for the safety of the passengers. Traditional verification and validation techniques, where the functionality of the system is usually tested, might not cover the full range of hazardous scenarios required for the system. Therefore, it is also necessary to include novel techniques in order to validate the safety requirements of those systems. Simulation and scenario based verification and validation allows virtual testing of ECS in a cost-time effective way but need to be developed in order to demonstrate its correlation with real physical tests.

In addition to that, as the number of electronics increases, the communication systems' bandwidth becomes limited. Therefore, newer communication protocols will become necessary (e.g. FlexRay or Ethernet as a possible replacement for CAN). The validation of these more complex networks will require additional efforts and more formal methods.

Key research activities:

- Standardisation of the processes of bench validation, integration validation and full vehicle validation in combination of numerical models, simulations and statistical methods. Analysis of the feasibility of whole vehicle electronics simulation techniques for validation purposes.
- Standardisation of Software and Hardware in the Loop techniques
- Analysis of the validation vs quality ratio. Identification of a minimum set of tests which provide a great portion of estimation of the quality in an evolving, mixed environment with a gradually penetration of connected and automated vehicles
- Electromagnetic Compatibility (EMC) and Functional Safety: identification of techniques for risk analysis and minimum set of tests to guarantee the safe working over the whole lifetime of the vehicle, including the aging of the electronics
- Accelerated testing under combined electrical and mechanical loading (e.g. vehicle sensors)
- Analysis and standardisation of "Highly Accelerated Lifetime Testing" or "Multi-Environmental Overstress Testing" techniques to optimize the reliability of the electronics early in the design cycle
- Roadworthiness of the (automated) vehicle or feature in relation to functional safety of its Hardware / Software components and Safety of the Intended Function
- Cybersecurity including both external (V2X) and internal connectivity (between ECUs) and data
- Linking personal sensing with vehicle sensing (e.g. adapting vehicle cruise based on a person profile)
- Privacy protection aspects, respecting the EU data protection regulations

Expected impact

1. Industrial impact :
    a. Europe as the leading automotive technology provider
    b. Improve added value of European automotive industry
    c. Supporting EU's strategy (Europe 2020) on re-industrialisation of Europe
2. Societal impact of ECS innovation in the European automotive sector

The EC in its White Paper "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" [1]defines the mid and long term objectives in 2050, mainly, reduction of up to 60% of GHG emissions and the Zero fatalities vision, which aims to minimize victims in European roads. To be able to reach these objectives, Electronics and Communications are a fundamental key technology enabler to succeed. Among other figures

- Safety: 90% of the accidents are caused by human or driver behavioural errors. ECS enables ADAS and C & AD functions that increase comfort and thus safety for our drivers as well as other VRUs.
- Decoupling of GDP growth and mobility congestion/safety: 1% of European GDP is lost because of traffic congestion. Investment in new automotive solutions rather than new roads, through new ECS that will enable advanced seamless, multimodal, door-to-door mobility.
- New mobility concepts and business models as Mobility as a Service, last mile automation which have the potential to define new ownership concepts and are bases in ECS.
- Improved productivity of European citizens thanks to the enhancement of public transport modes and the introduction of new paradigms i.e. highly automated driving, together with better health and life quality for the elder and impaired.
- Impact on the CO_2 and GHG emissions as well as carbon footprint of transport systems aligned with the European goals for 2050: ITS, ICT enhanced EVs, IoT, efficient automated functionalities (e.g. C-ACC) will support the reduction of the dependence on fossil carbon fuels and the migration to new, alternative fuels.

Maintain and increase the leadership of European automotive industry and thus create qualified jobs in Europe. The transport industry in itself represents an important part of the economy: in the EU it directly employs around 10 million people and accounts for about 5% of GDP.

Relation to other roadmaps

The industry and policy makers have already defined several roadmaps in which they describe a certain timeline for the market introduction of different services, applications and functionalities. These milestones require mature, reliable and affordable technologies which have been field of study through different R&D projects.

EARPA members can provide expertise in the whole value chain at different TRLs and can be valuable assets to the industry in order to develop the technologies from level 1 up to 9.

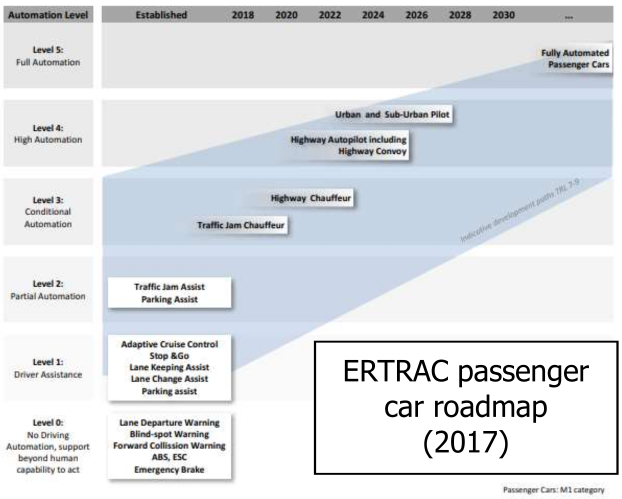
Among the different roadmaps available in the EARPA TF ECs has identified some of them as the most relevant:

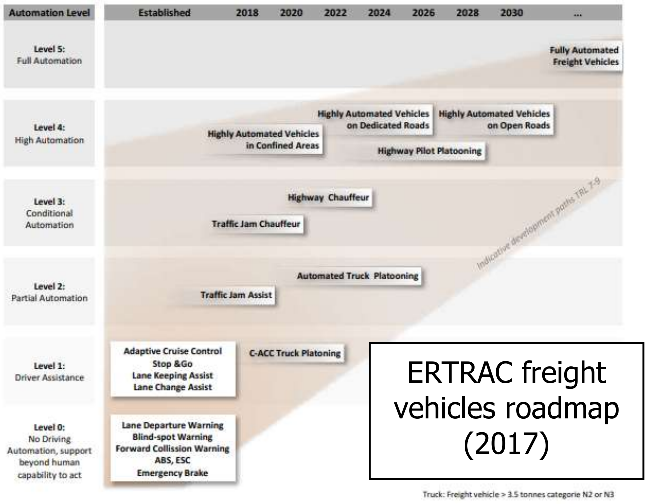
1. ERTRAC[2]

ERTRAC has published and periodically updates a roadmap for the gradual introduction of connected and automated driving function into the market (towards full automation), taking into account urban mobility, passenger and commercial vehicles, and mapping levels of automation with functions.

[1] http://ec.europa.eu/transport/themes/strategies/

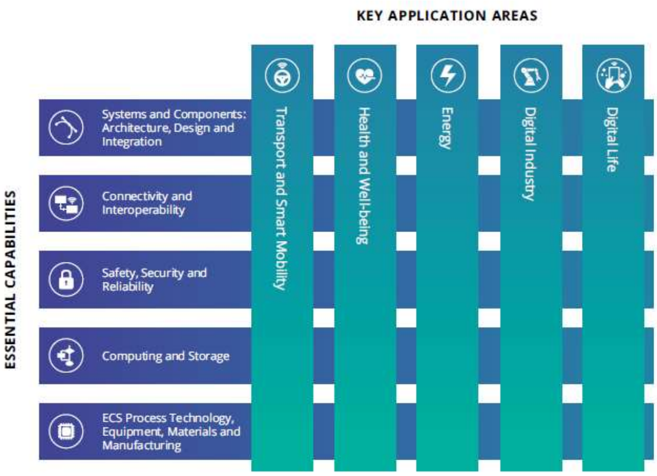
[2] http://www.ertrac.org/uploads/documentsearch/id48/ERTRAC_Automated_Driving_2017.pdf





ERTRAC and the AWG have also defined different challenges to enable automated driving in our roads, with a great relevance of electronics and communications developments.

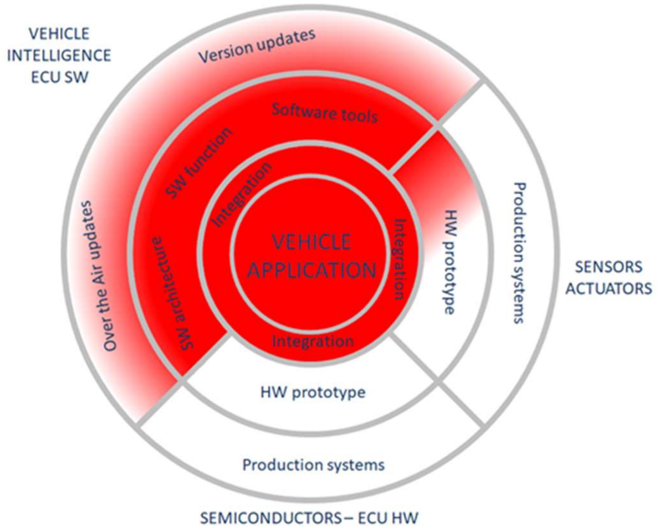
2. *ECSEL program research strategy agenda*[3]



The ECSEL JU program (Electronic Components Systems for European Leadership) offers funding for Research, Development and Innovation projects with systemic and strategic impact for smart, sustainable and inclusive economic growth. To do this, they have defined 5 key applications that are supported by 4 essential capabilities. Each of them has a different roadmap in which the TRL is defined.

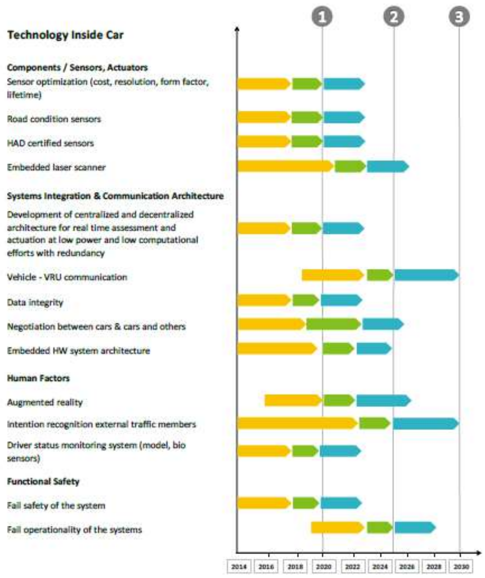
EARPA traditional role is strongly associated to the Transport and Smart Mobility Key Application Area, however, the capabilities of EARPA partners regarding the defined Essential Capabilities can also support many of the other areas.

[3] https://ecscollaborationtool.eu/publication/download/ecssra2018.pdf



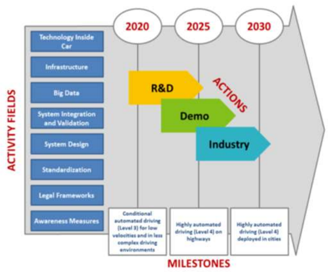
Although a research partners association, EARPA and the TF-ECS can play a relevant role in the ECSEL program projects, providing expertise from lower to higher TRL levels and support the industry in the whole process: from the design and implementation of vehicle and mobility based applications to the development of associated services and tools that surround the intelligent vehicle ecosystem.

3. *EPoSS roadmap*[4]



The Working Group Automotive of the European Technology Platform on Smart Systems Integration (EPoSS) in January 2015 published a European Roadmap on "Smart Systems for Automated Driving".

Based on surveys and consultations among major companies from the European automotive and electronics industries and relevant research institutes, the roadmap reveals the importance of ECS R&D efforts in in-car technologies during the next decades.



[4] http://www.smart-systems-integration.org/public/news-events/news/eposs-roadmap-smart-systems-for-automated-driving-now-published

EARPA TF-ECS and expertise in the future RTD needs of Europe

EARPA TF-ECS together with the other task forces, provide an extensive knowledge in RTD ready to successfully solve the challenges identified by different roadmaps and pave the way to the benefits of ECS in the automotive industry.

Identified challenges	EPoSS	ERTRAC/AWG	ECSEL	TF ECS expertise
Data Security	X	X	X	x
Big Data	X	X	X	x
Legal issues	X	X		
Liability	X	X		
Safety, reliability & Robustness	X	X	X	x
Energy efficiency	X		X	x
Economic aspects & industrialisation	X	X	X	x
Validation and testing aspects	X	X	X	x
Ethics	X			x
Perception	X	X	X	x
Demonstrations & FOTs		X	X	x
User and societal acceptance		X		x
HMI & Human Factors		X		x
Infrastructure requirements		X	X	x
Standardisation	X	X	X	x

The EC, through the past Framework Programs and the ongoing Horizon 2020, supports R&D in Europe in order to help its industry and academia to maintain its leading position in the automotive industry worldwide.

Conclusion

The design, testing, validation and implementation of reliable, functionally safe and secure Electronics and Communication Systems will play a dominant role in the successful deployment of Connected and Automated driving systems in Europe. The TF ECS is ready to support the deployment, addressing the underlying challenges as stated in this position paper.

For further information, please contact our contact persons of the Task Force ECS:

Contact

TF ECS Chairman
Álvaro Arrúe
E: alvaro.arrue@idiada.com
T: +34 977 189360

TF ECS Secretary
Bastiaan Krosse
E: bastiaan.krosse@tno.nl
T: +31 888 66 53 96

More information at our website: www.earpa.eu