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Territorial and Industrial Challenges in the Automotive and Aeronautic Sectors

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Overview of the Purpose and Scope

Automotive and Aeronautic Perspective

Rural areas in the SUDOE region have been experiencing depopulation and deindustrialization, with a 0.1% annual decline in the resident population, while large cities have seen a 0.4% annual increase (Eurostat 2023). This shift poses significant challenges, including environmental concerns, economic disparities, and the loss of industrial capacity in less urbanized regions. At the same time, industries must adapt to remain competitive, resilient, and attractive to younger generations, driving the need for innovation in sustainable practices and economic revitalization.

The SUDOE region, spanning parts of Spain, Portugal, and southern France, plays a vital role in Europe's industrial and technological landscape, particularly in the aerospace and automotive sectors. These industries are pivotal in fostering cross-border collaboration, advancing sustainability, and implementing circular economy principles. This white paper explores their interconnected roles in shaping industrial and territorial development, drawing insights from the SCAIRA project to identify obstacles and opportunities for strengthening regional value chains. By integrating strategic approaches to innovation, sustainability, and competitiveness, this report presents a framework for transforming mobility and industrial ecosystems across the region.

Key Findings, shared challenges, opportunities and Conclusions

The SUDOE region, encompassing Spain, Portugal, and France, stands at a pivotal moment of transformation in both the automotive and aeronautical sectors. These industries face significant challenges and opportunities as they adapt to a low-carbon future shaped by stringent environmental goals, evolving customer expectations, and technological advancements.

Both the automotive and aeronautical industries face the dual challenge of corporate and product sustainability, essential for meeting ambitious decarbonization goals like those in the European Green Deal. The automotive sector is rapidly evolving through electrification, connectivity, and autonomous mobility, with electric vehicles projected to exceed 50% of global new sales by 2030. Meanwhile, aeronautics must innovate in sustainable aircraft design and operational

efficiency. Achieving these transformations requires cross-sectoral collaboration, integrating circular economy principles and simultaneous engineering across automotive, aeronautics, rail, and maritime transport to drive sustainable progress.

The Role of the Iberian Sustainable Mobility Ecosystem (ISME)

This white paper presents the Iberian Sustainable Mobility Ecosystem (ISME) as a transformative framework to drive technological innovation, circular economy practices, smart infrastructure, and adaptive regulation. By fostering advancements in electrification, automation, and green manufacturing, ISME aims to enhance regional competitiveness by 15-20% and generate over 100,000 high-skilled jobs by 2030. Additionally, it seeks to cut CO_2 emissions in the automotive sector by 55% by 2030 and 90% by 2050, while attracting over €50 billion in green investments, positioning the Iberian Peninsula as a global leader in sustainable mobility.

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Aeronautical Sector Challenges and Actions

The aeronautical industry must undergo a fundamental transformation to meet sustainability goals, particularly by reducing fossil fuel dependence. Success will require fostering trust-based collaboration across the value chain, revising corporate accounting to prioritize planetary boundaries over short-term gains, and leveraging digital technologies for full-cycle decarbonization. With strong industrial foundations, political commitment, and dynamic innovation ecosystems, the SUDOE region is well-positioned to lead the shift toward sustainable mobility. Aligning the automotive and aeronautical sectors under frameworks like ISME will enable the region to drive economic growth, environmental leadership, and resilience in a low-carbon future.

Introduction

Background and Context

Automotive and Aeronautic Sectors

The automotive and aeronautical industries are undergoing profound transformations driven by climate urgency, resource constraints, and the increasing demand for sustainable mobility solutions. The automotive sector faces challenges related to electrification, evolving supply chains, and shifting consumer expectations, while the aeronautical industry must reconfigure its production systems to meet carbon neutrality goals. Both industries require innovative strategies, particularly in adopting circular economy principles, digitalization, and sustainable materials, to ensure long-term competitiveness and resilience.

This study provides a strategic analysis of both industries, focusing on Portugal, Spain, and France, mapping critical value chains to identify key trends, obstacles, and opportunities for innovation. Special attention is given to the role of rural areas, where industrial transformation can drive economic resilience and balanced regional development. By integrating sustainability-driven approaches, including advanced manufacturing techniques and cross-sector collaboration, both industries can effectively navigate the energy transition while maintaining their economic significance.

The report explores the structural, regulatory, and economic challenges faced by both sectors, highlighting parallels in their sustainability transitions. It examines the adoption of sustainable materials, digitalization in production processes, and circular economy principles, offering a roadmap for adapting to an increasingly regulated and competitive landscape. Additionally, it assesses the integration of local startups into the innovation ecosystem, reinforcing their role in driving sustainable mobility solutions.

To support this transformation, the study presents actionable recommendations for industry stakeholders and policymakers, aiming to foster sustainable growth, enhance international competitiveness, and accelerate the shift toward a low-carbon economy. By aligning the automotive and aeronautical sectors within strategic frameworks, the SUDOE region has the potential to become a leader in sustainable mobility, setting an example for industrial innovation and environmental responsibility on a global scale.

Sectors Overview

Comprehensive Overview

Automotive Industry

Europe is leading automotive innovation, particularly in sustainability, as the EU sets ambitious emissions reduction targets and mandates that all new vehicles be zero-emission by 2035. The transition to electric vehicles (EVs) is no longer optional but essential for meeting environmental regulations and maintaining global competitiveness. Beyond electrification, the industry is undergoing a major transformation, with over €250 billion invested in digitalization, connectivity, and autonomous mobility. Technologies like 5G, cloud computing, and AI are redefining transportation, creating a complex ecosystem where the integration of diverse technologies and business models is key to success.

The automotive sector is increasingly intertwined with energy and IT industries, requiring collaboration to integrate renewable energy sources in production and charging infrastructure. Digitalization, driven by IT advancements, is enabling smart mobility solutions and connected vehicle technologies. However, these interdependencies also pose strategic and regulatory challenges that must be addressed for sustainable growth.

Additionally, global value chains are being restructured to meet sustainability goals, with a growing focus on circular economy principles, recycled materials, and waste reduction. The Draghi Report advocates for a dedicated EU industrial action plan covering the entire value chain. As the industry undergoes its most significant structural transformation, Europe has the opportunity to lead the transition toward a greener and more digital automotive future—provided that it adopts a coordinated, cross-sectoral, and innovative approach

The global automotive industry is undergoing a profound transformation driven by climate urgency, technological advancements, shifting consumer preferences, and evolving regulatory frameworks. The sector is under immense pressure to decarbonize, as road transport remains the largest contributor to global CO2 emissions. The adoption of electric vehicles (EVs), projected to surpass 50% of new vehicle sales by 2030, is a key pillar of this transition, yet it introduces new challenges, including reliance on critical materials like lithium and cobalt, as well as the restructuring of global supply chains. Additionally, urbanization and new mobility models such as Mobility as a Service (MaaS) are reshaping vehicle ownership trends, requiring manufacturers to rethink traditional business models.

Simultaneously, the industry faces growing geopolitical tensions, economic nationalism, and supply chain vulnerabilities, particularly concerning critical raw materials for EV production. The COVID-19 pandemic exposed fragilities in global value chains, further accelerating the push for localization and resilience strategies. At the same time, automakers must navigate increasing digitalization, with vehicles evolving into connected service platforms. However, this shift also raises cybersecurity risks, data privacy concerns, and the need for ethical AI frameworks, particularly in autonomous driving applications. Furthermore, the rapid pace of innovation is rendering legacy production systems obsolete, necessitating significant investments in Industry 4.0 technologies, automation, and workforce reskilling.

To remain competitive and sustainable, the industry must embrace circular economy principles, prioritize sustainable materials, and integrate new technologies while balancing social and labour impacts. Collaboration with smart city initiatives, regulatory adaptation, and the development of vehicles tailored to an aging population are also crucial. The transformation of the sector is not solely a technological challenge but also an economic, environmental, and societal one. Automakers that successfully integrate these dimensions will lead the industry's transition toward a more sustainable, digitalized, and resilient future.

With regard to sustainability...

The global automotive sector is undergoing a rapid transformation driven by stringent environmental regulations, technological advancements, and shifting consumer preferences. The transition to electric and hybrid vehicles is at the forefront of this change, with countries like Portugal, Spain, and France leading the way. EV sales have surged in these nations, supported by expanding charging infrastructure and government incentives. However, challenges persist, particularly in less developed regions where limited access to charging stations hinders widespread adoption. Addressing these disparities, alongside ensuring a resilient supply chain for critical materials like lithium and cobalt, remains essential. To mitigate risks, the industry is diversifying supply sources, advancing battery recycling technologies, and exploring alternative energy storage solutions such as sodium-based and solid-state batteries.

Sustainability is also driving innovation in materials and production processes. The automotive industry is increasingly integrating circular economy practices, eco-design principles, and advanced recycling technologies to reduce its environmental impact. French manufacturers have achieved up to a 20% reduction in carbon footprint through battery recycling and biocomposite usage, while Spain has made significant progress in utilizing recycled metals. These efforts align with broader sustainability goals by ensuring that environmental considerations are embedded throughout the product lifecycle, from design to end-of-life management.

Beyond electrification and materials, digitalization is reshaping industry. Technologies such as blockchain, IoT, and big data are enhancing supply chain transparency, cybersecurity, and compliance with environmental

regulations. Additionally, alternative energy sources like green hydrogen and advanced biofuels are gaining traction, particularly in heavy-duty transport and industrial applications. France, Portugal, and Spain are making substantial investments in hydrogen infrastructure and biofuel research, further supporting Europe's path toward climate neutrality. By integrating these technological, environmental, and economic strategies, the automotive sector is positioning itself for a more resilient and sustainable future

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Challenges in the Automotive Sector

Global Challenges

The automotive industry is undergoing a profound transformation as it faces mounting pressure to decarbonize, embrace new technologies, and adopt sustainable business models. Currently, the sector is responsible for approximately 15% of global CO_2 emissions, prompting increasingly stringent regulatory targets, such as the EU's mandate to cut emissions from new cars by 55% by 2030. This urgent shift necessitates the rapid adoption of electric propulsion and other low-emission technologies while maintaining economic competitiveness.

Electrification is a key driver of this transition, with electric vehicles (EVs) expected to comprise 58% of global passenger car sales by 2040. However, significant challenges remain, including the development of more efficient and sustainable batteries, expansion of charging infrastructure, and securing critical material supply chains. Alongside electrification, digitalization is transforming the industry, with projections indicating that 95% of new vehicles sold by 2030 will be connected. This shift demands substantial investment in software, electronics, cybersecurity, and consumer data management to enhance vehicle performance and user experience.

Autonomous vehicle technology is another emerging trend, with the market expected to grow at a CAGR of 39.47% from 2021 to 2028. However, technological advancements must align with regulatory frameworks, ethical considerations, and consumer acceptance to ensure widespread adoption. Simultaneously, new business models such as Mobility-as-a-Service (MaaS) are disrupting traditional vehicle ownership, with the market projected to reach $52.6 billion by 2027. Automakers must adapt to evolving revenue streams and changing consumer behaviour.

Sustainability is becoming a critical pillar of the industry, particularly in supply chain management. With increasing regulatory scrutiny, such as the EU's proposed due diligence regulations, companies must ensure greater transparency, traceability, and adherence to circular economy principles. Balancing sustainability with operational efficiency will be essential to securing long-term competitiveness in a rapidly evolving automotive landscape.

Spain, France and Portugal

Spain, Portugal, and France play a crucial role in Europe's automotive industry, employing over 2 million people across the three countries. However, as the sector transitions toward electrification and digitalization, reskilling the workforce and attracting new talent in key areas such as software, electronics, and green technologies become pressing challenges. Ensuring a smooth transition for workers will be essential to maintaining industrial competitiveness in a rapidly evolving landscape.

Global competition further intensifies these challenges, with Europe's share of automotive production falling from 30% in 2000 to 22% in 2020, largely due to the rise of emerging markets in Asia. To counteract this decline, the region must focus on innovation, productivity enhancements, and the adoption of advanced manufacturing techniques to sustain its competitive edge.

Small and medium-sized enterprises (SMEs) form the backbone of the automotive supply chain in these countries, representing a significant share of employment—70% in Portugal alone. Supporting SMEs in their transition to new technologies, sustainable business models, and digitalization will be key to ensuring the resilience and adaptability of the sector.

A major infrastructure challenge lies in the expansion of EV charging networks. To meet electrification targets, the region must install over 3 million charging points by 2030. Coordinating public and private investments will be essential in building a robust, efficient, and widespread charging infrastructure that facilitates the adoption of electric vehicles across urban and rural areas.

Proposed Solution: The Iberian Sustainable Mobility Ecosystem (ISME)

To address these challenges and capitalize on emerging opportunities, we propose the establishment of the Iberian Sustainable Mobility Ecosystem (ISME). This holistic and integrated approach aims to transform the automotive sector in Spain, France, and Portugal, positioning the region as a global leader in sustainable mobility and innovation.

The Importance of Automotive Clusters in France, Spain, and Portugal – the SUDOE Region

France, Spain, and Portugal are key players in Europe's automotive industry, each contributing significantly to production, innovation, and sustainability. Spain, the continent's second-largest car manufacturer, continues to modernize its

industry, with a strong focus on EV production and digital transformation. France, home to major manufacturers like Renault and Stellantis, leads in sustainable mobility initiatives and green hydrogen development. Portugal, though smaller in production scale, has emerged as a leader in electric mobility, expanding its EV infrastructure and integrating renewable energy into manufacturing.

These three countries share a commitment to sustainability, with ambitious emission reduction targets and growing investments in circular economy practices. Innovative ecosystems in cities like Paris, Barcelona, and Lisbon foster collaboration between startups, research centers, and industry leaders, driving advancements in mobility solutions. Additionally, their strategic geographic position enhances their role as key hubs for trade and industrial integration between Europe, Africa, and Latin America.

Despite shared challenges such as infrastructure modernization and workforce upskilling, Spain, France, and Portugal have a unique opportunity to strengthen regional collaboration, enhance value chains, and position themselves at the forefront of Europe's automotive transformation. By leveraging their industrial strengths, technological advancements, and supportive government policies, these countries can lead the shift toward a competitive, sustainable, and future-ready automotive sector.

Sustainability in Rural Areas and Its Implications for the Automotive Sector

Sustainability in rural areas is essential for a balanced transition in the automotive sector, addressing both challenges and opportunities. Limited infrastructure and access to technology hinder the adoption of electric mobility, yet targeted investments are bridging this gap. In Portugal, rural charging stations have increased by 20% in two years, while Spain is developing charging corridors to connect urban and rural areas. France has successfully revitalized rural economies through green job creation, with a 15% rise in employment linked to electric mobility and renewable energy initiatives.

Integrating rural suppliers into automotive value chains strengthens local economies and reduces carbon footprints. Spain is leading efforts to incorporate SMEs into circular supply chains, while Portugal is advancing digitalization in rural industries to support a green economy. Additionally, regional innovation in materials, such as sodium-ion batteries, is reducing dependency on critical imports, fostering Europe’s leadership in sustainable battery technologies. Circular economic strategies, including advanced battery recycling, further enhance resource efficiency and create local economic opportunities.

While rural areas remain dependent on

private vehicles due to limited public transport, tailored solutions such as mobile charging stations and shared mobility services, like robot-buses, can improve accessibility and sustainability. Leveraging renewable energy sources in these regions presents an opportunity for economic revitalization while supporting decarbonization efforts. This study explores the unique needs of rural areas in France, Spain, and Portugal, offering strategic recommendations to align sustainability goals with inclusive regional development.

Aeronautics Industry

The European Union has introduced ambitious policies, such as the European Green Deal and ReFuelEU Aviation, to drive sustainability in the aeronautical sector. These initiatives enforce stricter CO_2 reduction targets, promote sustainable aviation fuels (SAF), and include financial incentives like the EU Emissions Trading System (EU ETS) to encourage cleaner operations. Additionally, the Single European Sky initiative optimizes air traffic management, reducing emissions through streamlined flight routes, while the European Union Aviation Safety Agency (EASA) ensures rigorous safety standards across the industry.

The aeronautics value chain in the SUDOE region (France, Spain, and Portugal) involves a complex network of aircraft manufacturers, specialized SMEs, suppliers, airlines, and research institutions. Close collaboration between these stakeholders is essential to meet environmental and technological challenges. Each stage—R&D, Manufacturing, Assembly, Operation, Maintenance, and End-of-Life—presents unique challenges and opportunities for sustainability and efficiency. From advanced research in fuel-efficient designs to rigorous manufacturing processes and quality control, every phase requires innovation and integration to maintain global competitiveness.

A key focus is circular economy principles, particularly in aircraft dismantling and recycling. At the end of their lifecycle, aircraft components such as engines and electronic systems are reconditioned or resold, supporting resource efficiency. The growing emphasis on Maintenance, Repair, and Overhaul (MRO) services also ensures longer operational life, reducing environmental impact. By integrating sustainability across the value chain, the aeronautical sector in SUDOE is positioning itself as a leader in sustainable aviation and industrial innovation.

Circularity in the Aeronautic Sector

Eco-design in the Aeronautic Sector

Eco-design in aeronautics is a Research & Development (R&D) initiative that integrates environmental criteria from the initial stages of product design, ensuring reduced environmental impact throughout the aircraft's life cycle. The responsibility for implementing eco-design lies with R&D teams, engineers, and designers, while key stakeholders include aircraft manufacturers and subcontractors. Although some industry leaders have incorporated sustainable practices into their design processes, achieving a fully integrated eco-design approach across the value chain remains a challenge. Life-cycle assessments (LCAs) provide valuable insights into current environmental impacts but do not always lead to actionable change.

A primary focus of eco-design is

reducing the sector's carbon footprint, but a more comprehensive approach must also address broader sustainability challenges. Decarbonizing aircraft propulsion is critical, with advancements such as Sustainable Aviation Fuels (SAFs), electrification, and hydrogen propulsion expected to reach technological maturity by 2035. Additional innovations, including Open Rotor technology, lightweight composite materials, and aerodynamic optimizations, are enhancing aircraft efficiency and driving the transition toward sustainable aviation.

Despite its benefits, eco-design faces several obstacles, including stringent safety and certification requirements, high development costs, and the complexity of the aerospace supply chain. Aircraft longevity (20-30 years) further slows down the adoption of greener technologies. However, key drivers such as growing environmental awareness, lower operational costs, and collaborative partnerships between manufacturers, suppliers, and research institutions are accelerating progress. The development of dedicated eco-design standards for the aerospace industry could also provide a common framework to facilitate broader adoption.

Sustainable and local sourcing in aeronautics

Sustainable and local sourcing, a fundamental aspect of manufacturing and production, aims to reduce the environmental footprint of aerospace materials while enhancing supply chain resilience. Value chain managers are responsible for its implementation, with suppliers, subcontractors, central procurement agents, and end-line aircraft users playing crucial roles. This approach promotes the use of eco-responsible and renewable materials, encouraging collaboration within regional ecosystems to minimize carbon emissions and reliance on global supply chains.

Despite its potential benefits, implementing sustainable sourcing in aeronautics faces significant challenges. The highly globalized nature of supply chains makes it difficult to replace existing sourcing models, as many procurement decisions are made centrally by major aerospace companies. Furthermore, stringent technical constraints and certification requirements slow down the adoption of alternative materials, as all components must meet strict safety and performance standards. While some materials, such as composites and textiles, can be produced locally, aerospace-grade metals remain largely sourced from international suppliers. Additionally, economic barriers pose challenges, as sustainable materials and certification processes often involve higher upfront costs, making it difficult for small suppliers to compete.

Nevertheless, there are key drivers supporting the shift toward sustainable and local sourcing. One of the main incentives is the reduction of carbon footprints, with increasing pressure to integrate lower-emission suppliers and prioritize renewable or recycled materials. Additionally, recent supply chain disruptions, such as those seen during the

COVID-19 crisis, have highlighted the need for greater resilience by reducing dependence on overseas suppliers. Regulatory frameworks, including REACH, CSRD, and CS3D, are also driving change by requiring companies to improve supply chain transparency and sustainability practices. Moreover, industry standards and certifications could facilitate the transition by providing clear guidelines for incorporating recycled materials into aerospace manufacturing.

Another crucial factor is the development of regional supply hubs to strengthen local industrial ecosystems. While certain certified materials remain difficult to source locally, non-aviation components such as packaging and tooling present immediate opportunities for sustainable procurement. Government incentives, such as the France Relance Plan, play a key role in supporting companies through tax breaks, innovation funding, and public-private partnerships. In this evolving landscape, sustainable and local sourcing will become increasingly important for enhancing competitiveness, reducing environmental impact, and securing long-term supply chain stability in the aerospace industry.

Processes to reduce waste and impact

Innovative manufacturing and assembly processes in the aerospace industry are essential for reducing waste and minimizing environmental impact. These efforts involve optimizing existing production techniques, reusing materials such as metal and composite off-cuts, and improving energy efficiency. The responsibility for implementing these innovations lies with designers, key players in the aircraft manufacturing chain, and research institutes, while other stakeholders, including maintenance teams, recycling specialists, and waste reclamation entities, play a crucial role in ensuring sustainable practices across the aircraft lifecycle.

One of the most promising innovations is additive manufacturing, which significantly reduces material waste. However, challenges remain, including the recyclability of metal powders and the need for these materials to meet stringent safety and durability standards. Additionally, implementing eco-friendly processes requires significant investment, particularly for smaller suppliers, and must navigate complex certification procedures that can delay adoption. Compatibility with existing specifications and materials is another constraint, as recycled or alternative materials must meet the same high-performance requirements as traditional ones.

Despite these challenges, proactive strategies can accelerate the transition to more sustainable manufacturing. Anticipating regulatory changes will help companies align with future environmental standards while investing in innovation strengthens competitiveness in an increasingly eco-conscious industry. Lower energy consumption and optimized resource use can also lead to economic benefits, helping the sector balance environmental responsibility with long-

term profitability.

Recovering production waste in the aeronautics industry

Manufacturing and assembly are the primary areas generating waste in the aeronautics sector, with players in the aircraft manufacturing chain responsible for managing and optimizing recycling processes. Involved actors, such as recycling companies and other industry stakeholders, play a crucial role in ensuring efficient material recovery. Waste from production—including machining offcuts, swarf, and assembly residues—differs from end-of-life waste and requires distinct treatment methods. While European regulations prioritize waste prevention, reuse, and recycling, the industry still faces challenges in optimizing these processes to align with circular economic principles.

Metal recycling, particularly for critical alloys like titanium and aluminum, is a growing priority due to supply chain vulnerabilities. However, effective recovery requires precise sorting at the production stage, which many companies struggle to implement due to logistical and economic constraints. Composite recycling presents additional difficulties, as current processes degrade fiber quality, limiting reuse in high-performance applications like aircraft structures. Meanwhile, electronic and polymer waste management remains underexplored in aeronautics, highlighting a gap in sustainable production practices.

Despite these challenges, key drivers for better waste recovery include reducing raw material costs through in-house reuse, advancing recycling technologies for complex materials, and fostering industrial partnerships to scale up recycling efforts. New regulations, such as the Critical Raw Materials Act, emphasize the need for sustainable material sourcing, pushing the industry toward more efficient waste management. Collaboration between manufacturers and regional partners can help establish viable recycling channels, improving both environmental impact and economic resilience in the sector.

Maintenance in the aeronautics industry

Maintenance, Repair, and Overhaul (MRO) is a critical component of the aeronautical industry, ensuring aircraft safety, airworthiness, and longevity. Airlines and approved maintenance organizations are responsible for these operations, while aircraft manufacturers, equipment suppliers, and regulatory authorities play supporting roles. MRO activities extend the service life of high-value components, such as engines, which can operate for decades through part replacements and refurbishments. However, challenges persist in managing spare parts supply chains, optimizing costs, and addressing workforce shortages, especially in light of recent global disruptions.

Safety remains the top priority, with maintenance checks conducted based on flight hours, operational duration, or equipment condition. Compliance with

evolving regulatory frameworks, including EASA Part 145 and FAA standards, is essential, driving the need for continuous adaptation. The growing integration of predictive maintenance and digital monitoring systems is transforming the sector, reducing unexpected failures and improving cost efficiency. However, these advancements require substantial investment, intensifying competition among service providers to adopt cutting-edge technologies.

While refurbishment presents opportunities, its feasibility is limited to non-critical components like cabin interiors. Strict safety and airworthiness standards make refurbishing technical parts highly complex and costly. Additionally, the decentralized nature of MRO operations complicates supply chain localization, requiring flexible logistics. Key levers for advancing the sector include the adoption of predictive maintenance, process automation through digital MRO platforms, and stronger collaborations between industry leaders, startups, and research institutions. These efforts will enhance operational efficiency, reduce maintenance costs, and ensure compliance with increasingly stringent regulatory demands.

End-of-life aircraft

Aircraft end-of-life management involves decommissioning, dismantling, and recycling processes, with brokers and specialized dismantling companies leading these efforts. Airlines, aircraft manufacturers, and recycling companies also play crucial roles in ensuring that valuable components and materials are recovered efficiently. Despite progress in this area, the sector remains largely unregulated on a global scale, leading to inconsistent recycling practices and the persistence of aircraft graveyards.

Economic recovery of aircraft components is a key focus, with high-value parts such as engines, landing gear, and avionics being removed, refurbished, and resold. However, only around 10% of an aircraft's total weight is currently recovered for resale, highlighting the need for improved material recycling. While metals like aluminum and titanium can be efficiently processed, composite materials present significant challenges due to their complex bonded structures and degradation during flight operations. Similarly, foams, textiles, and electronic components often end up in landfills or incinerators, as recycling solutions for these materials remain underdeveloped.

To enhance aircraft recyclability, advancements in chemical and mechanical recycling technologies are essential, particularly for composite materials. Integrating eco-design principles from the outset can facilitate easier dismantling and material recovery, reducing end-of-life processing costs. The development of markets for recycled aircraft materials in sectors such as automotive and construction could further incentivize sustainable practices. Additionally, establishing globally harmonized regulations would standardize dismantling procedures and encourage investment in recycling infrastructure, preventing aircraft from being disposed of in regions with minimal environmental oversight.

Future Perspectives and Emerging Trends

Automotive and Aeronautic Sectors

Emerging Innovations and Trends in the Aeronautic Sector

The aeronautics industry is undergoing a transformation driven by sustainability, technological advancements, and regulatory pressures. From material extraction to aircraft dismantling, every stage of the value chain is facing new challenges and opportunities.

Material Extraction & Supply Chain Resilience

The aeronautics sector relies heavily on critical raw materials such as titanium, aluminium, and composites, which are subject to supply risks due to geopolitical dependencies and environmental concerns. To mitigate these risks, companies must map material and energy flows, diversify suppliers, and integrate recycling and alternative materials into production. Strategies like SteelZero and the European Raw Materials Alliance are fostering sustainable sourcing. Long-term contracts, predictive demand planning, and transparent supplier assessments are essential for ensuring supply chain resilience.

Production & Resource Efficiency

Aircraft production is highly energy- and material-intensive, requiring a shift toward low-carbon manufacturing. Investments in carbon-free energy, digitalization of supply chains, and process optimization can help reduce emissions and costs. Circular economy principles are becoming central, with a focus on machining waste recovery, composite material recycling, and energy efficiency through innovative solutions like solar paints and waste heat recovery.

Logistics & Transport Optimization

The aeronautics industry depends on complex logistics networks that must be optimized for a low-carbon future. Key strategies include:

Reducing transport distances by localizing suppliers.

Reusing and recycling packaging materials to minimize waste.

Maximizing vehicle occupancy rates and avoiding empty return trips.

Using rail, river, and multimodal transport to reduce reliance on carbon-intensive trucking.

Operations & Aircraft Lifecycle Emissions

Aircraft operations account for 98% of

aviation emissions, making eco-design and alternative fuels critical for reducing environmental impact. Sustainable aviation fuels (SAF), hydrogen, and electrification are driving the transition, but challenges remain in scaling production. At the manufacturer level, optimizing aircraft and engine design is key to improving fuel efficiency. Airlines are increasingly focusing on lighter cabins, waste reduction, and digitalization to optimize operations. Airports are also investing in carbon reduction initiatives, including LED lighting, electric ground vehicles, and green energy integration.

Maintenance & Repair (MRO) Sustainability

Aircraft maintenance generates waste through spare parts replacement and chemical usage. While predictive maintenance and process digitalization improve efficiency, sustainability remains a secondary focus. New solutions such as remanufacturing and refurbishment can extend component lifespans, reducing material consumption and costs. Industrial partnerships with AI-driven diagnostics and automation are streamlining maintenance workflows while supporting environmental goals.

Dismantling & End-of-Life Aircraft Recycling

With over 20,000 aircraft expected to be retired in the next 20 years, dismantling and recycling processes are becoming increasingly important. Companies like TARMAC Aerosave have developed methods to recycle up to 92% of an aircraft's weight, but composite materials and complex alloys remain difficult to process. Expanding the market for recycled aviation-grade materials, improving sorting and traceability, and investing in chemical recycling technologies will be essential for integrating aeronautics into a circular economy.

Key Drivers for a Sustainable Aeronautics Industry

The aeronautics sector is advancing sustainability through circular economy integration, enhancing material recycling and traceability. Low-carbon technologies, such as SAF, hydrogen propulsion, and electrification, are key to reducing emissions. Digitalization and AI-driven analytics optimize logistics, maintenance, and supply chains for greater efficiency. Industrial partnerships and policy support foster collaboration between airlines, manufacturers, and recyclers, accelerating green innovation. Harmonized global regulations are essential for sustainable aircraft dismantling and end-of-life management. By combining innovation, cooperation, and regulatory alignment, the industry can ensure a resilient and sustainable future.

Emerging Innovations and Trends in the Automotive Sector

The automotive industry is undergoing an accelerated transformation, driven by the need for innovation, sustainability, and adaptation to evolving consumer and regulatory demands. Emerging technologies are reshaping the future of mobility, offering solutions that enhance efficiency, reduce costs, and address critical challenges. Below, we explore the key innovations or Key drivers for this transformation, highlighting their benefits, the needs they fulfil, and the problems they solve:

Advancements in battery technology and alternative energy sources are transforming the automotive sector. Solid-state batteries promise higher energy density, faster charging, and improved safety, though high production costs remain a challenge. Green hydrogen is emerging as a viable solution for heavy-duty transport, while solar panel integration extends EV range and reduces reliance on charging infrastructure. Microalgae biofuels and thermal energy storage systems offer additional sustainable alternatives, optimizing fuel efficiency and reducing emissions.

Innovations in materials and manufacturing are driving sustainability and efficiency. Nanotechnology, 3D printing, and biomaterials enhance vehicle performance while reducing environmental impact. 4D printing enables self-adaptive components, and self-healing coatings extend vehicle lifespan. Recycling and upcycling practices are also evolving, with circular economy initiatives improving the reuse of materials like titanium, aluminum, and composites.

Digitalization and AI-driven solutions are revolutionizing automotive operations. Predictive maintenance, AI-powered energy management, and blockchain-based component traceability enhance efficiency, safety, and sustainability. Autonomous Vehicles as a Service (AaaS) are reshaping urban mobility, while gamification promotes eco-friendly driving habits. Advanced sensors, drone inspections, and augmented reality further optimize logistics and maintenance.

Policy and industrial collaboration are key to sustainable transformation. Strengthening global regulations on end-of-life vehicle recycling, investing in low-carbon technologies, and fostering public-private partnerships will accelerate green innovation. Developing alternative propulsion systems like solid oxide fuel cells (SOFCs) and switched reluctance motors (SRMs) will further enhance the transition to a low-emission future.

Global Megatrends – Shaping the Automotive Industry in SUDOE Region

The automotive industry is undergoing a major transformation driven by polarization, automation, connectivity, and electrification. Regionalized supply chains are reshaping production to enhance local resilience, while AI and robotics are revolutionizing manufacturing and vehicle automation. At the same time, IoT integration is enabling smarter mobility solutions, and the widespread adoption of EVs and renewable energy is accelerating the shift toward sustainability.

For the SUDOE region, aligning with these megatrends is crucial to maintaining competitiveness. Strengthening local clusters and leveraging regional strengths will help navigate supply chain polarization. Meanwhile, the EU's 2035 zero-emission target reinforces the region's push for innovation and sustainability. By capitalizing on these trends, SUDOE can position itself as a leader in the future of the automotive sector, contributing to both economic growth and environmental progress.

The SUDOE region's automotive sector is well-positioned to lead in sustainability, innovation, and connectivity by leveraging its regional strengths and aligning with global megatrends. Future perspectives and trends should be framed through a lens of inclusivity, resilience, and adaptability, ensuring balanced development across urban and rural areas.

The automotive industry's transformation is driven by electrification, automation, connectivity, regionalization, and new business models. By 2040, Europe's BEV market share is projected to reach 99%, emphasizing the need for expanded charging infrastructure—particularly in rural areas—and renewable energy integration. France's leadership in hydrogen technology can guide Portugal and Spain in their adoption strategies. Challenges include critical material dependency and charging infrastructure gaps, requiring local battery recycling hubs and renewable-powered mobile charging units.

Automation and AI are reshaping R&D, manufacturing, and vehicle operation, with Level 4 autonomous vehicles (AVs) expected in urban areas by 2040. However, rural regions require tailored solutions, such as autonomous shuttles. Workforce displacement due to automation presents challenges but also opportunities for AI and robotics training programs. Meanwhile, software-defined vehicles will dominate, enabling continuous upgrades and enhanced vehicle-to-everything (V2X) connectivity, though cybersecurity risks and high implementation costs must be addressed.

With global markets polarizing, strengthening local supply chains and leveraging SUDOE's strategic location as a logistics hub between Europe, Africa, and Latin America is crucial. The shift toward service-based business models, including Mobility as a Service (MaaS) and subscription-based vehicle services, will redefine urban and rural mobility. Paris and Barcelona can pilot MaaS solutions, while rural areas benefit from shared EV fleets. Circular economy initiatives, such as bioplastics, battery recycling, and sustainable materials, must be accelerated despite high development costs.

Finally, workforce upskilling and social inclusion are key to ensuring a just transition. Cross-border training programs and green job

initiatives in rural areas will support digital literacy and workforce adaptation. By aligning with these trends, SUDOE can position itself as a leader in sustainable and innovative mobility, balancing economic competitiveness and environmental responsibility.

ISME – Iberian Sustainable Mobility Ecosystem

The ISME (Iberian Sustainable Mobility Ecosystem) is a comprehensive and interconnected framework that spans the entire automotive value chain, integrating research, production, usage, and end-of-life processes. It is built upon five key pillars: Circular Technological Innovation, Value Chain Transformation, Intelligent and Connected Infrastructure, Adaptive Regulation, and Cross-Border Collaboration. By addressing these areas holistically, ISME aims to accelerate the shift toward sustainable mobility, fostering an ecosystem where innovation, resource efficiency, and regulatory alignment drive long-term competitiveness.

At its core, ISME is guided by key principles that ensure sustainability and inclusivity. It prioritizes comprehensive sustainability across all lifecycle stages, collaborative innovation between industry, academia, and startups, and circularity through resource recovery and recycling. Digitalization is leveraged to optimize efficiency, while resilience ensures adaptability to market shifts and disruptions. Furthermore, ISME promotes inclusivity, ensuring that the transition to sustainable mobility is accessible across regions and social groups, while positioning the Iberian region as a global leader in next-generation mobility solutions.

Main Components of the ISME

Circular Technological Innovation

The Advanced Battery Excellence Center in Valladolid, Spain, aims to enhance solid-state battery technology, recycling, and intelligent battery management, with a goal of increasing energy density by 50% and cutting costs by 40% by 2030. Meanwhile, Portugal's Sustainable Materials Laboratory at INESC TEC is developing bio-composites, nanomaterials, and lightweight advanced steels, targeting a 30% reduction in vehicle weight by 2035. France's Hydrogen Propulsion Hub in Toulouse is focused on fuel cells, storage, and refueling infrastructure, with an ambition to achieve over 60% efficiency and 50% cost reduction by 2030. Additional research initiatives include piezoelectric energy generation in Madrid and compact redox flow batteries in Coimbra, both driving innovative energy solutions for the mobility sector.

The transformation of the value chain includes a blockchain-based digital traceability platform, ensuring 100% component traceability by 2030, and the establishment of smart, carbon-neutral factories, with a goal of transitioning 80% of facilities to carbon neutrality by 2035. A Green Logistics Consortium is developing electrified and hydrogen-powered transport networks, aiming for a 70% reduction in logistics-related emissions by 2030. Additionally, a Pan-Iberian ultra-fast charging network, autonomous mobility corridors, and AI-driven urban traffic

control centers will support the transition toward intelligent and connected infrastructure, reducing urban congestion by 40% and emissions by 50% by 2035.

To enable adaptive regulation, the creation of an Iberian Regulatory Sandbox for Mobility will accelerate time-to-market for new mobility technologies by 40%, while a harmonized incentive system across Spain, Portugal, and France aims to boost low-emission vehicle adoption by 50% by 2030. A Mobility Data Governance Framework will standardize data collection and privacy measures, fostering a secure and innovative mobility ecosystem by 2028. These regulatory advancements will ensure a unified, cross-border approach to sustainable mobility policies.

Finally, cross-border collaboration will be strengthened through a €5 billion Sustainable Mobility Innovation Fund, supporting 500 startups and projects by 2030. A Talent Exchange Program will facilitate 10,000 professionals and students' mobility and create a shared Sustainable Mobility Engineering curriculum. The Sustainable Mobility Cities Alliance will engage 50 cities by 2025, coordinating 100 pilot projects by 2030 to share best practices and accelerate urban mobility transformation across the region.

The successful implementation of the Iberian Sustainable Mobility Ecosystem (ISME) promises substantial benefits across economic, environmental, social, technological, and geopolitical dimensions, creating a virtuous cycle of innovation, sustainability, and growth.

Strategic Considerations for the Automotive Sector

To ensure the sustainable growth and competitiveness of the automotive sector, strategic actions must be taken by key stakeholders, including governments, manufacturers, suppliers, research institutions, and investors. These recommendations focus on fostering innovation, promoting regulatory harmonization, enhancing infrastructure, and supporting workforce reskilling to drive a sustainable and competitive ecosystem.

Governments should establish a unified regulatory framework, invest in electric and hydrogen infrastructure, implement tax incentives for low-emission vehicles, and support large-scale training programs for future mobility skills. Automotive manufacturers must accelerate electrification, adopt digital transformation, explore new business models, and embrace open innovation to remain competitive. Suppliers need to diversify technological portfolios, integrate sustainable practices into value chains, and strengthen collaborations with OEMs. Research institutions should focus on cross-border research in critical areas like advanced batteries and AI, while investors are encouraged to develop specialized sustainability funds, integrate ESG criteria, and engage in public-private partnerships.

By implementing these measures, all stakeholders can contribute to a resilient and innovative automotive industry, aligning economic growth with environmental and societal objectives.

To advance the implementation of ISME,

immediate actions include organizing a trilateral summit between Spain, France, and Portugal to formalize commitments, establishing a dedicated working group, and developing a detailed implementation roadmap with clear objectives and responsibilities. A joint financing mechanism will be created, leveraging public and private resources, alongside a robust monitoring system to track progress and ensure effectiveness.

In parallel, future industry scenarios have been developed using morphological analysis and expert input through meta-analysis. These scenarios consider key uncertainties such as the adoption rate of electric vehicles, advancements in autonomous driving, shifts in vehicle ownership models, progress in sustainable mobility infrastructure, and regulatory evolution. By mapping out these potential trajectories, stakeholders can better navigate the industry's transformation and align strategies with emerging challenges and opportunities.

Scenario 1 – Sustainable Leadership

In this optimistic scenario, the region positions itself as a global leader in sustainable mobility, with 90% of new vehicles being electric by 2035 and autonomous vehicles making up 40% of urban traffic. A 70% reduction in CO_2 emissions is achieved, and the region secures 30% of the global market for sustainable mobility technologies. Reaching this vision requires massive investments in R&D, infrastructure, and close collaboration between public and private sectors to drive innovation and ensure a sustainable competitive edge.

Scenario 2 – Gradual Transition

A more moderate but steady transformation unfolds in this scenario, where 70% of new vehicles are electrified (including hybrids) by 2035, and autonomous technology remains limited to specific applications. The sector achieves a 50% reduction in CO_2 emissions, and the region maintains its competitive position without becoming a global leader. This approach minimizes short-term disruptions but misses the opportunity for market dominance, suggesting that a bolder strategy would be needed to maximize long-term gains.

Scenario 3 – Disruption of Mobility Services

Here, business model innovation surpasses technological advancements, leading to a 40% decline in private vehicle ownership in urban areas as shared mobility services dominate the market. Traditional car manufacturers pivot towards mobility services, significantly reducing the total number of vehicles but increasing their utilization. This shift demands a major industry restructuring, with a strong focus on service-oriented business models and advanced data management to stay competitive in an evolving mobility landscape.

Scenario 4 – Stagnation and Loss of Competitiveness

This pessimistic scenario reflects a failure to adapt to global shifts, resulting in only 40% of vehicle sales being electric by 2035 and delays in autonomous technology development. The region loses market share to Asian and American competitors, failing to meet emission reduction targets, which leads to financial penalties and declining investments. This underscores the risks of inaction or insufficient progress, emphasizing the urgent need for a proactive, coordinated strategy to secure long-term viability and competitiveness.

These scenarios are not predictions, but strategic tools designed to test the resilience of proposed plans under different future conditions. By exploring multiple possibilities, they help identify hidden opportunities and risks, offering a broader perspective on potential challenges. Additionally, they encourage proactive strategic thinking, enabling stakeholders to anticipate market, technological, and regulatory shifts. Integrating these scenarios into planning and investment decisions enhances adaptability, aligns strategies with emerging trends, and maximizes opportunities while mitigating risks.

Future and Hypothetical Case Studies as a Prospective Exercise

Case Study 1: Advanced Battery Cluster in Navarra, Spain

The establishment of a "gigafactory" in partnership with a global battery manufacturer aims to create 5,000 direct jobs and 15,000 indirect jobs by 2030. An R&D centre focusing on solid-state battery technologies could reduce battery costs by 30% for local manufacturers. A cutting-edge battery recycling facility would result in a 45% increase in energy density for batteries produced between 2025 and 2035. Additionally, a training program in partnership with local universities could establish Navarra as a European leader in battery technology.

Lessons Learned for this Scenario include the importance of public-private collaboration for funding and planning, the need for simultaneous advancements in production, R&D, and recycling, and the value of integrating training and skills development from the start.

Case Study 2: Autonomous Mobility Corridor Paris-Bordeaux

The implementation of 5G infrastructure along the corridor could reduce traffic accidents by 60%. Safe transition zones for entering and exiting autonomous mode would increase traffic flow efficiency by 30%. A centralized AI-based traffic management system could contribute to a 25% reduction in CO2 emissions from transportation within the corridor. Collaboration among various manufacturers would position France as a leader in autonomous vehicle infrastructure.

Lessons Learned for this Scenario highlight the importance of close collaboration between transportation authorities, telecom companies, and automakers, addressing safety and regulatory issues early on, and adopting a phased approach, starting with Level 3 applications before advancing to more complex solutions.

Conclusion

In a low-carbon future, the aeronautics sector faces two primary challenges: corporate sustainability and the sustainability of its products and services. While current roadmaps for the industry propose actions to make aircraft use more sustainable, they often fall short in addressing the critical issue of reducing fossil fuel dependency in aircraft production. To navigate this, the aeronautical industry must restructure by adopting collaborative systems and evolving the traditional "customer-supplier" relationship towards collective paradigms like simultaneous engineering. A revision of the corporate accounting framework will also be essential, placing planetary boundaries above economic performance to prioritize environmental sustainability.

Decarbonization, amid limited natural resources, is a collective responsibility that can be advanced through digital technology and the exchange of best practices across industries. As industries like aviation and mobility transition, the need for cross-sector collaboration, including road, rail, and sea transport, becomes increasingly crucial. Innovations and new priorities must be embraced swiftly to meet environmental challenges and ensure long-term sustainability in these sectors.

The global automotive sector is undergoing a paradigm shift, largely driven by electrification, connectivity, and autonomous mobility. By 2030, electric vehicles (EVs) are expected to comprise over 50% of global vehicle sales, a transformation accelerated by EU policies such as the European Green Deal. Spain, France, and Portugal, with their strong industrial bases and political commitments to sustainability, are well-positioned to lead this transition toward sustainable mobility, creating opportunities for innovation and competitiveness within the automotive sector.

The transformation of the automotive industry should focus on systemic innovation, strategic agility, and comprehensive sustainability. This includes adopting circular economy principles, embracing deep digitalization, and forging expansive collaborations with sectors like technology, energy, and urban planning. A shift toward customer-centric mobility solutions and resilient supply chains will be essential for addressing both technological disruptions and societal demands, while ensuring social responsibility and just transition for workers.

The Iberian Sustainable Mobility Ecosystem (ISME) offers an integrated solution to these challenges, aiming to drive technological innovation, value chain transformation, and cross-border collaboration. ISME's successful implementation is projected to boost competitiveness by 15-20% by 2030, create over 100,000 jobs, and significantly reduce CO2 emissions in line with EU climate goals. Additionally, the initiative could attract over €50 billion in green investments by

2030, positioning Spain, France, and Portugal as global leaders in sustainable mobility. The urgency of adopting such integrated strategies is clear, as the region stands at a critical juncture to shape a resilient, green automotive future

Suggestions to accelerate Innovation in the Automotive Sector

To drive innovation in the automotive sector, several key recommendations have been proposed. Public incentive policies are essential, particularly those that encourage investment in research and development (R&D) through financial support and tax benefits. National and regional policies can attract foreign direct investment (FDI) and positively impact local SMEs, especially in less developed regions. Additionally, fostering collaboration between companies, universities, and innovation centers will strengthen the automotive innovation ecosystem, while developing training and capacity-building programs will prepare professionals for the sector's evolving technological demands. Regulatory simplification is also crucial for accelerating the introduction of new technologies, while targeted incentives can promote the adoption of sustainable practices and technologies.

Another recommendation is the prioritization of regional innovation hubs, which will create local solutions that reduce dependency on global markets and enhance resilience. By investing in specialized innovation clusters, regions can foster cross-sector collaboration, drive technological advancements, and improve competitiveness. Strengthening research and development, particularly in areas like electrification, automation, and alternative battery chemistries, is essential for staying competitive in the rapidly evolving automotive industry. Additionally, the workforce must be equipped with new skillsets through reskilling and training programs in areas such as software development, robotics, and green technologies. Collaborating with academia and offering on-the-job training will ensure the workforce can effectively adapt to new technologies.

In conclusion, the Iberian Peninsula is uniquely positioned to lead the transformation of the automotive sector, benefiting economically, environmentally, and socially. The Iberian Sustainable Mobility Ecosystem (ISME) offers a roadmap for navigating the challenges of this transition, positioning Spain, France, and Portugal as global leaders in sustainable mobility. This initiative will rely on close collaboration, innovation, and adaptability to ensure long-term success. By embracing this vision and taking decisive action, the region has the opportunity to transform its automotive sector and lead a global mobility revolution, driving positive impacts for the economy, the environment, and the quality of life for citizens.

Appendices

Methodology and Approach

To provide a comprehensive understanding of the automotive innovation ecosystem in Europe, this study adopted a methodological approach based on extensive document analysis. Various sources, including technical reports, scientific articles, and case studies, were examined to identify emerging trends, challenges, and opportunities, particularly regarding sustainability and energy transition. The selection of documents was guided by their relevance to automotive clusters in France, Spain, and Portugal, as well as their contributions to understanding rural dynamics. The analysis was structured to categorize critical information, facilitating the formulation of strategic recommendations.

A systemic approach was employed to assess the automotive ecosystem as a complex, interconnected system. This method enabled the identification of value chain interactions, constraints limiting performance, and key dynamics influencing sustainability and innovation. Several analytical tools were used, including Content Analysis, SWOT Analysis, and Thematic Mapping, to categorize information into key themes such as sustainability, technological innovation, and rural challenges. Additionally, frameworks such as VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) and the OODA (Observe, Orient, Decide, Act) cycle were applied to navigate industry complexities and anticipate potential disruptions.

The Theory of Constraints (TOC) was also employed to identify bottlenecks affecting the sector, particularly in charging infrastructure and sustainable material sourcing. By integrating these methodologies, the study provided a structured approach to identifying obstacles and opportunities, supporting the development of strategic recommendations for a more sustainable and resilient automotive industry. The findings were synthesized into a final report, ensuring a well-documented, actionable roadmap for stakeholders navigating the sector's evolving landscape.

DOCUMENT INFORMATION

Title

Resume on "Territorial and Industrial Challenges in the Automotive and Aeronautic Sectors."

Start - end date

01/01/2024 - 01/01/2027 (36 months)

Programme

Interreg VI-B SUDOE

Project type

"Promoting social cohesion and territorial and demographic balance in the SUDOE region through innovation and the transformation of productive sectors".

ERDF funding

1.865.807,42 €

Coordinator

Aerospace Valley

Project overview

The SCAIRA project, co-funded by the Interreg SUDOE Programme, aims to develop a customized training programme to support the creation and acceleration of start-ups in rural areas of the SUDOE region. A consortium of twelve beneficiaries (local incubators, regional clusters, and industrials) and eighteen associated partners located in regions of France, Portugal, and Spain will support the initiative.

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