BRTA
BASQUE RESEARCH & TECHNOLOGY ALLIANCE

SUSTAINABLE AND INTELLIGENT MOBILITY

THE BRTA RESEARCH AGENDA

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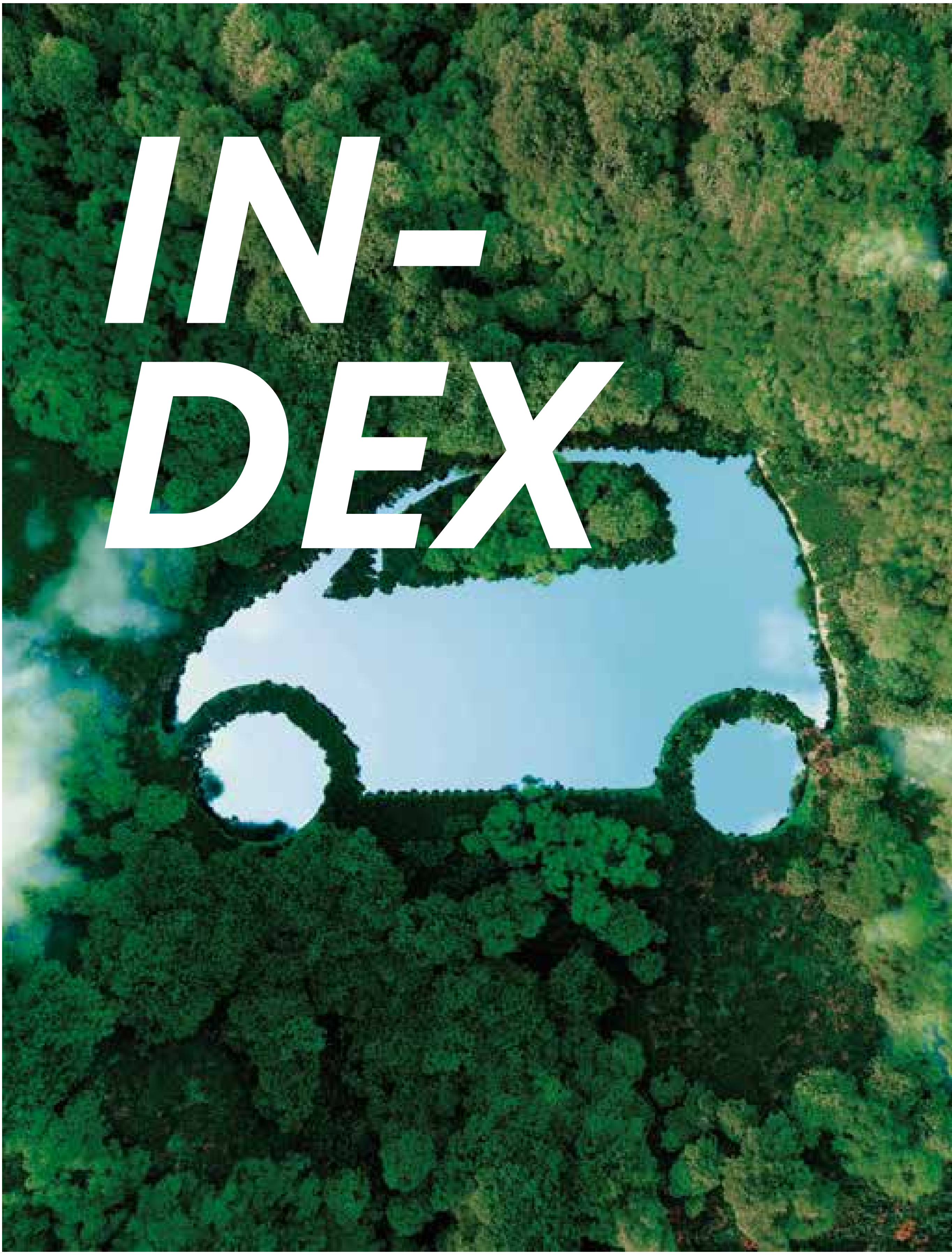
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BRTA
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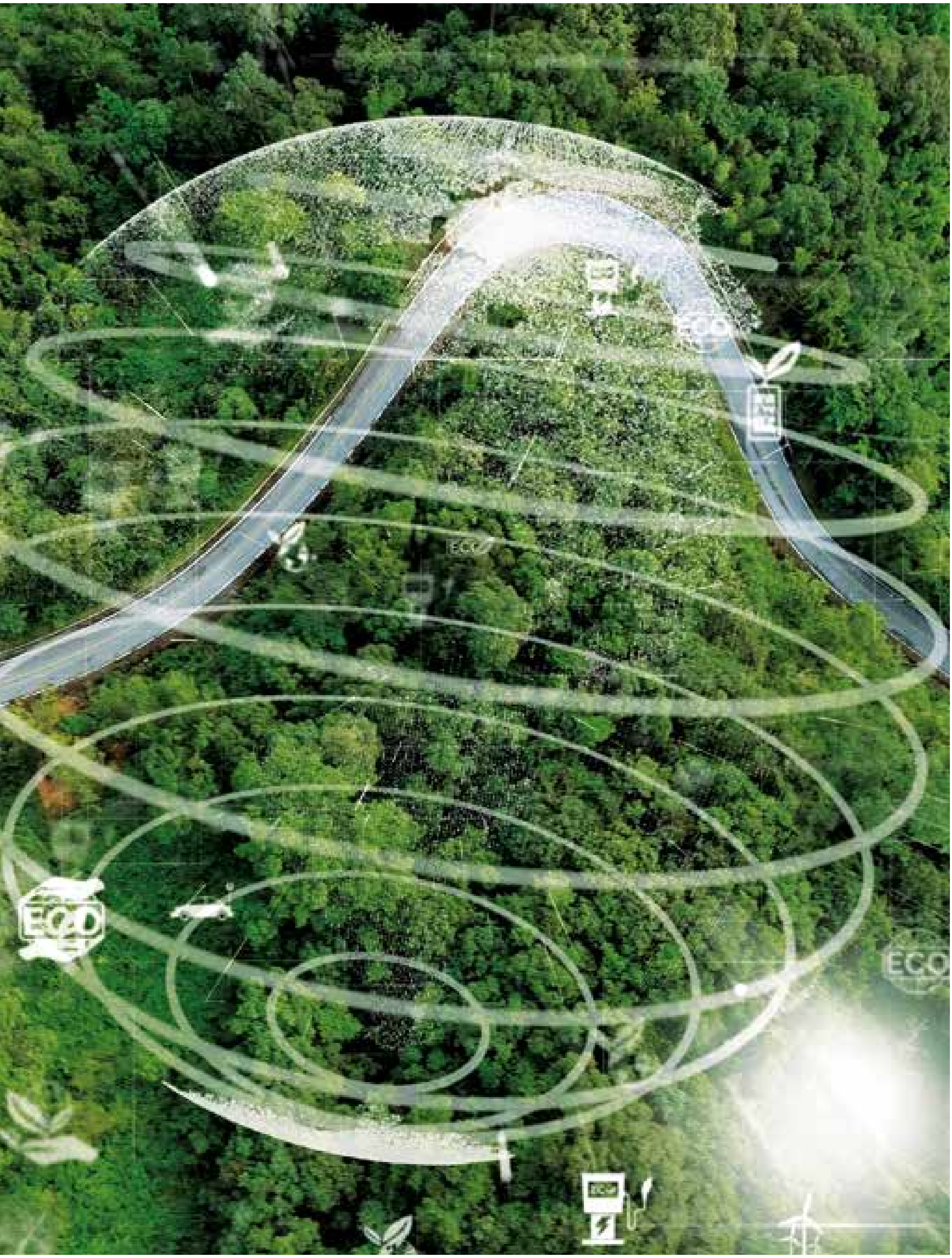
ALLIANCE

01

INTRODUCTION AND GLOBAL CONTEXT



01 INTRODUCTION AND GLOBAL CONTEXT

This document addresses the general challenge of achieving sustainable mobility of people and goods, establishing a technological roadmap for BRTA based on the capabilities and experience of its centres to respond to this challenge and taking into account the potential of the business fabric of the Basque Country and the opportunities that present themselves for its development and international competitiveness.

Mobility brings numerous socio-economic benefits, but it is not without costs to the environment and to our society.

Key objectives of the sustainable mobility challenge

The transport sector contributes 5% to European GDP and directly employs around ten million workers, and while **mobility brings numerous socio-economic benefits, is not free of**

environmental and societal costs. These include greenhouse gas emissions, air, noise and water pollution, but also traffic accidents, congestion and loss of biodiversity, all of which have an impact on our health and well-being.

Therefore, the overall challenge of sustainable mobility encompasses two very ambitious fundamental objectives: European climate neutrality by 2050 and safety, aiming to reach what is known as "Vision Zero" fatalities on European roads by 2050.

Climate neutrality

The EU is committed to achieving climate neutrality by 2050. To achieve this, the transport sector must experience a transformation that will require a 90% reduction in greenhouse gas emissions, while ensuring affordable solutions for citizens. Today, the transport sector remains the second largest emitter of greenhouse gases (GHG) after the energy sector, producing more than 20% of emissions across Europe.

In this context, the European Commission presented in July 2021 the **«Target 55»** package of measures, which is the EU's plan to meet the climate targets of the European Green Pact.

Such measures include the revision of EU legislation in the field of transport, the Commission proposed to extend the emission reduction target to 55 % for passenger cars and 50 % for vans from 2021 levels by 2030; it further proposed to set a 2035 target of 100 % for both passenger cars and vans; the new rules will also require manufacturers of trucks and other heavy-duty vehicles to reduce CO2 emissions from new vehicles from previously adopted limits in 2019.

The reduction of CO2 emissions requires the widespread implementation of low-emission and zero-emission vehicles in all modes of transport, which must be accompanied by the creation of a global network of recharging and refuelling infrastructures.

Security - "Vision Zero"

As far as road safety is concerned, the EU's commitments have been fleshed out in the document EU Road Safety Policy Framework 2021-2030. Next Steps towards 'Vision Zero', stating that the «Vision Zero» mindset must take root more than it has so far, both among policy makers and in society at large. The document also discusses trends in mobility and road safety to be expected for the decade (such as automation, collaborative economy or new forms of personal mobility) and the special attention to be paid to people with reduced mobility and those over 64 years of age.

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Recently, changes in traditional forms of mobility and the emergence of new ones have been observed, mainly in urban environments.

Trends

The evolution of mobility to be expected in the coming years will depend not only on endogenous factors associated with specific policies defined by public administrations, but also on exogenous socio-economic and technological trends in the field of mobility. These trends include the following:

- Aging population: A trend fully present in our society in recent years, whose impact on road safety was already contemplated in the Road Safety Strategy 2011-2020, but whose magnitude is growing over time. It is therefore a challenge to safely meet the mobility needs of the growing population of older people, in all their forms of participation.
- Increasing urban population and rural depopulation: From the point of view of road safety, this poses two challenges. On the one hand, safe travel in urban areas, with increasing mobility needs and the emergence of new forms of mobility that attempt to respond to these needs. On the other hand, the safety of travel in rural areas, which are becoming increasingly depopulated and where the incidence of population aging is even greater, and where most journeys are made on conventional roads.
- New forms of mobility: For some time now, changes in the forms of mobility have been observed, mainly in urban environments

and the emergence of new ones. As a result, there is a growing heterogeneity in traffic, with types of vehicles with very different masses, speeds and vulnerabilities. This reality presents the challenge of ensuring the safe coexistence of all means of mobility.

- The culture of young people: This is another factor to be clearly considered, because it marks the future in the short and medium term. Young people are committed to pay-per-use, sharing, sustainability, multimodal mobility and the use of smartphones to consult and contract mobility-related services. In other words, some of the above trends are particularly accentuated in this group; therefore, it is to be expected that these trends will increase in importance soon.

- Road safety in organizations: Public administrations and private entities have an enormous influence on society, which should have an impact on improving road safety. Directly, by promoting road safety in their workforces, customers or suppliers; and indirectly, by adopting road safety criteria in their value chains and in their purchasing decisions for goods and services.

- Technological advances both in infrastructures and traffic surveillance and management systems, as well as in vehicles: The integration of these advances aims to reduce the accident rate attributable to errors and risky behaviour, although it poses the challenge of doing so adequately to increase safety, ensuring that new risks are not being indirectly created thereby, such as a possible increase in distractions associated with new communication systems.

The strategies adopted in Europe and in representative countries such as the United States and Japan in relation to the general challenge of sustainable mobility are presented below.

Young people are committed to pay-per-use, sharing, sustainability, multimodal mobility and the use of smartphones to consult and contract mobility-related services.

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1.1 European strategy for sustainable and intelligent mobility

Europe has defined a strategy that establishes a roadmap to put European transport on the path to a sustainable and intelligent future. To this purpose, 10 emblematic areas have been identified with an associated action plan that will coordinate actions in the coming years. The plan includes concrete actions and policy measures to achieve the goal of a 90% reduction in emissions from the transport sector by 2050. The strategy sets out several milestones to achieve this goal. Thus, it is expected that:

In 2030

- At least 30 million zero-emission vehicles will be on European roads.
- 100 European cities will be climate neutral.
- High-speed railway traffic will be doubled.
- Scheduled collective journeys of less than 500 km will be carbon neutral within the EU.
- Automated mobility will be implemented on a large scale.
- Zero-emission ships will be market-ready.

In 2035

- Possible prohibition, new vehicles coming on the market from 2035 onwards will not emit CO2*.
- Large zero-emission aircraft will be ready for the market.

In 2050

- The entire road transport sector will be carbon neutral.
- Almost all cars, vans and buses, as well as new heavy-duty vehicles, will be zero-emission.
- Freight rail traffic will double.
- High-speed rail traffic will triple.
- The multimodal Trans-European Transport Network (TEN-T) equipped for sustainable and intelligent transport with high-speed connectivity will be operational for the entire network.

The action plan of this European strategy is structured around the following 10 flagship initiatives:

1. Promote the adoption of zero-emission vehicles, renewable and low-carbon fuels and related infrastructure and related infrastructure.sostenible y saludable.

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* https://www.europarl.europa.eu/topics/es/article/20221019STO44572/la-prohibicion-de-vender-nuevos-coches-de-gasolina-y-diesel-a-partir-de-2035

2. Create zero-emission airports and ports.
3. More sustainable and healthier interurban and urban mobility.
4. Greener freight transport.
5. Carbon pricing and better incentives for users.
6. Making connected and automated multimodal mobility a reality.
7. Innovation, data and artificial intelligence for smarter mobility.
8. Strengthening the single market.
9. Fair mobility for all.
10. Improve transport safety.

Of this set of flagship initiatives, the following are those that will be addressed in this document and that will require innovation and research to achieve their objectives.

1.2 Mobility research needs for Europe

Regarding the priority initiatives of the previous section, this White Paper will not consider the priorities that refer to aeronautics or that have legislative aspects or that are only related to legislative aspects and are the following:

2. Create zero-emission airports and ports.
5. Carbon pricing and improved incentives for users.
8. Strengthening the European single market.

The following are the remaining initiatives that are of interest.

1.2.1 Zero-emission vehicles

In order to achieve the targets presented in the 2030 Climate Target Plan and to be on a clear trajectory towards zero-emission mobility from 2025, the EC has proposed a revision of the CO2 standards for cars and vans in June 2021. The Commission will also review the CO2 standards for heavy duty vehicles in this regard.

Different European initiatives, such as «Batteries Europe», «2Zero» y «Clean Tech Europe», contribute to the supply of technologies for zero-emission vehicles. In the case of road transport, zero-emission solutions are already being deployed. Today, manufacturers are investing in the development of battery electric vehicles. Commercial uptake is growing, especially for cars, vans and buses used in urban areas, while trucks and coaches are starting to take off.

Manufacturers are also investing in hydrogen fuel cell vehicles, particularly for use in commercial fleets, buses and heavy transport. These promising options are supported by the EU strategies for energy and hydrogen system integration, as well as the Strategic Action Plan for Batteries. Energy efficiency must be a criterion for prioritizing the future choice of appropriate technologies on a full life-cycle basis. Transitional technology solutions must fully comply with CO2 and pollution standards.

As noted, significant efforts have been made in recent years to reduce emissions of air pollutants from motor vehicles. However, many activities remain to achieve such ambitious goals and with significant research needs.

1.2.2 More sustainable and healthy interurban and urban mobility

The EU presented in December 2021 its new Urban Mobility Framework to establish European guidelines on how cities can reduce emissions and improve mobility. This will benefit a large majority of users, considering that more than 70% of the EU population currently lives in urban environments.

1.2.3 Greener Freight Transport

Multimodal logistics must be part of the transformation of freight transport, within urban areas and beyond. The growth of e-commerce has significantly changed consumer habits, but the external costs of millions of deliveries must be taken into account, including the reduction of unladen and unnecessary journeys. Consequently, sustainable urban mobility planning must also encompass the freight dimension through specific sustainable urban logistics plans. Such plans will accelerate the deployment of already available zero-emission solutions and research into more efficient and sustainable freight delivery.

1.2.4 Making connected and automated multimodal mobility a reality

La UE debe aprovechar al máximo las soluciones digitales inteligentes y los sistemas de transporte inteligentes (ITS). Los sistemas conectados y automatizados tienen un enorme potencial para mejorar fundamentalmente el funcionamiento de todo el sistema de transporte y contribuir a los objetivos de sostenibilidad y seguridad. Las acciones se centrarán en apoyar la integración de los modos de transporte en un sistema multimodal que funcione.

Europa debe aprovechar las oportunidades que ofrece la movilidad conectada, cooperativa
The EU must take full advantage of intelligent digital solutions and intelligent transport systems (ITS). Connected and automated systems have enormous potential to fundamentally improve the performance of the entire transport system and contribute to sustainability and safety objectives. Actions will focus on supporting the integration of transport modes into a functioning multimodal system.

Europe must take advantage of the opportunities offered by Connected, Cooperative and Automated Mobility (CCAM). CCAM can provide mobility for all, improve road safety and make transport and mobility more efficient. The Commission drives through the CCAM Partnership and through other partnerships focused on digital technologies. These partnerships are important in developing and implementing a shared, coherent and long-term European research and innovation agenda, bringing together actors from across the value chain. The EU must ensure that efforts are well coordinated and that results reach the market. For example, the lack of harmonization and coordination of relevant traffic rules and liability for automated vehicles needs to be addressed. The vision is to make Europe a world leader in the development and deployment of CCAM services and systems and thus make a significant contribution to European leadership in safe and sustainable road transport.

Promoting research into solutions that allow for new, affordable and accessible mobility in all regions and for all passengers, including those with disabilities and reduced mobility.

1.2.5 Innovation, data and artificial intelligence for smarter mobility

The EU must ensure the highest level of performance of digital infrastructures, through 5G, which offers a wide range of services and helps to achieve higher levels of automation between different mobility applications. On the other hand, it is necessary to achieve connectivity with seamless coverage across major transport corridors throughout Europe with 5G connectivity infrastructures.

Artificial intelligence (AI) is becoming fundamental to transport automation in all modes and digital components and technologies are at the heart of it. From Europe, regulations on artificial intelligence have been proposed defining sectors where the application of AI such as automated driving is critical.

The digital transformation of the transport and mobility sector requires addressing aspects related to data availability, access and exchange. In Europe, the construction of a common European mobility data space is to be proposed. This will consider cross-cutting governance and data standards, as well as the principle of technological neutrality. The aim is to collect, connect and make data available to achieve EU objectives, from sustainability to multimodality.

Since access to vehicle data will be critical to the exchange of data related to transportation and intelligent mobility, research into secure and quality information sharing is needed.

1.2.6 Fair mobility for all

The economic crisis has shown the need for affordable, accessible and fair mobility for passengers and other users of transport services. Research into solutions that enable new, affordable and accessible mobility is promoted in all regions and for all passengers, including those with reduced mobility.

1.2.7 Improve transport security (Safety&Cybersecurity)

Europe remains the safest transport region in the world. However, in 2019, approximately 22,700 people lost their lives on EU roads, and for every person killed, around five more suffer serious injuries with lifelong consequences. The EU has therefore defined its 2018 road safety strategy. From a research point of view, it is worth highlighting the need for design, validation and certification aspects of automated vehicles in the dimensions of functional safety and cybersecurity by integrating reliable artificial intelligence solutions.

1.3 Context in the rest of the world

This section describes the strategies adopted by the United States and Japan, selected because they are two of the most representative countries in relation to the challenge of the transition to a future sustainable mobility.

1.3.1 United States

In September 2022, the heads of the Departments of Energy, Transportation, Housing and Urban Development, and the Environmental Protection Agency signed a historic memorandum of understanding (MOU) to enable the four federal agencies to accelerate the nation's clean, affordable, and equitable transportation future. The MOU called for the agencies to publish a comprehensive strategy for decarbonizing the transportation sector that would help guide future policy decisions, as well as research, development, demonstration and deployment in the public and private sectors.

The different federal agencies have released the National Plan for Decarbonizing U.S. Transportation, an interagency framework of strategies and actions to eliminate all emissions from the transportation sector by 2050. The Plan provides a whole-of-government approach to address the climate crisis and meet the overarching goals of a 100% clean electric grid by 2035 and zero net carbon emissions by 2050.

The actions in that strategy are similar to those in Europe and identify that, the widespread use of connectivity and automation will dramatically change future mobility in ways that are difficult to foresee. Policies and technology solutions can leverage these changes to improve safety, comfort and affordability and enable more efficient mobility while helping to avoid the risk of increased travel. Transportation systems must be flexible enough to adapt to new technologies and unforeseen changes in mobility.

1.3.2 Japan

Japan is facing challenges such as declining birth rate, aging population, energy and environment. The Japanese government is working on a blueprint for "Society 5.0," a social system that solves or mitigates these problems using IoT (Internet of Things), AI and robotics technologies. Solving problems in the transportation sector is also on the agenda.

The creation of next-generation mobility systems is one of the flagship projects that must be addressed to make "Society 5.0" a reality.

The creation of next-generation mobility systems is one of the flagship projects that need to be addressed to realize "Society 5.0". The Japanese government is promoting institutional development, technology development, and demonstration projects with attached key performance indicators (KPIs), such as the unmanned automated driving transportation service on public roads in limited areas. Automated driving is expected to contribute to safer and smoother road transportation, where more people can travel comfortably, and to the improvement of industrial efficiency and related industries.

In addition, the "Reform 2020" strategy of public-private projects to accelerate growth (within the framework of Japan's revitalization strategy), includes the "Use of new generation mobility systems and automated technology" among the government's priorities for demonstration of specific projects.

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1.4 Context in the Basque Country

Law 11/2023 on sustainable mobility in the Basque Country, published in November 2023, establishes the principles and objectives to which the transport of people and goods must respond in order to achieve the integral development of sustainable, healthy and safe mobility from the social, economic and environmental perspectives, in line with European policies and guidelines. These principles include the prioritization of means of transport with lower environmental costs and the application of new technologies and innovation in the service of transport.

In this sense, in the Basque Country, electric mobility has experienced significant growth in recent years, supported by initiatives of the different administrations and the commitment of all stakeholders to sustainability. Among the different strategic initiatives, the “Basque hydrogen strategy” and the “Basque electric mobility strategy” should be highlighted. Likewise, in the Basque Country there are several infrastructures and initiatives related to the new electric, sustainable, cooperative, connected and autonomous mobility.

1.4.1 Basque hydrogen strategy

The objective of the Basque Hydrogen Strategy is to establish the guidelines to promote the creation of a hydrogen ecosystem based on the **production of renewable hydrogen and on storage, transport and distribution** infrastructures that support the local market and serve as a basis for establishing a logistics center with relevance in the international export market. This will represent an opportunity for decarbonization for the Basque industry and, at the same time, for industrial development to position itself as an exporter of technology.

1.4.2 Basque electric mobility strategy

This strategy was developed with the collaboration of different agents through meetings where the different areas of electric mobility were analysed. Contact has been maintained with recharging service companies, the municipal administration, clusters, vehicle commercial networks, associations of property administrators, automotive manufacturers and fleet operators, among others.

The Basque electric mobility strategy was developed with the collaboration of different agents through meetings where the different areas of electric mobility have been analysed.

Aligned with other initiatives such as the “Klima 2050 Strategy”, “Basque Country Energy Strategy 2030” and the “Sustainable Transport Master Plan”, this initiative proposes specific objectives for 2030 in 3 of the 4 axes in which it will develop its action plan:

• **AXIS 1 Electrification of mobility.**

- 16% of the vehicle fleet, electrified.
- 50% of urban buses, electrified.
- 80% of cab fleets, electrified.

• **AXIS 2 Implementation of recharging infrastructure.**

- To double the number of fast charging points in the Basque Country: 80 charging points of 50 kW.
- 12 sites with ultra-fast charging terminals.

• **AXIS 3 Technological and industrial development.**

- 15 electric mobility projects in the Basque automotive sector, driven by private initiative and supported by the Basque Government.
- 10 projects of a marked technological nature in the field of electric vehicle recharging, driven by private initiative and supported by the Basque Government.

• **AXIS 4 Policy coordination and regulatory framework.**

The achievement of these objectives will require an investment agenda to be led by private agents and a strong commitment from all levels of government:

- To promote the acquisition of electric vehicles, covering the additional costs required by this technology, an investment of between 1,000 and 1,500 million euros is estimated.
- To promote fast and ultra-fast recharging infrastructures, an investment of 300 to 500 million euros is estimated.
- To boost technological and industrial development, it is estimated that between 250 and 340 million euros will be needed.
- For cross-cutting aspects, such as regulatory adjustments or education and awareness-raising actions, between 1 and 2 million euros will be required.

1.4.3 Basque Country strategic initiatives and infrastructures related to new mobility

There are several initiatives in the field of the creation of experimentation spaces led mainly by the 3 Provincial Councils.

. Bizkaia Connected Corridor (BCC)

This is a public-private initiative - Provincial Council of Bizkaia and TECNALIA - to test, validate and demonstrate technologies related to Cooperative, Connected and Autonomous Mobility and Intelligent and Digital Infrastructures in a real scenario.

Bizkaia Connected Corridor makes available to the Basque industrial and research fabric the **1,200 km of roads in Bizkaia** with all their associated infrastructures: tunnels, viaducts, embankments, service roads, control centres, etc., to be used as a test laboratory for CCAM technologies and Smart and Digital Infrastructures, both physical technologies, linked to Materials, Resilience, Sustainability, etc., and digital initiatives, linked to Smart and Digital Infrastructures, to be used as a test laboratory for **CCAM technologies and Smart and Digital Infrastructures**, both physical technologies, linked to Materials, Resilience, Sustainability, etc., and digital initiatives, linked to artificial intelligence, Cybersecurity, Advanced Communications, Software Technologies, etc.

. Gipuzkoa Living Lab (GLL)

Gipuzkoa Living Lab has 3 main objectives: the creation of a real experimentation environment in which companies and technology centres can test their CCAM solutions in a real experimentation environment, the adaptation of road infrastructures to the mobility of the future and the creation of advanced mobility services for citizens. To this end, it provides the different agents with practically its entire road network, the necessary physical and logical infrastructure and the management and operation of the tests.

. Vitoria-Gasteiz Mobility Lab

Mobility Lab aims to identify and test innovative solutions in the field of urban mobility and logistics, taking advantage of the unique business and research ecosystem in Vitoria-Gasteiz and Araba. One of the strategic lines of the Mobility Lab is the creation of a living lab consisting of several regulated physical spaces for experimentation which simulate the test conditions of a laboratory in a real controlled environment and under regulations which allow it (regulatory sandbox). In this way, the aim is for different innovation agents (companies, research centres, universities, etc.) to design and test innovative solutions in the field of mobility and logistics. Specifically, six specific spaces are proposed for drones, autonomous and connected vehicles, last mile delivery, intelligent public transport, intermodal logistics and high-capacity roads. There are also other strategic initiatives in the Basque Country to promote collaboration and research in the field of electric and sustainable mobility:

. Mubil

New Mobility Hub of the Basque Country, which brings together the existing capacities in the territory and provides differential infrastructures to generate new opportunities in the field of intelligent and sustainable mobility through innovation and collaboration.

. BasqueCCAM

The BasqueCCAM association promotes the generation of an R&D and innovation ecosystem for the promotion of technologies and solutions for Connected, Cooperative and Autonomous Mobility (CCAM) in the Basque Country, with local, national and international projection.

There are several initiatives in the field of the creation of experimentation spaces led mainly by the 3 Provincial Councils.

. Industry eMobility

Gipuzkoa New Mobility Forum, made up of companies and organisations linked to the New Mobility sector and led by the Gipuzkoa Chamber of Commerce.

. Automotive Intelligence Center (AIC)

Global competence centre offering specialised infrastructures and a multidisciplinary workspace in the automotive field, including an Electrification Competence Centre (ECC).

. Basque Automotive Manufacturing Center (BAM)

Advanced automotive manufacturing research centre specialising in technologies for the development of electric vehicles and digital technologies. It is a public-private collaboration initiative, promoted by Mercedes-Benz, Gestamp and MB Sistemas de Corporación Mondragón.

. Basque Hydrogen Corridor (BH2C)

A public-private association in the Basque Country that promotes research and innovation activities in hydrogen technologies (production, infrastructures, distribution logistics, decarbonisation applications in industry and transport and other uses).

. Zirkular Bat

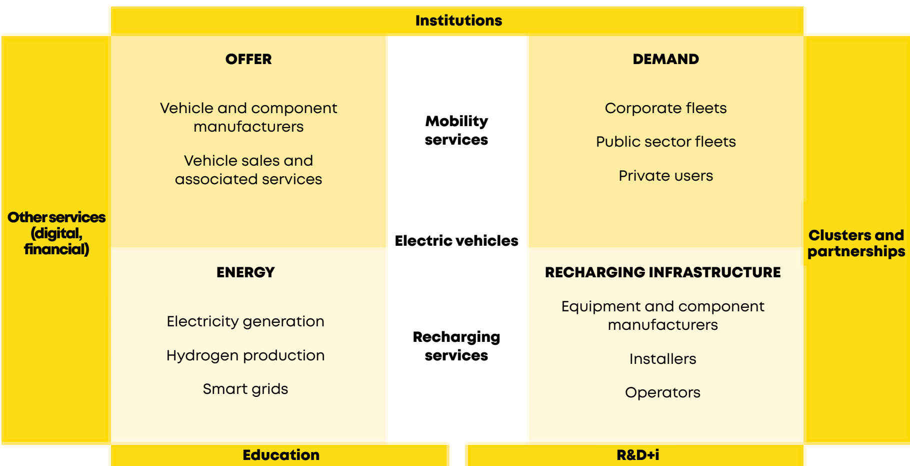
An initiative promoted by the Department of Sustainability of the Provincial Council of Gipuzkoa, the Naturklima Foundation and with the technical support of CIDETEC Energy Storage, it is a community of companies whose main objective is to stimulate and promote a circular battery ecosystem in Gipuzkoa, with a global scope. It carries out its work in an environment of public-private collaboration, led by actors from the local industrial environment, with a vocation to collaborate with driving companies from other territories.

1.5 Value chain and opportunities in the Basque Country

The strategies and initiatives described in the previous sections provide an invaluable framework for boosting the competitiveness and international positioning of the different agents in the electric mobility value chain in the Basque Country.
The collaborative spaces and living labs will generate opportunities for technological and non-technological innovation, giving rise to new added value proposals and new business models.

This development of the industrial and service sector around electric mobility will generate positive economic, environmental and social impacts (new training opportunities, job creation, health benefits from decarbonisation, etc.) and will also provide other benefits such as providing flexibility to electricity distribution networks.

The following graph shows the composition of the different agents involved in the electric vehicle value chain in the Basque Country:



The Basque Country has an important business fabric in the automotive sector. It also has important companies in the railway and aeronautical sectors. In addition, there is a whole network of SMEs supplying components for the different transport sectors.

Business network

It is worth highlighting the importance of the Basque automotive sector, with a turnover currently equivalent to 25% of the Basque Country's GDP, 90% of sales in the international market and more than 40,000 jobs in the territory.

The Basque Country has major companies in the automotive sector, such as Mercedes, Irizar, CIE Automotive and Gestamp, among others, and the Mondragón Corporation, as the leading Basque industrial group, which among its divisions includes some related to the manufacture of automotive components. It also has important companies in the railway sector, such as CAF, and aeronautics, such as ITP Aero. In addition, there is a whole network of SMEs supplying components for the different transport sectors.

The Basque Country also has a combination of technological and industrial positioning and know-how in other areas directly related to electric mobility, such as energy storage, electric motors and power electronics.

In the specific field of batteries, the Basque Country has Cegasa, Basquevolt and CIDEcell as cell manufacturers and various companies along the battery value chain, including the development of materials for cells and battery casings, the assembly of battery packs -LANZO Batteries, aimed at the aerospace sector-, the development of battery management systems (BMS, TMS) -such as the start-up Optimized Battery Systems, OBS-, recycling, etc. In the field of electric motors, there are Basque manufacturers such as Obeki, Lancor and Alconza, and in power electronics applied to electric vehicles, companies such as Ingeteam and Jema, among others, are working.

As far as the energy sector is concerned, companies can be identified in the Basque Country that are clearly well positioned in the field of recharging infrastructures, such as Iberdrola and Ibil.

The Basque Country also has numerous companies in the ICT sector that are relevant to the development of Cooperative, Connected and Autonomous Mobility, such as Ibermatica, Ikusi, Gertek, etc., as well as many auxiliary companies that can supply sensors and others that can install sensors and monitoring elements in infrastructures.

The presence in the Basque Country of important engineering companies such as Sener, Idom, etc. should also be mentioned.

Clusters

It is worth highlighting the importance of the clusters in the Basque Country as drivers of collaboration between the different scientific-technological agents and Basque companies to boost their competitiveness. Those most closely related to electric mobility are:

- ACE - Energy Cluster of the Basque Country.
- ACICAE - Automotive Cluster of the Basque Country.
- GAIA - Basque Association of Knowledge and Applied Technology Industries (including Electronics, IT, Telecommunications, Engineering).
- HEGAN - Basque Aerospace Cluster.
- MLC-ITS - Mobility and Logistics Cluster of the Basque Country.

Scientific and technological agents

The Basque Country has the capabilities and experience of several BRTA Centres working on topics related to the development of zero-emission vehicles (AZTERLAN, CEIT, CIC energiGUNE, CIDETEC, GAIKER, IKERLAN, LEARTIKER, LORTEK, TECNALIA, TEKNIKER, VICOMTECH). These Centres have lines of research aligned with electric mobility and participate in multiple R&D projects at international, national and regional level, in many of them collaborating with universities and/or Basque companies. They are also well positioned in associations, platforms, knowledge networks and other international and national initiatives. Presence in platforms, associations and other international initiatives related to electric mobility:

- ALISTORE - Network of research in the field of batteries and battery materials.
- Batteries 2030+ - Sustainable Batteries of the Future.
- BATTERIES EUROPE - European Technology & Innovation Platform on batteries.
- BEPA - Batteries European Partnership Association and BATT4EU - Batteries European Partnership.
- CCAM - European Partnership on Connected, Cooperative and Automated Mobility.
- EBA - European Battery Alliance.
- EARPA - European Automotive Research Partners Association.
- ECH2A - European Clean Hydrogen Alliance.
- EGVIA2ZERO - European Green Vehicles Initiative Association and 2Zero Partnership.
- EMIRI - Energy Materials Industrial Research Initiative.
- ERTICO - ITS Europe.
- ERTRAC - European Road Transport Research Advisory Council.
- EUROBAT - Association of European Automotive and Industrial Battery Manufacturers.
- HYDROGEN EUROPE RESEARCH.
- LiPLANET - Network of research pilot lines for lithium battery cells.
- UPCELL - European Battery Manufacturing Alliance.

Presence in national platforms and associations:

- AEC - Spanish Road Association.
- AEH2 - Spanish Hydrogen Association.
- AEPIBAL - Spanish Association of Batteries, Cells and Energy Storage.
- BATTERYPLAT - Spanish Storage Technology Platform.
- ITS Spain.
- M2F - Spanish Automotive and Mobility Technology Platform.
- PTE HPC - Spanish Hydrogen and Fuel Cell Technology Platform.
- SERNAUTO - Spanish Association of Automotive Suppliers.

The targets set by the EC for the decarbonisation of the transport sector, and particularly the milestones set in the CO2 vehicle emission standards, provide a major opportunity to boost the research and technological development needed to advance the deployment of zero emission vehicles.

Opportunities for technological development and innovation in the Basque Country

The support of the Public Administration and the presence of industrial and scientific and technological agents throughout the entire value chain of electric mobility mean that the Basque Country is in an excellent position to carry out research, development and innovation activities, generating economic value in the region.

The objectives set by the EC for the decarbonisation of the transport sector, and particularly the milestones established in the standards on CO2 emissions from vehicles, represent a great opportunity to boost the research and technological development necessary to advance in the deployment of zero greenhouse gas emission vehicles, either through electrification (batteries and hydrogen fuel cells) or through hydrogen combustion engines. No technology adapts to all transport use cases, so it is necessary to make progress in the development of the main options, directing efforts towards reducing the current costs associated with their implementation, improving their performance to meet user demand and improving aspects of safety, reliability and circularity.

Cooperative, connected and autonomous electric mobility requires smart infrastructures to enable charging of electric vehicles, energy management, communication between vehicles and infrastructure, as well as monitoring and control of systems. R&D activities are required to enable efficient charging management, interoperability between different systems, energy management, security and system monitoring and control.

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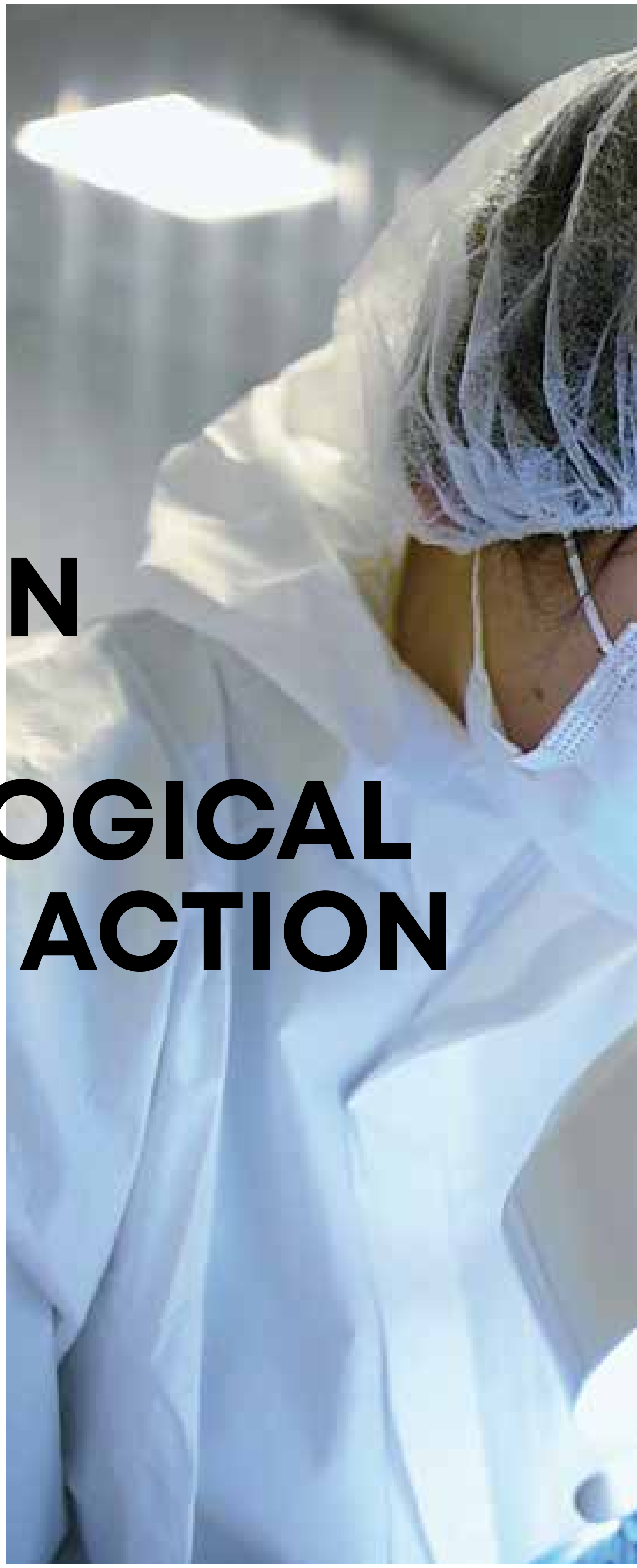
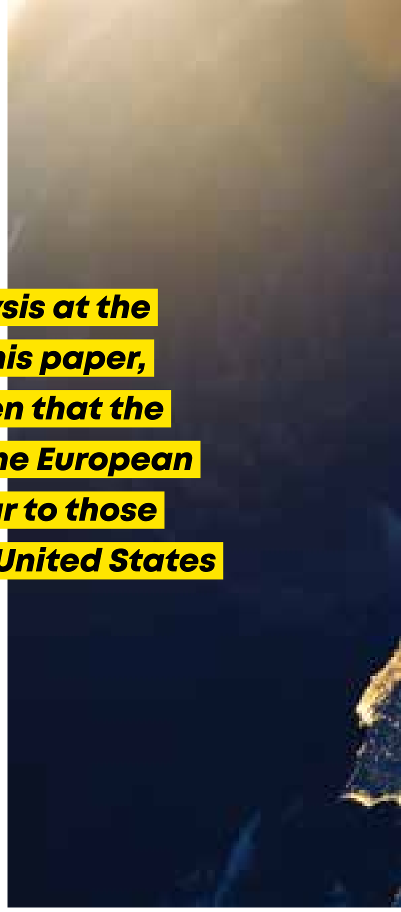
DEFINITION OF BRTA'S TECHNOLOGICAL FIELDS OF ACTION



SUSTAINABLE AND INTELLIGENT MOBILITY

02 DEFINITION OF BRTA'S TECHNOLOGICAL FIELDS OF ACTION

From the analysis at the beginning of this paper, it has been seen that the initiatives at the European level are similar to those defined in the United States and Japan.



From the analysis made at the beginning of this document, it has been seen that the initiatives at European level are similar to those defined in the US and Japan. A translation of the R&D needs into broad headlines referring to the EU priority initiatives for a transition towards sustainable mobility can be made and summarised in the following table.

These R&D needs have led us to establish areas of action that implicitly incorporate the initiatives proposed from Europe.

R&D needs of the different priorities

European Priority Initiative	Need for R&D&I
(1) Drive the uptake of zero emission vehicles, renewable and low carbon fuels and related infrastructure	. Electric vehicles . Recharging infrastructures
(3) More sustainable and healthy inter-urban and urban mobility	. New mobility services
(4) Greener freight transport	. Advanced urban logistics
(6) Making multimodal, connected and automated mobility a reality connected and automated mobility	. Connected and autonomous cooperative mobility
(7) Data and artificial intelligence for smarter mobility	. Enabling technologies: connectivity, data and artificial intelligence
(9) Fair mobility for all	. Inclusive mobility
(10) Improve transport safety	. Cybersecurity, validation and certification

Relationship between areas, R&D needs and initiatives

Scope of action BRTA	Need for R&D&I	EU Initiative
Electric vehicles	. Research on EV components . Hydrogen research	(1) (1)
Infrastructure for sustainable mobility	. Research on recharging infrastructures . Digitisation of infrastructures . AI, Data, Connectivity	(1) (6) (7)
CCAM Connected and autonomous cooperative mobility	. Connectivity . Creation of CCAM services . Autonomous vehicles . IA . Cybersecurity, validation and certification . Inclusive mobility	(6) (7) (6) (6) (7) (10) (9)
Management and Services Mobility Logistics	. New mobility services . Enabling technologies . Inclusive mobility . Advanced urban logistics . Cybersecurity, validation and certification	(3) (7) (9) (4) (10)

02

DEFINITION OF BRTA'S TECHNOLOGICAL FIELDS OF ACTION

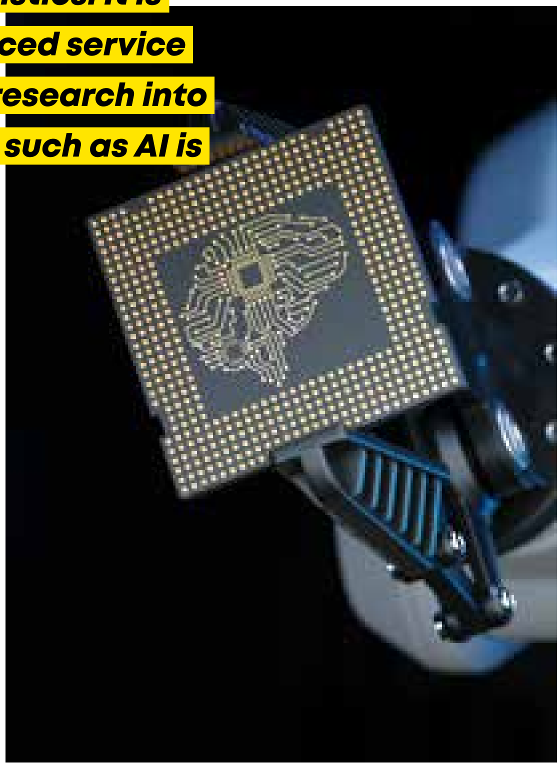
The division into these areas has been made mainly based on the areas on which the research aspects of sustainable mobility are to be addressed. on which the research aspects of sustainable mobility are to be addressed.

The first area of action defined, electric vehicles, is directly related to the European priority initiative 1 on zero-emission vehicles and related infrastructures. In this first area we will include the challenges and R&D priorities relating to batteries and hydrogen fuel cells, electric motors and power electronics, as well as aspects relating to the validation operation of electric vehicles.

All R&D&I aspects related to infrastructures will be the subject of the second scope of work. This second scope will therefore cover infrastructures for sustainable mobility related to the European initiative 1 for charging infrastructures, but also smart infrastructures for CCAM, using data enabling technologies (data platforms), AI for digital twin and connectivity.

The third area (CCAM) is directly related to initiative 6 of making multimodal, connected and automated mobility a reality, but also to the enabling technologies of initiative 7, by the very nature of connectivity, because perception of the environment is related to AI techniques and data is central to guidance and perception strategies. It is obviously also related to the certification and validation aspects required by autonomous vehicles.

A more sustainable inter-urban and urban mobility and logistics. It is the very idea of advanced service generation, for which research into enabling technologies such as AI is needed.



The fourth area is directly related to European initiatives for more sustainable interurban and urban mobility and logistics. It is the same idea of advanced service generation, for which research into enabling technologies such as AI, connectivity and data is needed and should be inclusive for all as required in initiatives 4 and 9. As well as mobility, logistics and is directly related to the greener freight transport initiative, focusing on the aspects of urban logistics, because it has an impact on mobility in cities and by narrowing the scope of application.

The following table shows the relationship between the fields and the European initiatives.

Relationship between BRTA areas, R&D needs and initiatives

Initiatives	Areas			
	Electric vehicles	Infrastructure	CCAM	Mobility and logistics
Zero emission vehicles and related infrastructure	•	•		
More sustainable and more sustainable and healthy urban mobility				•
Freight transport greener				•
Connected and automated multimodal mobility		•	•	
Fair mobility for all			•	•
Innovation, data and artificial intelligence for smarter mobility		•	•	•
Improving transport safety			•	•

03

ELECTRIC VEHICLES

SUSTAINABLE AND INTELLIGENT MOBILITY

03 ELECTRIC VEHICLES

One of the main strategies to advance the decarbonisation of transport is electrification, replacing internal combustion engines in vehicles with electric motors.

3.1 Introduction and scope

One of the main strategies to advance in the decarbonisation of transport is electrification, replacing internal combustion engines in vehicles with electric motors, which do not generate CO2 emissions into the atmosphere. Another strategy is the use of hydrogen combustion engines, as hydrogen does not generate CO2 emissions during combustion.

There are other decarbonisation strategies such as the use of renewable fuels (biofuels or synthetic fuels), whose CO2 emissions can be balanced by the CO2 captured during their production process, which are not the subject of this document, although they are currently of great interest to sectors such as the aeronautical or naval sectors as alternatives for meeting their requirements in a technically and economically viable way.

The scope of this area is therefore vehicles that do not produce carbon emissions. In the case of electric vehicles, the engines can be powered by batteries or hydrogen fuel cells (which do not generate NOx). Each technology has its own strengths and intensive research is currently underway to advance their development and better respond to the requirements of different modes of transport and trends in society's demand (greater vehicle autonomy, shorter charging time, greater safety, etc.)".

Five sub-fields or areas of work have been defined and for each of them the main associated technological challenges and the R&D priorities of the BRTA Centres to address these challenges have been established. The scope of the 5 sub-areas is briefly described below:

1. **Batteries for electromobility:** includes batteries of different chemistries with short- and medium-term application in electromobility, from the cell to the battery pack, including cooling systems, BMS (Battery Management System) management systems, development of digital twins, etc. and covering the entire life cycle of the batteries, from their manufacture to their second useful life or recycling.
2. **Hydrogen:** includes fuel cells and hydrogen combustion engines as well as in-vehicle hydrogen storage systems.
3. **Electric machines:** covers various types of advanced electric motors for powering electric vehicles, covering aspects related to improved performance, reliability and circular design.
4. **Power electronics:** covers all electrified vehicle systems (electric drive train, charging system and auxiliary systems for air conditioning, entertainment, etc.), including the design of materials, components and architectures, as well as design tools, operation and control strategies.
5. **Electric vehicle operations and validation:** encompasses solutions based on digital twins (software and hardware) and test benches to reduce testing and validation times of new electric vehicle functionalities and technologies (based on driving scenarios, vehicle parameters, etc.), as well as the development of efficient control profiles and predictive control systems.

3.2 Batteries for electromobility

3.2.1 Introduction and definition of the subfield

One of the main advantages of battery electrification is the high energy efficiency in different modes of transport, which globally can be as high as 75%. Batteries are playing an increasingly important role in decarbonising light-duty transport - and particularly passenger cars and vans - which accounts for around 50% of CO2 emissions in the European transport sector. Battery electrification also contributes to the decarbonisation of heavy transport - trucks, rail, aeronautics, construction machinery, etc. However, batteries have the intrinsic disadvantage of a much lower energy density than conventional hydrocarbon liquid fuels. Despite the lower efficiency of internal combustion engines, they still result in higher net ranges, among other considerations.
In this context, it is crucial to continue to focus on research and development in batteries for transport and mobility applications in order to overcome the operational challenges they present in relation to fossil fuels, and consequently facilitate their acceptance by the market.

3.2.2 Specific challenges

Battery electrification is applicable to a variety of mobility modes for people and goods transport. Moreover, while the most established battery technology for this field is lithium-ion, there are other chemistries and variants of interest with options to occupy significant market segments, such as solid electrolyte lithium batteries, sodium ion batteries, lithium/sulphur batteries and others. In this context, while each application sector has specific requirements, there are a number of general challenges that can be formulated in a generic way for all modes of transport and battery chemistries:

- Mejorar las prestaciones de las baterías: densidad de energía gravimétrica y volumétrica, densidad de potencia.

Batteries are playing an increasingly important role in decarbonising light-duty transport, which accounts for around 50% of CO2 emissions in the European transport sector.

- Improve battery performance: gravimetric and volumetric energy density, power density.
- Improved durability: cyclability and ageing.
- Decrease battery charging time (fast charging).
- Increasing battery safety, with particular emphasis on avoiding and controlling risk situations such as thermal runaway.
- Efficient integration of advanced management systems (BMS) in battery packs.
- Advancing in digitalisation, as a cross-cutting concept that helps to simulate battery behaviour, manufacturing processes, etc.
- Optimising the cost of both materials and manufacturing processes.
- Advance in the different aspects related to the circular economy, sustainability and the reduction of environmental impact, including eco-design and second life concepts.

3.2.3 R&D Priorities

Based on the general challenges outlined above, the following main R&D thrusts can be highlighted:

- Development and evaluation of new electrode and cell materials with high energy density, cyclability, fast charge and intrinsic safety for current and future battery chemistries: Li ion, Na ion, Li/S, etc.
- Development of new solid electrolytes with high electrochemical stability, wide thermal window of operation and fast charging for solid and semi-solid batteries.
- Development of new manufacturing processes for solid state electrodes and electrolytes in a more sustainable way, avoiding the use of solvents.
- Advanced battery management systems (BMS) with high accuracy, advanced sensor integration (safety and thermal event prevention), standardisation, interoperability, cyber-safety, functionalities and vehicle-to-grid communication.
- Battery state of function (SoX) algorithms using artificial intelligence technologies to manage a vehicle battery or a fleet.
- Advanced battery pack cooling solutions; thermal integration with other parts of the vehicle (passenger compartment, etc.).
- New structural materials such as composite, aluminium alloys and steel alloys for lightweighting the battery casing, with high strength/stiffness/weight ratio.
- Development of new materials related to the packaging of modules and complete batteries capable of maintaining battery efficiency throughout their useful life and exceeding the new fireproof, thermal and electromagnetic compatibility specifications.
- Eco-design of battery systems with maximum packaging efficiency, making assembly and disassembly operations for second or end-of-life use easier and cheaper.
- Design of safe battery systems taking into account thermal runaway mitigation, and minimising or avoiding propagation should it occur.
- Development of digital twins along the entire value chain: from battery manufacturing and assembly lines to final application (passenger vehicles, freight transport). Optimisation of manufacturing, operation and preventive maintenance processes based on digital twins and communication with the cloud.
- Development of procedures and standards for testing and evaluation of batteries at the end of their useful life with a view to their management for second-life applications, warranties, etc.
- Technologies for the automation of sorting and management/disassembly of batteries in recycling plants, guaranteeing the safety of the process.
- New battery recycling technologies with low environmental impact: hydrometallurgical and direct recycling.

3.3 Hydrogen

3.3.1 Introduction and definition

Hydrogen can be used as a feedstock for other compounds, as a fuel or vector for transport and energy storage; and it has many applications for reducing greenhouse gas emissions in power generation (especially enabling greater penetration of renewables in the electricity system), industry, transport (fuel cell vehicles) and housing. However, costs and their lack of technological maturity mean that their use is currently limited.

The use of hydrogen as an energy carrier is one of the strategies with the greatest potential for the decarbonisation of land transport. Its high energy density gives it a substantial advantage over purely electric systems for application especially in heavy-duty vehicles, such as freight transport. It also offers the possibility of significantly extending the range of light-duty vehicles for applications in urban environments.

Hydrogen-based propulsion systems are well known in the automotive sector, specifically with fuel cell powered vehicles, battery/fuel cell hybrid systems and hydrogen combustion-based vehicles.

In this context, it is very important to research into cutting-edge technologies to achieve optimised and safe hydrogen management solutions in the field of sustainable road transport, and their acceptance by users and the market.

3.3.2 Specific challenges

In this context, the most relevant R&D challenges and priorities to make hydrogen one of the most important vectors for the mobility of the future, as well as hydrogen powered electric vehicles, are described. There are several general and specific challenges for technological solutions for optimised and safe management of hydrogen generation, storage, transport and utilisation projects, the most important of which are mentioned below.

- Cost of implementation in fuel cell vehicles.
- Use of critical raw materials.
- Power density and specific power of fuel cells.
- Gravimetric and volumetric performance of hydrogen storage systems.
- Working under cryogenic and high pressure conditions.
- Test methodologies under specific operating conditions.
- Modelling of material behaviour under working conditions.
- Joints in storage and transport systems.
- Sensorisation in cryogenic conditions.
- Sustainability, circular economy and environmental impact.

The use of hydrogen as an energy carrier is one of the strategies with the greatest potential for the decarbonisation of land transport.

3.3.3 R&D priorities

Based on the general challenges outlined above, the following main R&D thrusts can be highlighted:

- Reducing the cost of equipment and making large-scale production feasible without limitations due to the use of critical raw materials, it is essential to reduce the precious materials used as catalysts in PEM fuel cells (platinum, iridium, etc.), either through more efficient deposition that enhances their effect or through the use of abundant and cheap substitutes such as combinations of oxygen, nitrogen and various transition metals such as iron and cobalt.
- Reducing the weight of fuel cell systems (particularly critical in the aerospace sector).
- Manufacture and assembly of cells - cell, module, pack.
- Development of propulsion systems based on hydrogen combustion, which presents greater difficulties for combustion stabilisation and a higher adiabatic flame temperature than traditional fuels.
- Improvement in advanced control strategies and components (electrical -BMS-, thermal TMS-) for fuel cell systems.
- Modelling the useful life of fuel cell systems.
- Improving hydrogen refuelling protocols to reduce tank refuelling times without requiring higher energy consumption during the process.
- Research and development of materials that can operate under cryogenic conditions in a durable manner.
- Research and develop thermal insulation materials.
- Research and development of materials that minimise the hydrogen permeation process, as well as microcracking phenomena due to thermal jumps and mechanical cycles.
- Development of materials that improve reaction and resistance to fire.
- Development of adhesives and research into the integrity and safety of joints in storage and transport elements.
- Research into sustainable and recyclable materials.
- Manufacture of liquid hydrogen tanks that minimise their mass and volume by improving the materials used and controlling the admissible boil-off for each specific application.
- Development of maintenance plans for equipment working with liquid hydrogen to minimise the thermal stress that causes them to stop operating and, therefore, to change from cryogenic to ambient conditions.
- Reducing the mass of compressed hydrogen storage systems by improving materials or eliminating liners (development of V-type tanks).
- Design and manufacture of safe on-board hydrogen distribution, refuelling and storage systems.
- Development of test methodologies in working conditions (i.e. permeability).

3.4 Electrical machines

3.4.1 Introduction and definition

There is no doubt that the mobility of the future is geared towards the electrification of transport. For example, sales of electric vehicles are increasing and are expected to continue to do so, even surpassing sales of internal combustion vehicles as early as 2035. A key component for such electrification is the electric motor, since it must be present regardless of the energy carrier and the degree of electrification of the means of transport. For this reason, the market for electric motors for the transport sector is expected to grow at a compound annual growth rate of 5.5% over a decade. Research into more efficient, power efficient, recyclable and recycled electric motors is a priority in the European Commission's plans, and this is a worldwide trend.

The propulsion systems expected to require these more advanced electric motors are as follows:

- Electric propulsion systems for aeronautical applications.
- Traction systems for light electric cars.
- Traction systems for heavy electric vehicles (buses, trucks...).
- Marine propulsion systems.
- Propulsion systems for urban electromobility.

Y las topologías a las que van orientadas las innovaciones que se requieren en el futuro son las listadas a continuación.

- Permanent magnet synchronous motors (PMSM).
- Synchronous motors with synchronous or switched reluctance.
- Asynchronous or induction motors (ASM).
- Electrically excited rotor synchronous motors (EESM).

3

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There is no doubt that the mobility of the future is oriented towards the electrification of transport.

.4.2 Specific challenges

challenges needed for the mobility of e related to performance, reliability e “from the cradle to the grave”.

es to be achieved are the following:

que/power density motors, in other tors with very low weight and capable ng in confined spaces.

ient and compact heat extraction

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the recyclability and circularity of ystems.

f high voltage for efficiency ent and high voltage derivatives (dv/ of more compact converters.

on of fault tolerance, where multi- tors offer better performance than se motors.

3.4.3 R&D priorities

Finally, in order to meet the specific challenges set for the electric propulsion engines of the future, the lines of work on which research should focus are as follows:

- Electromagnetic, thermal and mechanical optimisation methodologies for three-phase and multi-phase motors.
- Topological optimisation of components. Use of additive manufacturing for electromagnetic, structural and cooling components.
- Design of new direct cooling systems for electric motors with new coolants.
- Development of circular design methodologies. Use of recycled magnetic materials, reduction of the use of critical materials such as rare earths in permanent magnets. Recycling-oriented design of components.
- Partial discharge free high voltage insulation systems capable of operating in adverse environmental conditions of temperature, humidity and atmospheric pressure.
- NVH (Noise, Vibration, Harshness) mitigation in high-speed electric motors.
- Integration of motors and electronic converters. Integrated Modular Motor Drives (IMMD).
- EMI mitigation in on-board systems (motor + converter).
- Development of accelerated component testing procedures for predicting the useful life of electric motors.
- Design of internal and external motor protection methodologies in case of failure.

3.5 Power Electronics

3.5.1 Introduction and definition

The electrification of transport implies, in the case of power electronics, not only the development of the electric drive train and its recharging system, but also the conception of the electric vehicle from scratch, including the control system and the supply of auxiliary systems (air conditioning, safety systems, entertainment, etc.). The trend is towards, on the one hand, the sizing of components according to the needs of each case of use, promoting the design of efficient, modular and integrated architectures, and, on the other hand, the development of control strategies that facilitate multi-mission systems with real-time control optimisation.

In addition, the electrification of heavy transport vehicles and other sectors, such as aviation, is driving the development of hybrid, modular, safe, weight- and volume-optimised systems. In air transport, the concept of more electric aircraft, where all systems except propulsion are electrified through high power density components, is a first step towards the development of sustainable aircraft. For manufacturers, the replacement of hydraulics and pneumatics means greater efficiency in flight and on the ground, as well as reduced CO2 and NOx emissions, improved reliability and reduced maintenance costs.

3.5.2 Specific challenges

- Energy management for engine and auxiliary systems control (dependence on autonomy).
- Test bench for testing operating cycles equivalent to vehicle operation.
- Vector control of synchronous machines.
- Dynamic short-circuits between phases.
- Voltage loss analysis.
- Design of efficient converters with reduced volume and weight.
- Design in accordance with safety standards methodologies.
- Design of modular and scalable systems.
- Analysis and optimisation of system architectures.
- Development of adaptive operation and control algorithms.
- Enabling predictive maintenance systems.
- System-level and scenario-based design.

3.5.3 R&D Priorities

- Design and integration of modular converters based on Wide Band Gap technologies (GaN and SiC), for traction and auxiliary power supply systems in electric vehicles, ships and aircraft.
- Design and manufacture of magnetic materials and components to operate at high frequency.
- Development of control strategies and degradation analysis based on cognitive converters and artificial intelligence.
- Integrated development of compact components encapsulating power electronics, electrical machine and cooling.
- Design of safe and fault-tolerant systems oriented towards compliance with safety regulations.
- Development of design and operation tools based on multi-physics models and artificial intelligence.

3.6 Electric vehicle operation and validation

3.6.1 Introduction and definition

The control software developed in the automotive sector must be developed in an agile way and based on standards that minimise the testing time in the vehicle and maximise the security of the developments. This process can produce errors and can lead to complexity in code traceability, testing, integration on different platforms... This is why the current trend is to develop control software based on procedures that streamline the traceability of requirements, testing, automatic code generation, and always from a perspective of abstraction of the final hardware.

For the operation and validation of new technologies in electric vehicles, it is a priority to reduce test times, as well as early detection of possible defects in vehicle assembly, with the consequent cost savings. Digital twins, based on reliable models, help in the validation of these functionalities (speed cycle, driving scenario and vehicle parameters).

In the automotive sector, digital twins allow the excitation of real actuators by means of control signals/excitations from mathematical models running on a computer or real-time system. This same structure would serve as the foundation for the creation of the bench assembly for the control of real-time functionalities.

3.6.2 Specific challenges

In this context, the most relevant R&D challenges and priorities for the validation of functionalities for electric vehicles are described. Specific challenges are mentioned for the technological solutions of energy management, digital twins, validation, control cycles (speed, scenarios, parameterisation). The most relevant challenges are:

- Digital twin for validation of functionalities.
- Bench for validation of field tests.
- Real-time bench control system.
- Configuration of driving cycles, based on consumption prediction models.
- Design of unified ECUs (Electronic Control Units) to eliminate complexity in the architecture and save on components.
- Calibration of systems on test benches.
- Management and control in distributed traction.
- Predictive control systems based on electronic horizons.
- Ensuring a certain level of security in both software and hardware development.
- Validation of electric vehicle models and subsystems.

3.6.3 R&D priorities

Depending on the specific challenges identified, the following main axes of R&D can be highlighted:

- Development of tools that allow the global optimisation of systems, knowing in advance the pre-established route, which allow the development of efficient control profiles.
- Development of tools for the generation of digital twins, which are very faithful to reality and based on real data, for validation and simulation in adverse conditions.
- Development of HW with sufficient potential to combine several ECUs (Electronic Control Units) into one, reducing the complexity of the final architecture. Today, commercial vehicles have more than 100 ECUs/vehicle and many lines of code. The aim is to reduce both.
- Development of models, digital twins, which allow a test bench to be fed back with real data, thanks to the sensors and communication systems that feed these systems in real time.
- Research into alignment with the standards corresponding to each system, both in hardware and software development, in order to optimise testing, validation and verification processes.
- Distributed traction control, e.g. electric vehicles with in-wheel motors, to improve system dynamics and in turn safety and efficiency with these new configurations.
- Predictive control systems based on electronic horizons, which can anticipate control actions better than a human can. The aim is to optimise the entire system, using knowledge of traffic maps and models for more efficient prediction.

04

INFRASTRUCTURE FOR SUSTAINABLE MOBILITY

SUSTAINABLE AND
INTELLIGENT MOBILITY

04 INFRASTRUCTURE FOR SUSTAINABLE MOBILITY

Smart infrastructures enable efficient charging management of electric vehicles, which is essential for the implementation of electric mobility.

4.1 Introduction and scope of the area

The deployment of low-carbon and renewable fuel vehicles must go hand in hand with the creation of a comprehensive network of refuelling and recharging infrastructures to bring low-emission vehicles onto our roads. The EU target is to build half of the 1 000 hydrogen stations and one million of the three million public refuelling points needed by 2030 by 2025. This will allow for a widespread network to facilitate access for everyone.

The integration of recharging points into the network, the generation of recharging maps, the monitoring of recharging points and the collection of all the information on them are the object of this area. This section also considers recharging points for other vehicles such as bicycles or motorbikes. However, it does not consider aspects related to energy generation itself, aspects that are dealt with in detail in the Energy Transition White Paper.

This area also takes into account infrastructures for connected and automated cooperative mobility, which are the set of technologies, systems and devices that enable communication and interaction between vehicles, infrastructures and users, with the aim of improving the safety, efficiency and comfort of transport. These infrastructures include, among other elements, vehicle-to-infrastructure (V2I) connectivity, intelligent navigation systems, traffic management systems, sensors and cameras for the detection of obstacles and dangers on the road, and speed control and automatic braking systems.

This area is completed with the enabling technologies for properly maintained infrastructures that meet the quality and safety criteria required for each type of road. To this end, actions are envisaged in this area related to infrastructure monitoring and intelligent management tools.

4.2 Recharging infrastructures

4.2.1 Introduction and definition

Charging infrastructures encourage the uptake of alternative fuel vehicles and their availability is critical. Drivers need to be confident that they will be able to recharge their vehicles when they require it.

The deployment of charging infrastructures stimulates innovation and technological development in the mobility sector, fostering research and development of more efficient and cost-effective technologies for vehicle charging. In addition, new business opportunities are created in the mobility sector, such as the construction and maintenance of charging stations, the production of charging equipment, and the provision of charging services to drivers.

Smart infrastructures enable efficient management of electric vehicle charging, which is essential for the implementation of electric mobility. These infrastructures can manage vehicle charging according to demand, avoiding congestion and ensuring that vehicles are available when needed. These infrastructures can intelligently manage energy based on demand, optimising the use of electric power and reducing costs.

There is also a growing business that should be taken into account in this section associated with charging stations for personal mobility vehicles such as bicycles or motorbikes. There are charging stations that need to be managed and monitored in terms of installation in the network, vehicle availability, vehicle charging status, etc.

4.2.2 Specific challenges

The challenges in this sub-area are the following:

- Implementation of charging stations for hydrogen-based vehicles.
- Charging speed: it is important to increase the charging speed of batteries to reduce the time needed to charge an electric vehicle and therefore make the charging experience more comfortable and attractive for users.
- Interoperability: common standards and communication systems need to be developed to allow different electric vehicles and charging points to interact with each other efficiently.
- Safety: it is necessary to develop safety systems that protect both users and charging equipment from possible electrical risks or risks derived from the use of hydrogen.
- Monitoring of recharging points.
- Energy management in the installation containing multiple recharging points.

4.2.3 R&D Priorities

R&D priorities are:

- Design of power electronics for fast charging.
- Designing sensor elements for charging stations.
- Designing intelligent network management systems based on demand.
- Design of hydrogen refuelling stations with on-site production: production, storage, safety and management.
- Develop safety techniques adapted to the needs of hydrogen installations.

4.3 Intelligent infrastructures for CCAM

4.3.1 Introduction and definition

Smart infrastructures are necessary for the successful implementation of cooperative, connected and automated mobility (CCAM) because these technologies require real-time communication between vehicles and infrastructure in order to operate efficiently and safely. The following are some of the reasons why smart infrastructures are needed for CCAM:

Smart infrastructures are necessary for the successful implementation of cooperative, connected and automated mobility (CCAM) because these technologies require real-time communication between vehicles and infrastructure in order to operate efficiently and safely.

The Basque Country has a relevant activity in the creation of smart infrastructures for CCAM. Bizkaia has a testing corridor for CCAM solutions on the AP8 and A8, the Bizkaia Connected Corridor (BCC)[1], from the border with Gipuzkoa to the border with Cantabria and consists of 25 ITS-G5 CV2X communications beacons. It also has a monitoring system for critical infrastructures. The Provincial Council of Gipuzkoa has a Living Lab[2] for mobility in which to test new technologies and create CCAM services. It has 25 ITS-G5 and CV2X beacons on the AP8 from the Irún border to the border with Bizkaia and on the AP1 from Eibar to the border with Araba. In addition, there are other interesting initiatives such as the Beasain Rural Living Lab integrated in the Smart Mobility Beasain strategy and the Mobility Lab Vitoria Gasteiz Living Lab[3].

- Two-way communication: Smart infrastructures enable two-way communication between vehicles and infrastructure, which is essential for the implementation of cooperative mobility in CCAM. This communication allows vehicles to receive real-time information about traffic conditions, the location of other vehicles and the availability of parking spaces, among other important data.
- Safety: Smart infrastructures can improve safety in cooperative mobility in CCAM by enabling two-way communication between vehicles and infrastructure, facilitating risk identification and accident prevention.
- Monitoring and control: Smart infrastructures enable monitoring and control of systems, which implies real-time error monitoring and correction, helping to improve quality of service and ensure system reliability.

4.3.2 Specific challenges

The overall challenge for this section is to prepare infrastructures for cooperative, connected and automated mobility. In this new mobility paradigm, the infrastructure will be integrated with vehicles and other infrastructures to achieve an ecosystem in which relevant information is shared to make mobility safe and reliable. This main challenge leads to the identification of the following specific challenges:

- Digitalisation of infrastructures. Digitisation of infrastructures is necessary for decision-making and to be able to inform vehicles of changing situations.
- Monitoring of road conditions. It will be necessary to identify the state of the infrastructure itself.
- Monitoring of events: road works, accidents, weather conditions, other incidents.

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1 https://bizkaiaconnectedcorridor.biz

2 https://www.ceit.es/noticias/-/contents/23/02/2023/ceit-y-la-diputacion-de-gipuzkoa-entran-de-lleno-en-la-era-de-las-carreteras-inteligentes-a-traves-del-living-lab/content/1tZ9oin6Nj8k/43977942

3 https://mobilitylab.eus/

SUSTAINABLE AND INTELLIGENT MOBILITY

04

INFRASTRUCTURE FOR SUSTAINABLE MOBILITY

- ODD (Operational Design Domain) extension. ODDs are the conditions under which autonomous/automated vehicles operate. The infrastructure should be monitored to inform the vehicles so that they can extend their operating range.
- Information management elements. All information should be managed and centralised by the infrastructure operator.
- Communication elements. Communication elements shall be installed or used in the infrastructure for I2X communications.
- Standardisation of communications and protocols. One of the challenges is the standardisation of communications, for which work is being carried out at European level in different standardisation groups.
- Infrastructure maintenance for automated vehicles. The European directive on infrastructure maintenance provides for infrastructures to be adequately maintained for the needs of automated vehicles.
- Cybersecurity: ICT (Electronics, Information and Communication Technologies) needed to meet the challenges outlined above are susceptible to attack, jeopardising the security, availability, integrity and confidentiality of infrastructures, services and data. Therefore, cybersecurity must be considered from the design of the solutions and managed throughout their life cycle.

4.3.3 R&D Priorities

The R&D priorities that can respond to the challenges identified are shown below:

- Creation of high definition maps (HD Maps) for the digitalisation of infrastructures.
- Creation of digital twins to simulate the evolution of traffic, the elements installed in the infrastructures and the state of the roads.
- Advanced perception systems for monitoring the state of infrastructures.
- Deploying sensors and perception systems that can extend ODDs.
- Modular and structured design of infrastructure management platforms.
- Research on automated translation systems between Datex II and C-ITS standards.
- Design of gateways for different communication technologies.
- Advanced perception for infrastructure maintenance.
- Predictive models of the evolution of the state of the infrastructure.
- Cybersecurity by design at component and system level, cybersecurity assessment, threat monitoring, incident management and software updates, etc.

05

CCAM CONNECTED AND AUTOMATED CO-OPERATIVE MOBILITY

SUSTAINABLE AND INTELLIGENT MOBILITY

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CCAM CONNECTED AND AUTOMATED CO-OPERATIVE MOBILITY

In recent years, in-vehicle perception systems have become a scientific field of great importance for the development of autonomous vehicles and driver assistance systems.

5.1 Introduction and scope of the field

Cooperative, connected and automated mobility is one of the major trends in the automotive industry. This initiative is designed to help EU countries and the European automotive industry in their transition towards connected and automated driving, while ensuring both safety and service to meet society's needs.

CCAM, therefore, is a general term for intelligent mobility, also called Smart mobility: today and in the future to ensure automated mobility, vehicles must communicate with each other, be connected to each other and to their environment (e.g. with traffic lights).

The scope of the CCAM extends from autonomous and semi-autonomous vehicles to intelligent transport systems, communication infrastructures and mobility service platforms. This means that the CCAM is not only limited to passenger vehicles, but also to commercial, freight and emergency vehicles.

CCAM aims to provide safer, more sustainable and efficient mobility solutions through the integration of advanced technologies such as artificial intelligence, machine learning, augmented reality and IoT (Internet of Things).

The field of CCAM is experiencing rapid growth due to increasing demand for more efficient and sustainable mobility solutions, as well as growing investment in advanced technologies by industry and governments. In short, CCAM is a fundamental part of the digital transformation of transport and a key factor in the creation of smart and sustainable cities in the future.

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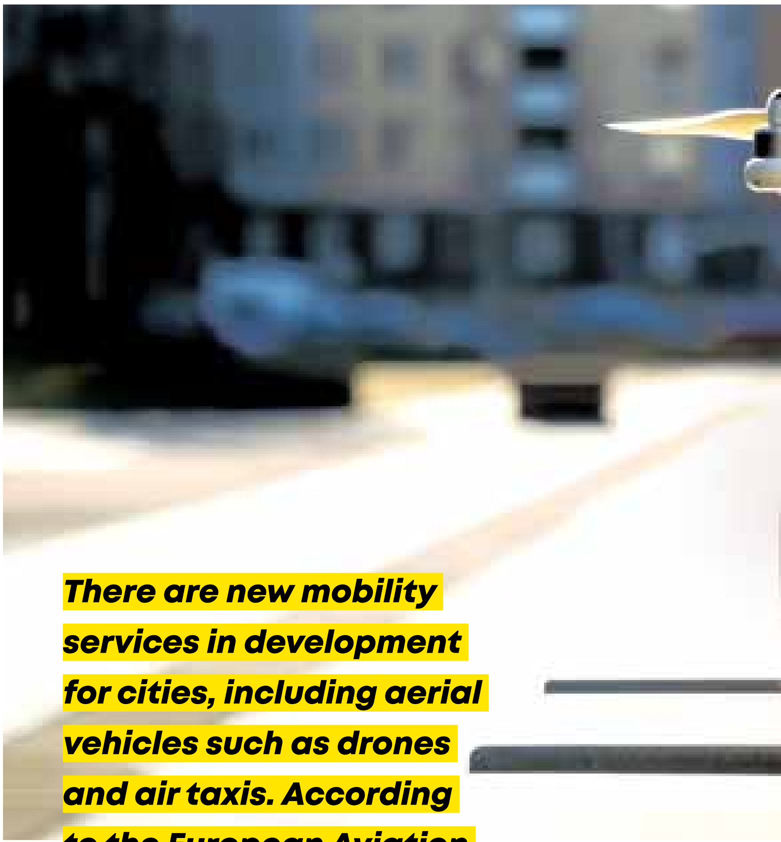
CCAM CONNECTED AND AUTOMATED CO-OPERATIVE MOBILITY



The overall objectives of CCAM are:

- Reduction in the number of deaths and injuries in road transport.
- Safe and efficient coexistence between automated and non-automated "conventional" traffic for a long transition period of mixed traffic.
- High public acceptance and adoption of CCAM with a clear understanding of its benefits and limits.
- Increased efficiency of transport flows (people and goods) leading to better use of infrastructure capacity and preservation of public space.
- Reduced transport emissions and congestion.
- Make Europe a world leader in the deployment of connected and automated mobility for people and goods.
- More focused and long-term investments in R&D&I, development.
- Support the creation, dissemination and capitalisation of knowledge to accelerate the development and improvement of CCAM-enabled solutions.

Seven sub-areas or areas of work have been defined and for each of them the main associated technological challenges and the R&D priorities of the BRTA Centres to address these challenges have been established. The scope of the 7 sub-areas is briefly described below:

- Accurate and safe environment recognition.
- In-vehicle monitoring.
- Precise positioning.
- Secure communications.
- Decision and control systems.
- Cooperative services.
- Safety, Verification, Validation.

There are new mobility services in development for cities, including aerial vehicles such as drones and air taxis. According to the European Aviation Safety Agency (EASA), 83% of the population is in favour of urban aerial mobility, which would include delivery drones and air taxis.

5.2 Accurate and safe environmental recognition

5.2.1 Introduction and definition

In recent years, in-vehicle perception systems have become a scientific field of great importance for the development of autonomous vehicles and driver assistance systems. These systems play a key role in enabling vehicles to accurately and safely recognise and understand their environment, which is crucial for making appropriate decisions in real time.

Surround recognition encompasses the ability of a vehicle to identify, classify and understand objects and situations in its immediate environment. This involves the detection of pedestrians, vehicles, road signs, obstacles and other elements relevant to safe driving. The aim is to obtain a detailed and accurate representation of the environment, enabling the vehicle to make informed decisions and anticipate potential risks.

A variety of sensors and perception techniques, such as cameras, radar, lidar and image processing systems, are used to achieve accurate and safe environmental recognition. These systems capture and analyse data in real time, generating a digital representation of the vehicle's environment. Through advanced detection, classification and tracking algorithms, moving objects are identified and tracked, allowing an accurate interpretation of the surrounding scene.

The development of in-vehicle perception systems presents complex scientific challenges. Accurate real-time object detection and classification requires the development of efficient and robust algorithms capable of dealing with adverse conditions, such as lighting variability, the presence of fast-moving objects and the presence of hidden obstacles. In addition, the integration and fusion of data from different sensors is essential to obtain a complete and reliable representation of the vehicle environment.

Safety is a fundamental aspect of environmental recognition. Perception systems must be able to identify and anticipate hazardous situations, such as impending collisions or unsafe behaviour of other road users. This implies the ability to assess and predict the trajectory and intention of moving objects, allowing the vehicle to make proactive decisions to avoid accidents.

5.2.2 Specific challenges

The development of in-vehicle perception systems for accurate and safe recognition of the environment poses a number of scientific and technical challenges. Some of the main challenges are the following:

- Object detection and classification: Achieving accurate detection and classification of different objects in real time is critical.
- Complex environments and harsh conditions: Sensing systems must be able to operate reliably in a variety of complex environments and harsh conditions.
- Multi-modal data fusion: Integrating and fusing data from different sensors, such as cameras, radar and lidar, is essential to obtain a complete and accurate representation of the environment.

Advances in artificial intelligence, computer vision and machine learning are driving the development of increasingly sophisticated and accurate systems for monitoring vehicle interior and driver status.

- Object tracking and prediction: It is important to be able to continuously and accurately track moving objects in the environment.
- Computational efficiency: Perception systems must be efficient in terms of computational resource consumption and processing time. This is especially relevant in real-time applications, where speed of response is critical.
- Validation and robustness: Robust validation methods and techniques are needed to assess and ensure the reliability and accuracy of perception systems.
- Interaction with other vehicle systems: Perception systems must be able to interact and communicate effectively with other systems, such as traffic control systems and intelligent infrastructures.

5.2.3 R&D Priorities

- Develop machine learning algorithms and techniques that can accurately identify pedestrians, vehicles, cyclists, traffic signs, obstacles and other relevant elements in the vehicle environment scene.
- Develop perception systems capable of performing well in situations of low visibility, sudden changes in lighting, challenging weather conditions (rain, snow, fog), as well as the presence of obstacles and distractions in the environment.
- Develop data fusion algorithms that effectively combine information from multiple sources, taking advantage of the strengths of each sensor and compensating for their individual limitations.

- Not only objects need to be detected, but also their future trajectories need to be predicted in order to make early and safe decisions. Predicting behaviours and estimating the intention of moving objects pose additional challenges in terms of accuracy and reliability.
- Optimisation of algorithms and processing techniques is required to achieve a balance between accuracy and computational efficiency.
- Creation of training and test data sets that are representative of various traffic conditions, as well as the development of test and evaluation techniques that address varied and extreme scenarios.
- Interaction of the perception system with other vehicle systems.

5.3 Vehicle interior monitoring

5.3.1 Introduction and definition

Vehicle interior and driver condition monitoring is a constantly evolving field that seeks to ensure the safety and well-being of occupants while driving. With advances in technology and sensors, it is now possible to effectively and accurately monitor various aspects within the vehicle cabin, as well as assess the driver's physical and mental state.

Vehicle interior monitoring encompasses the monitoring of elements such as seat position, seat belt, temperature, air quality, lighting, etc. These data provide valuable information to ensure a comfortable and safe environment for the occupants. This data provides valuable information to ensure a comfortable and safe environment for occupants.

Driver condition monitoring, on the other hand, focuses on assessing the driver's level of attention, fatigue, distraction and emotions. Advanced sensors and algorithms are used to detect patterns and behaviours that may indicate drowsiness, lack of concentration or emotional agitation. This information allows preventive measures to be taken, such as alerting the driver or even autonomously intervening in the control of the vehicle if an imminently dangerous situation is detected.

In-vehicle and driver condition monitoring plays a crucial role in road safety and in promoting responsible driving. By detecting and addressing risk factors related to driver behaviour and in-vehicle conditions, it aims to reduce accidents and improve the overall driving experience.

In this context, advances in artificial intelligence, computer vision and machine learning are driving the development of increasingly sophisticated and accurate systems for monitoring vehicle interior and driver status. These technologies promise to deliver safer and more efficient driving and pave the way for autonomous driving in the future.

5.3.2 Specific challenges

Driver and in-vehicle monitoring poses several scientific challenges that require continuous research and development to achieve efficient and reliable systems. Some of the most important challenges are:

- Accuracy and reliability: Ensuring the accuracy and reliability of monitoring systems is critical.
- Sensor integration: Driver and vehicle interior monitoring involves the use of a variety of sensors, such as cameras, pressure sensors, temperature detectors, etc...
- Fatigue and drowsiness detection: Accurate detection of fatigue and drowsiness is a major challenge in driver monitoring.
- Distractions assessment: Driver monitoring also involves the detection and assessment of distractions, such as the use of electronic devices while driving.
- Privacy and ethics: Driver and in-vehicle monitoring raises privacy and ethical concerns.
- Adaptability and customisation: Monitoring systems should be adaptable to the individual characteristics of each driver.
- Integration with safety and driver assistance systems: Driver and in-vehicle monitoring should be effectively integrated with existing safety and driver assistance systems, such as adaptive cruise control and emergency braking.

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Positioning accuracy is essential to ensure the safety and reliability of automated driving systems.

5.3.3 R&D Priorities

- Develop algorithms and sensors capable of accurately and reliably detecting driver states and behaviours, as well as in-vehicle conditions.
- Integrate monitoring sensors effectively, avoiding intrusion into the driver's space and maintaining smooth operation.
- It requires the development of algorithms and sensors that can identify early signs of fatigue, such as changes in driving patterns, eye movements and blinking, in order to take appropriate preventive measures.
- Techniques need to be developed to identify these distractions accurately and in real time, to alert the driver and reduce the associated risks.
- It is essential to ensure the protection of the data collected and its appropriate use, respecting the driver's rights and privacy.
- Developing algorithms and models that can adapt to different driving styles, preferences and physical characteristics of drivers.
- Coordination of monitoring systems with vehicle safety systems in order to obtain a rapid and appropriate response to dangerous situations.

5.4 Vehicle interior monitoring

5.4.1 Introduction and definition

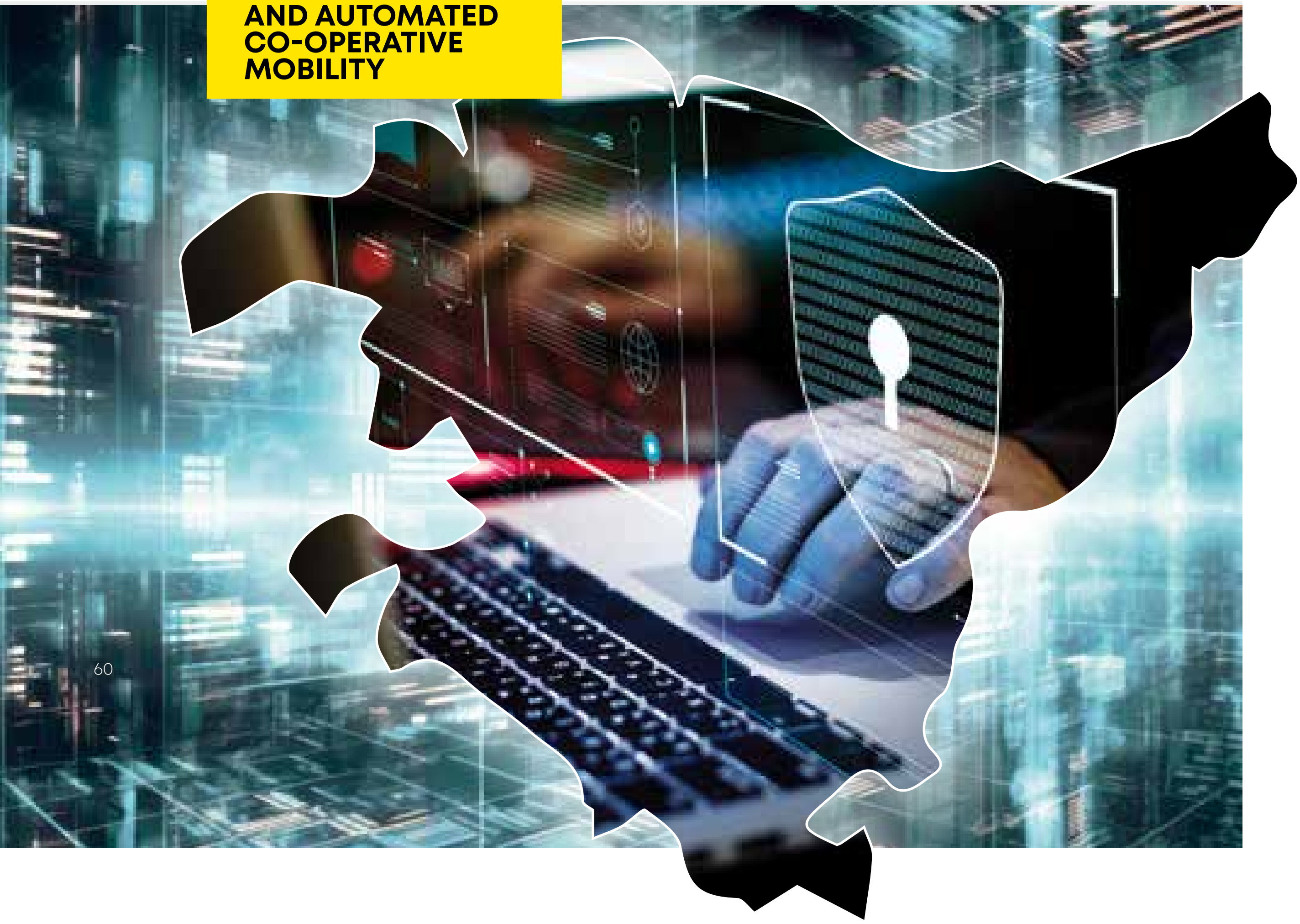
In-vehicle precise positioning systems play a crucial role in the advancement of highly automated driving. These systems enable vehicles to know their precise location in real time, which is essential for making safe and accurate decisions in dynamic and complex environments.

Highly automated driving requires vehicles to be able to navigate autonomously and accurately in different traffic situations and changing environments. Precise positioning systems provide the ability to determine vehicle position with a higher accuracy than conventional navigation systems, such as standard GPS/Galileo/Glonass (GNSS).

These systems make use of a variety of technologies and techniques, such as the combination of satellite signals, the integration of inertial sensors and the use of high-resolution digital maps. By combining these elements, vehicles can determine their position in real time with an accuracy of centimetres or even millimetres.

Positioning accuracy is critical to ensure the safety and reliability of automated driving systems. The ability to know the exact position of the vehicle enables faster detection and response to unexpected traffic situations, as well as more efficient route planning and safe interaction with other road users.

However, achieving accurate positioning in dynamic and complex environments presents significant scientific and technical challenges. These challenges include mitigating signal errors caused by obstacles, accurately calibrating the sensors used in the system, and fusing data from multiple sources to obtain an accurate estimate of position.



In addition, precise positioning systems must be robust and reliable in a variety of environmental conditions, such as changes in visibility, electromagnetic interference and adverse weather conditions. System accuracy and reliability must be maintained even in dense urban environments, where the presence of tall buildings and structures can affect signal quality.

5.4.2 Specific challenges

The development of precise positioning systems in vehicles for highly automated driving poses a number of scientific and technical challenges. Some of the most important challenges are the following:

- Accuracy and robustness: Achieving high accuracy in determining vehicle position is essential to ensure safe and reliable driving. However, this can be affected by various factors, such as the presence of obstacles, signal interference and adverse environmental conditions.
- Sensor fusion: Fusion of data from different sensors, such as GNSS, visual odometry, lidar and radar, is essential to obtain an accurate estimation of vehicle position.
- Urban and challenging environments: Driving in urban environments presents more complex and challenging conditions, such as the presence of tall buildings, narrow streets and various signage. These factors can make it difficult to receive and process positioning signals.

The Basque Country is in a unique position to lead the development of advanced cybersecurity solutions. Collaboration between industry, technology centres and government agencies is essential to comprehensively address cybersecurity challenges in this emerging sector.

- Response time: For highly automated driving, it is essential that positioning systems provide real-time position estimation with minimal response time.
- Validation and certification: Ensuring the accuracy and reliability of precise positioning systems for automated driving requires rigorous validation and certification processes. Appropriate standards and methodologies need to be developed to assess the performance of these systems in different driving scenarios and to establish clear acceptance criteria.
- Scalability and cost: Precise positioning systems must be scalable and affordable for large-scale deployment in autonomous vehicles.

5.4.3 R&D Priorities

- Develop algorithms and techniques to mitigate these effects and maintain consistent and robust accuracy in different driving environments.
- Efficiently and coherently integrate and combine information from these sensors, taking into account their individual characteristics, potential discrepancies and limitations.
- Advanced techniques need to be developed to overcome these obstacles and maintain high accuracy in densely populated urban environments.
- Reducing latency in sensor data acquisition and processing, as well as optimising position estimation algorithms for fast and timely response.
- Seek solutions that are efficient in terms of cost, energy consumption and computational resources, without compromising positioning accuracy and reliability.

5.5 Secure Communications (Cybersecurity)

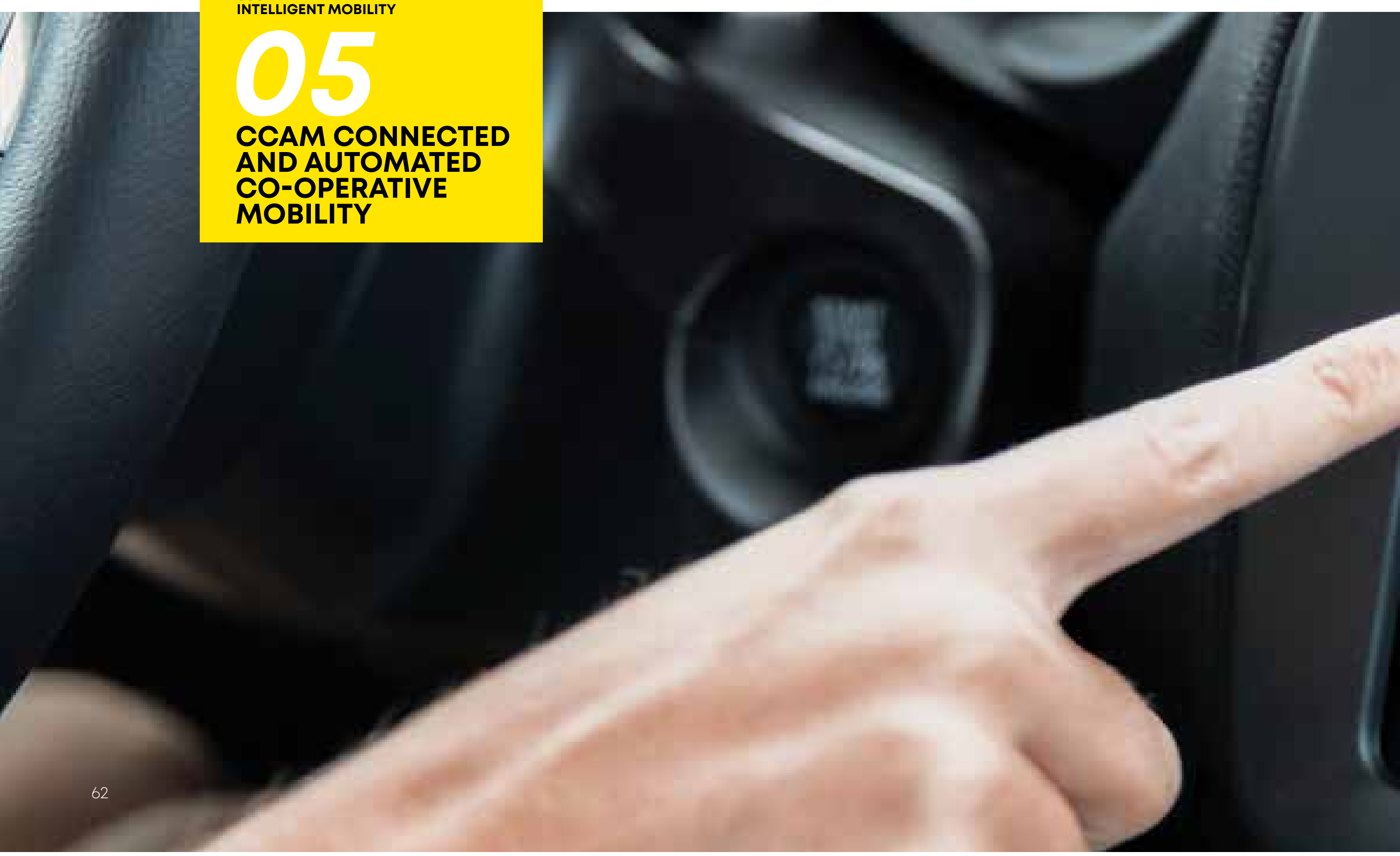
5.5.1 Introduction and definition

The integration of advanced technologies has enabled the development of autonomous vehicles, which rely on sophisticated communication systems. These vehicles use sensors, cameras and automated control, and require a reliable communication network to exchange data and make real-time decisions.

In the Basque Country, the implementation of automated and connected vehicles also poses challenges and opportunities in cybersecurity. Protecting the communications of these vehicles is essential to guarantee the safety of vehicle occupants and the roads in general.

Cybersecurity in connected and autonomous vehicles involves protecting vehicle-to-vehicle communication networks, road infrastructure and traffic management systems. The integrity of this data is essential to ensure safe and reliable operation, and to prevent threats such as unauthorised access or information theft.

The Basque Country is in a unique position to lead the development of advanced cybersecurity solutions. Collaboration between industry, technology centres and government agencies is essential to comprehensively address cybersecurity challenges in this emerging sector, where we can consolidate our position as leaders in the safe and efficient adoption of cybersecure autonomous vehicle technology, promoting the mobility of the future.



5.5.2 Specific challenges

Connected and automated vehicles have many challenges ahead, where secure communications play an important role. The most important specific challenges are mentioned below:

- Design communications that seek to avoid vulnerabilities to attacks between vehicles and infrastructure.
- Design and develop communications systems that are resistant to cyber-attacks, which could compromise the integrity and security of vehicles and users.
- Ensure the integrity of data, which is then used in decision-making in automated vehicles. Data manipulations can have serious consequences.
- Ensure the privacy of users of connected and automated vehicles.
- Design scalable systems that can receive remote and secure updates and maintenance.
- Contribute to the development of uniform regulations and standards for the cyber security of autonomous vehicles.
- Move towards disaster and emergency resilient systems with secure communications.

5.5.3 R&D Priorities

- Research robust security measures to protect communications against unauthorised access, denial of service attacks and data manipulation.
- Develop and maintain advanced cyber defences to prevent intrusions, malware and targeted attacks on vehicle systems and related infrastructure.

Research with the aim of actively contributing to building a safer, more efficient and sustainable mobility future.

- Ensure data integrity by implementing digital signatures, encryption and validation of the authenticity of exchanged information.
- Establish robust privacy policies and mechanisms that protect personal information and respect privacy regulations.
- Design secure systems for remote software updates, guaranteeing the authenticity of updates and preventing possible malicious manipulation.
- Collaborate across industry and government to establish robust regulations and standards that comprehensively address cyber security.
- Design systems that are resilient and capable of operating securely even under adverse conditions, ensuring the continuity of critical communications.

5.6 Automated vehicle control and decision systems

5.6.1 Introduction and definition

As mentioned above, the rapid evolution of technology in the field of mobility has led to an increasingly prominent focus on research and development of advanced control systems for connected, autonomous and shared vehicles. However, other areas such as perception and communications have evolved more rapidly than decision-making and control. This is because the latter involve less human driver interaction and a higher level of automation in complex environments where unforeseen circumstances may arise.

Move towards a significant reduction in road accidents.

In this context, a number of specific challenges have been identified in this subfield that require priority attention. They focus on fundamental aspects such as adaptability to changing environmental conditions, efficient integration into urban environments, fault tolerance to improve safety, real-time decision making, effective interaction with human drivers, optimisation of trajectories and, ultimately, the imperative to move towards a significant reduction in road accidents.

It is important to highlight that some technological agents in the Basque Country have participated in this technological evolution, allowing the implementation in some relevant demonstrators or even as use cases within European consortia. However, the implementation of these systems in commercial vehicles is only possible under special conditions. This section presents these challenges and research priorities with the aim of actively contributing to the construction of a safer, more efficient and sustainable future of mobility.

5.6.2 Specific challenges

Decision and control for connected and automated vehicles has many challenges ahead. The most important specific challenges are mentioned below:

- Design robust control systems that can adapt to changing environmental conditions.
- Integrate new vehicles with high levels of automation in urban environments.
- Design fault-tolerant systems to improve the behaviour of automated vehicles.
- Reduce the time of on-board decision systems to ensure real-time behaviour.
- Design systems based on behaviour and interaction with human drivers, both for the transition from autonomous to manual driving and vice versa.

- Work on optimising trajectories, both laterally and longitudinally, for more efficient routes and speed profiles.
- Move towards reducing road accidents. Investigate technologies and safety strategies that contribute to the significant reduction of road accidents, taking advantage of the capabilities of autonomous vehicles.

5.6.3 R&D Priorities

Based on the general challenges outlined above, the following main R&D thrusts can be highlighted:

- Robust Algorithm Development: to research and develop robust control algorithms capable of dynamically adapting to varying environmental conditions, improving the safety and efficiency of autonomous vehicles.
- Urban Integration of Autonomous Vehicles: To prioritise research on strategies for effective integration of highly automated vehicles in urban environments, as well as in other ODD (Operational Design Domains) addressing specific challenges such as interaction with pedestrians, cyclists and other road users.
- Fault Tolerant Systems: Research on the design and development of fault tolerant systems to improve the reliability and safety of autonomous vehicles, considering unforeseen scenarios and possible malfunctions.
- Decision Time Optimisation: Prioritise research on reducing the decision-making time of on-board systems, ensuring real-time behaviours and improving responsiveness to dynamic traffic situations.
- Human-Vehicle Interaction: Research on systems that improve the interaction between autonomous vehicles and human drivers, especially in the transition between autonomous and manual driving modes, ensuring a safe and smooth experience. These methods are encompassed within shared control systems.
- Trajectory Optimisation: research into the development of advanced algorithms for the optimisation of trajectories, both laterally and longitudinally, with the aim of achieving more efficient and safer routes and speed profiles.
- Accident Reduction: Focus research on specific measures to move towards reducing road accidents, using autonomous vehicle technologies and control systems as key tools in this effort.
- Research and develop system architectures that are able to efficiently identify and manage failure situations.
- Optimise decision-making algorithms so that they can process information quickly, ensuring real-time responses.

5.7 Safety, Verification, Validation

5.7.1 Introduction and definition

Verification and validation of autonomous functions in vehicles is a crucial aspect in the development of autonomous driving technologies. As these functions become more complex and sophisticated, it is critical to ensure their safety and performance before deployment in the real world.

Safety is the primary concern when validating and verifying autonomous functions in vehicles. These functions must meet rigorous safety standards and pass extensive testing to ensure that they operate reliably and without compromising the integrity of the system or the safety of occupants and other road users.

Verification refers to the process of confirming that the autonomous system meets pre-defined specifications and requirements. It involves testing and evaluation to ensure that the system functions correctly in different situations and scenarios. This involves testing in controlled and simulated environments, as well as on-road testing to validate the performance of the system in real conditions.

Validation, on the other hand, focuses on demonstrating that the autonomous system is capable of fulfilling its purpose and performing safely and effectively in the real world. It involves testing the system in a wide variety of situations and conditions, including unexpected situations and boundary scenarios. Validation is based on extensive testing, both in controlled environments and in field tests under real traffic conditions.

However, verification and validation of autonomous functions present significant scientific and technical challenges. These challenges include defining clear safety criteria, developing robust testing and evaluation techniques, capturing representative data and simulating complex scenarios, among others.

In addition, verification and validation must address the uncertainty inherent in autonomous functions and their interaction with a dynamic and changing environment. This involves considering unpredictable factors, such as the behaviour of other drivers, adverse weather conditions and obstacles on the road.

5.7.2 Specific challenges

The scientific-technical challenges related to the safety, verification and validation of autonomous functions in vehicles involve addressing a number of important challenges. Some of these challenges are listed below:

- Reliability and robustness: Ensure that autonomous functions are reliable and robust in a wide variety of driving conditions and situations.
- Functional safety: Ensure that autonomous functions comply with established safety standards and requirements.
- Sensor and perception integration: Develop advanced perception systems that can accurately capture and understand the vehicle's environment.
- Efficient validation and verification: Develop efficient methods and techniques for validation and verification of autonomous functions.
- Human-machine interaction: Improve communication and interaction between the autonomous vehicle and the driver/users.
- Regulations and standards: Address the challenges related to the definition of appropriate regulations and standards for autonomous functions in vehicles.

- Ethics and liability: Consider ethical and legal aspects in the development of autonomous functions, such as decision-making in risky situations and legal liability in case of accidents.

5.7.3 R&D Priorities

- Develop algorithms and systems capable of adapting to different environments and dealing with unforeseen scenarios.
- Implementing appropriate safety measures, performing risk analysis and extensive testing to ensure the safety of vehicle occupants and other road users.
- Integrating different types of sensors, such as cameras, radar and lidar, and implementing data processing algorithms for accurate detection and recognition.
- Simulation and testing in controlled environments as well as testing under real driving conditions.
- Develop intuitive and understandable interfaces to enable safe and effective cooperation between humans and autonomous systems.
- Work with regulators and industry to establish regulatory frameworks to ensure the safety and interoperability of autonomous systems.
- Define clear ethical principles and develop mechanisms to ensure appropriate accountability.

Validation, on the other hand, focuses on demonstrating that the autonomous system is capable of fulfilling its purpose and performing safely and effectively in the real world.

06

SUSTAINABLE MOBILITY AND LOGISTICS SERVICES

06
SUSTAINABLE MOBILITY AND LOGISTICS SERVICES

The mobility of people and the transport of goods are two of the main social, environmental and economic challenges facing humanity.

6.1 Introduction and scope of the field

Mobility of people and freight transport are two of the major social, environmental and economic challenges facing humanity, with profound implications for employment, economic welfare, wealth creation and distribution, and people's health.

Today, the management of mobility services for people and freight logistics has become a highly relevant issue due to the increase of transport in urban and interurban environments. The need to improve efficiency in last mile delivery and reduce waiting times has become a challenge for companies seeking to improve their competitiveness. In this regard, the management of warehouses, ports, rail transport and airports has become a key part of improving urban and inter-urban mobility. To address this challenge, it is necessary to adopt a sustainable and healthy perspective in the management of mobility and logistics services.

The implementation of solutions that promote the reduction of polluting emissions and the use of more efficient and safer means of transport becomes a priority. The optimisation of logistics processes and the use of advanced technologies for fleet management and shipment tracking are some of the strategies that can be applied to improve urban and interurban mobility in a sustainable and healthy way. In short, the aim is to seek solutions that allow for a more efficient and sustainable management of mobility and logistics services to improve the quality of life in cities and reduce environmental impact.

6.2 Sustainable and inclusive public transport

6.2.1 ntroduction and definition

The Basque Government, as well as other administrations in the area, is committed to the development of sustainable and inclusive public transport.

This involves the promotion of more environmentally friendly transport options, such as electric transport and the use of bicycles, as well as improving accessibility for people with disabilities.

In addition, options such as Mobility as a Service (MaaS) and shared mobility to improve the efficiency of people transport and logistics, which help reduce congestion in urban areas are part of the agenda. Efforts are also being made to improve mobility in rural areas by improving public transport connections and encouraging car sharing. In this context, specific challenges and priorities are defined for this area.

Sustainable and inclusive public transport for the mobility of the future, both in urban and rural environments.

6.2.2 Specific challenges

In this context, the most relevant challenges to make public transport sustainable and inclusive for the mobility of the future are described. The most important specific challenges are mentioned below:

- Implement the massive use of Mobility as a Service (MaaS).
- Make shared mobility a plausible reality in cities, involving the integration of different transport options.
- Reduce urban congestion, minimising the impact on the environment.
- Design applications that ensure their acceptance by citizens to improve the sustainability of mobility (i.e.: see the traffic in real time before leaving, or choose the most environmentally friendly means of transport).
- Improve mobility in rural areas, as they present specific mobility challenges, such as: low population density, long distances between cities, ageing population, poor connections to airports, railways and road nodes.
- Use available data, or implement sensors in infrastructure and vehicles, in order to make efficient mobility management possible.
- Work on route optimisation to improve efficiency and reduce costs in the transport of goods and people, both in urban and rural environments.

6.2.3 R&D Priorities

Based on the general challenges outlined above, the following main R&D thrusts can be highlighted:

- Mobility as a Service (MaaS). Improve sustainable, flexible, continuous and more economical mobility with the aim of replacing the private car and through the use of mobility as a service (MaaS).
- Develop intelligent algorithms for the integration of sustainable solutions based on various forms of transport, public or private, into a single service accessible on demand.
- Use AI-based solutions for the development of more sustainable mobility in urban and rural environments.
- Implement on-demand transport services in rural areas, enabling better connectivity with different means of transport.
- Develop artificial intelligence-based algorithms with real data (i.e. from the Integrated Mobility Data Space (EDIM)). The available data and information will enable their analysis, and facilitate mobility management, to improve the design of sustainable and efficient mobility solutions.
- Implement efficient algorithms, based on real data and artificial intelligence-based systems, for route optimisation, including multimodal systems.

6.3 New mobility services (including air vehicles)

6.3.1 Introduction and definition

There are new mobility services in development for cities, including aerial vehicles such as drones and air taxis. According to the European Aviation Safety Agency (EASA), 83% of the population is in favour of urban aerial mobility, which would include delivery drones and air taxis. These new services aim to reduce traffic congestion and pollution levels in urban areas, while improving access for emergency services and creating a new space for aerial mobility over metropolitan areas.

These systems require some time to implement, but may be in high demand in the future. New mobility services will need to be safely integrated into the urban space (including airspace) alongside existing mobility systems.

6.3.2 Specific challenges

There are different types of transport within cities. In this sub-chapter we will focus on the most relevant challenges in new mobility services. The most important specific challenges are mentioned below:

- Making shared mobility a plausible reality in cities, involving the integration of different transport options.
- Integrate personal mobility systems outside large train and bus stations: bicycles, electric scooters, etc.
- Further promote car sharing, with ride-sharing, ride-pooling (with several stops) or ride-hailing (and car sharing with a driver).
- Develop new means of air transport, based on people-carrying drones, allowing flights of up to 15 min/15 km to city centres.

6.3.3 R&D Priorities

Based on the general challenges outlined above, the following main axes of R&D can be highlighted:

- Developing intelligent algorithms for the integration of sustainable solutions based on various forms of transport, public or private, into a single service accessible on demand.
- Developing intelligent algorithms for the redistribution of last mile vehicles for people, especially at peak hours when demand increases.
- Develop common platforms to make the different services available to users in real time.
- Work on the validation and certification of new drone concepts for people in cities.

06 SUSTAINABLE MOBILITY AND LOGISTICS SERVICES

New technologies have enabled the growth of e-commerce and the emergence of new players in the retail sector. The rise of e-commerce has changed people's consumer habits and is forcing the industry to evolve and transform the delivery of parcels and goods in cities.

6.4 Urban distribution of goods

6.4.1 Introduction and definition

Urban Freight Distribution (UFD), also known as last mile logistics, refers to the final leg in the physical distribution logistics process, from the last place of storage of a product (distribution centre) to the point of delivery to the final consumer or retailer. This is an essential element in the socio-economic activity of cities and presents several challenges and opportunities.

New technologies have enabled the growth of e-commerce and the emergence of new players in the retail sector. The rise of e-commerce has changed the consumption habits of citizens and is forcing the industry to evolve and transform the delivery of parcels and goods in cities. Services with near-instant delivery at the location of the consumer's choice challenge retail chains and force them to rethink current delivery strategies to prevent digital commerce from causing problems for cities in terms of congestion, pollution and noise. In this sub-challenge we discuss the associated challenges and R&D priorities.

SUSTAINABLE AND INTELLIGENT MOBILITY

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SUSTAINABLE MOBILITY AND LOGISTICS SERVICES

6.4.2 Specific challenges

In this context, the most relevant challenges for last mile distribution of goods are described. The most important specific challenges are mentioned below:

- Multimodal logistics must be part of the transformation of last mile freight transport.
- The growth of e-commerce has significantly changed the consumption habits of our society. The challenge of immediacy.
- Sustainable urban mobility planning must also encompass the freight dimension through specific sustainable urban logistics plans.
- Accelerate the deployment of zero emission solutions already available and research into more efficient and sustainable freight delivery.
- Integration of artificial intelligence (AI) is essential for the automation of freight transport in all modes.
- Advancing the implementation of the Logistics One-Stop-Shop concept. This is a technological platform that brings together all the information in the logistics chain and ensures interoperability between the different modes of freight transport.

6.4.3 R&D Priorities

Based on the general challenges outlined above, the following main axes of R&D can be highlighted:

- Research into the implementation of transport corridors for the prioritisation and orderly and planned implementation of multimodality within the urban transport system.
- Work on awareness raising, explaining the carbon footprint associated with each delivery.
- Develop sustainable development plans for last mile parcel delivery systems.
- Optimisation of Hubs, urban Microhubs to achieve more capillary last mile distribution.
- Implement AI techniques for efficient fleet management for more efficient and sustainable last mile delivery.
- Use product traceability within the last mile distribution chain to achieve Logistics One Stop Shop implementation.

CAPABILITIES OF BRTA ACTORS

DISTRIBUTED BY TECHNOLOGICAL CHALLENGES

	AZTERLAN	CEIT
Electric vehicles (Not only road).		
Batteries for electromobility.	●	
Hydrogen.	●	●
Electrical machines (motors).		●
Power electronics.		●
Electric vehicle operation and validation.		
Infrastructure for sustainable mobility.		
Recharging infrastructure.		
Smart infrastructures for CCAM.		●
CCAM Connected and automated cooperative mobility.		
Accurate and safe environment recognition		●
Vehicle interior monitoring.		
Accurate positioning.		●
Secure communications.		●
Decision and control systems.		
Cooperative services.		●
Safety, verification, validation.		
Sustainable mobility and logistics services.		
Sustainable and inclusive public transport.		●
New mobility services (including air vehicles).		●
Urban distribution of goods.		

CIDETEC	CICenergiGUNE	GAIKER	IKERLAN	LEARTIKER	LORTEK	TECNALIA	TEKNIKER	VICOMTECH
●	●	●	●	●	●	●	●	
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AZTERLAN — AZTI — CEIT — CIC bioGUNE — CIC biomaGUNE — CIC nanoGUNE

CIC energiGUNE — CIDETEC — GAIKER — IDEKO — IKERLAN — LEARTIKER

LORTEK — NEIKER — TECNALIA — TEKNIKER — VICOMTECH

MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

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