D7.5 White Paper

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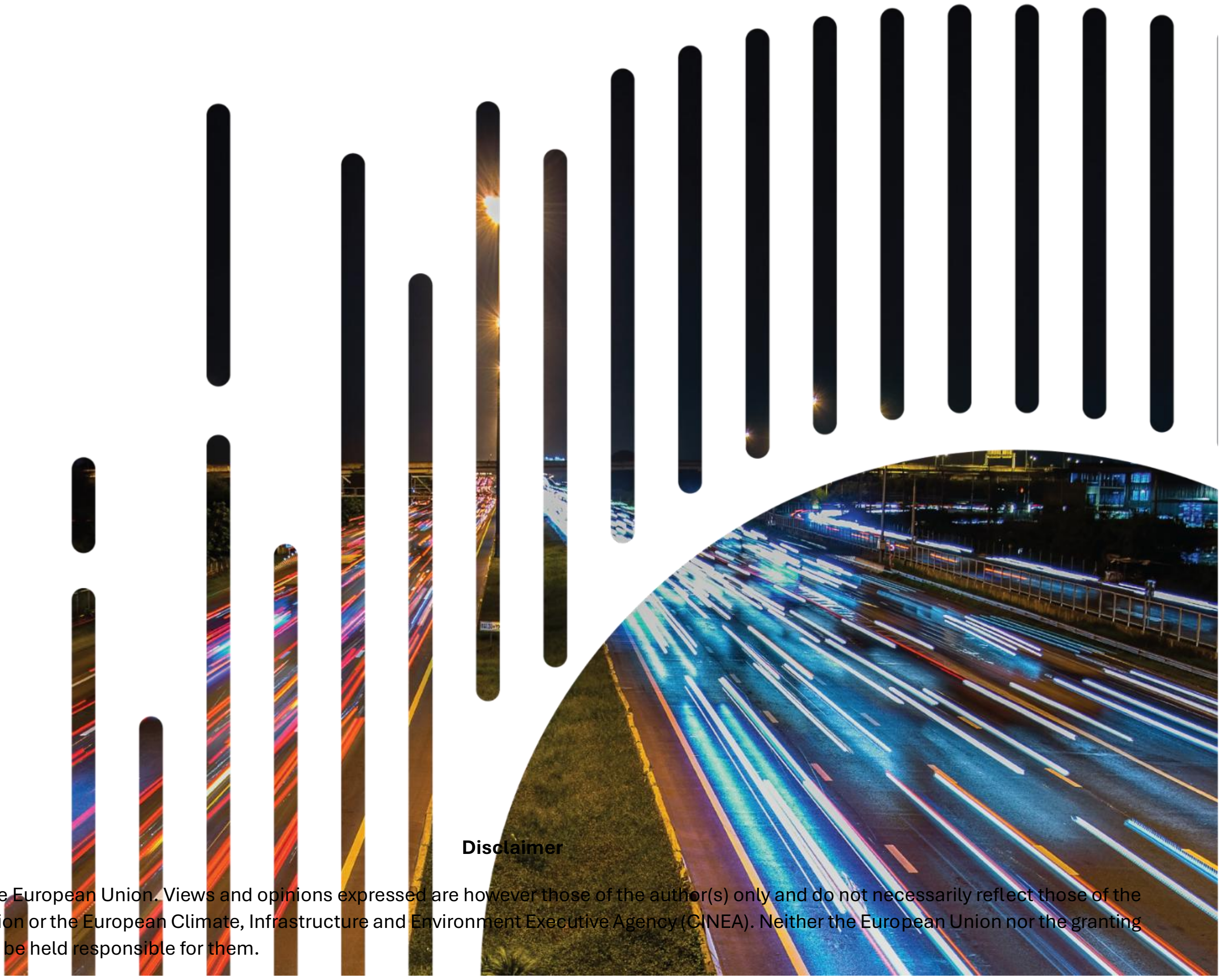

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Contents

Table of Tables

Table of Figures

1 Executive summary

Connected, Cooperative and Automated Mobility (CCAM) is often presented as a vehicle-technology transition. The work done within the CCAM-ERAS project demonstrates that should more accurately be understood as a socio-technical transition that reshapes value chains, work organisation, occupational profiles, education and training systems, public administration, and mobility planning. The central contribution of CCAM-ERAS has been to connect these dimensions in a single evidence chain: it moved from stakeholder-led horizon scanning and real-world use cases, through supply-chain and macroeconomic modelling, to skills foresight, occupational profiles, educational instruments, and policy-planning analysis.

The programme of work began by establishing a shared evidence base. A PESTLE analysis combined an extended stakeholder consultation, 28 semi-structured expert interviews and three thematic workshops to assess political, economic, social, technological, legal and environmental conditions for deployment. The analysis found that fragmented regulation, uncertain returns on investment, infrastructure and interoperability requirements, unresolved liability and data-governance questions, and uneven institutional readiness shape the pace and form of adoption. It also found that labour-market and inclusion questions are not secondary effects: they are conditions for safe, legitimate and scalable deployment.

The project then translated six passenger and freight use cases into an economic and operational framework: last-mile delivery, automated bus depots, ports and terminals, public shared transport, private shared transport, and services for specific groups. Supply-chain mapping showed that CCAM does not replace the conventional transport value chain; it expands and reweights it. Vehicle manufacturing, transport operations, warehousing and infrastructure remain important, but electronics, software and information services, telecommunications, electricity and charging, cybersecurity, insurance, certification and data governance become more central.

A scenario framework was developed to quantify employment effects over 2025-2050. It distinguished warehousing, road freight and road passenger transport; low, medium and high uptake pathways; and early-, mid- and late-adopter Member States. Cambridge Econometrics' E3ME model was used to combine adoption rates, additional investment, cost savings, productivity gains, supply-chain effects and occupational structures. The results are explicitly differences from a baseline rather than forecasts. They show that outcomes are strongly use-case dependent. In the model, high uptake in warehousing produces the largest negative difference from baseline by 2050, while a slower uptake pathway produces a positive difference because investment effects dominate. Road freight effects are smaller and concentrated in land transport and driving occupations. High uptake in road passenger transport produces a positive overall employment difference through investment, service demand and ICT-related supply-chain effects, whereas the medium pathway remains close to baseline.

The qualitative evidence provides the interpretation needed for these numerical results. Across sectors, the dominant pattern is not job elimination but task reconfiguration and occupational hybridisation. Routine driving, inspection, handling and clerical tasks become more exposed to automation, while demand increases for remote supervision, exception handling, software-enabled diagnostics, system integration, safety assurance, cybersecurity, data interpretation, customer support and regulatory oversight. The transition can improve some jobs by reducing physical strain and reallocating workers towards higher-value or customer-facing tasks, but it can also polarise opportunities if workers lack access to the foundations and flexible learning pathways required for hybrid roles.

Skills foresight identified eight recurring clusters: digital and systems literacy; data, analytics and AI-adjacent skills; cybersecurity and digital risk awareness; safety assurance, validation and evidence management; remote supervision and exception handling; software lifecycle assurance; coordination and systems integration; and transversal, human-centred competences. A persistent challenge is the mismatch between rapid technology cycles and slower curriculum, certification, recruitment and public-sector learning processes. The medium term is therefore likely to carry the highest risk of skills mismatch, as deployments scale faster than institutions adapt.

The work on educational instruments converted these findings into a long list of twelve occupational profiles spanning CCAM operations, enabling functions and system development. The profiles include customer service agents, remote operations specialists, fleet orchestrators, automated-vehicle technicians and mechanics, safety drivers, road-infrastructure engineers, policy and regulation officers, insurance underwriters, app-interface developers and analysts, automated-vehicle systems engineers, compliance officers, and cybersecurity specialists. Two pivotal occupations were elaborated into learning-outcome frameworks: the Remote Operations Specialist at EQF level 3 and the Policy and Regulation Officer at EQF level 6. The first focuses on service continuity, safety, monitoring, incident response and operational improvement; the second combines regulation, strategic policy and local integration or authorisation.

Finally, the planning and policy analysis tested whether current frameworks are ready to govern the socio-economic transition. A draft review of eleven policy and strategic documents and twenty local and regional mobility plans found that accessibility and safety are relatively well recognised, but affordability, equity, employment, digital inclusion, public trust, data governance and workforce transition are rarely operationalised through measurable targets, indicators, responsibilities and financing. The Sustainable Urban Mobility Planning cycle offers a practical structure for closing this gap, provided that socio-economic diagnostics, scenario building, measure packages, procurement and monitoring are expanded beyond conventional transport and environmental indicators.

The main policy conclusion is that technology deployment, workforce preparation and institutional capacity must be synchronised. Accelerating automation without training, transition support and public-sector capability can create avoidable bottlenecks and distributional costs. Conversely, workforce policy that is detached from actual operational designs and adoption pathways risks producing qualifications that do not match demand. A socially sustainable pathway requires continuous skills anticipation; modular and stackable learning; work-based and vendor-supported training with common quality standards; cross-sector governance; explicit inclusion goals; and differentiated responses for regions, sectors and occupations exposed at different speeds.

1.1.1 Key messages

- CCAM is a system transition, not only a vehicle innovation. Its effects extend across transport operations, software and data, energy, infrastructure, insurance, regulation, education and public administration.

- Employment effects vary by use case, uptake rate, investment pathway and national labour-market structure. Their interpreted as scenario differences from a baseline showcases the deviations from the current pathway which is business-as-usual.
- The dominant labour-market mechanism is task reconfiguration and hybridisation. Existing occupations acquire new digital, supervisory, safety and governance responsibilities.
- The main near- and medium-term constraint is institutional readiness: training cycles, role definitions, public-sector capability and qualification systems lag behind technological change.
- Education must be organised around learning outcomes and multiple entry routes rather than a single standard pathway, because future workers will come from diverse occupational and educational backgrounds.
- Socio-economic objectives must be embedded in planning, procurement and monitoring. General commitments to inclusion and accessibility are insufficient without indicators, responsibilities and funding.

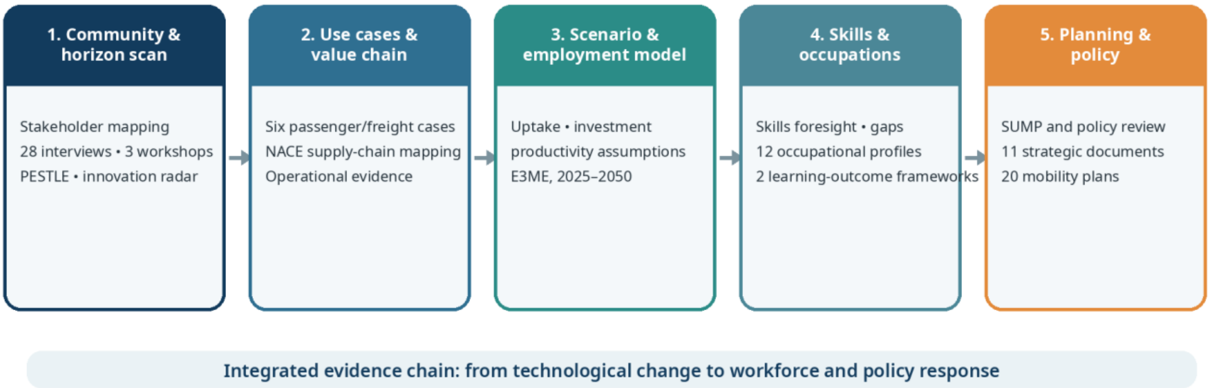


Figure 1The project created an integrated evidence chain for stakeholders and technology scanning to workforce and policy instruments. Source: consortium synthesis

2 Purpose and scope

This white paper synthesises the work documented in the attached CCAM-ERAS deliverables and project reports. Its purpose is not to reproduce each deliverable, but to explain what was done, how the workstreams connect, what the combined findings mean, and how the resulting evidence can be used by policymakers, transport operators, technology developers, education and training providers, social partners and mobility planners.

The source corpus covers project design and implementation progress; a stakeholder-led CCAM scan and PESTLE analysis; supply-chain mapping; scenario assumptions; macroeconomic employment modelling; skills foresight; six use-case assessments; occupational profiles and learning outcomes; and a draft analysis of socio-economic aspects in mobility planning and policy. The supplied versions span May 2025 to April 2026, while the project description and technical report provide the broader implementation context. The draft status of Deliverable 6.1 is retained throughout this synthesis, and its conclusions should be treated as provisional until the final version is adopted.

The analysis is organised around four questions:

1. How did the project build a credible evidence base for understanding the employment and skills implications of CCAM?

2. What does the evidence indicate about changes in value chains, employment, tasks and occupational profiles?

3. Which education, training and institutional responses are most urgent?

4. How can we reskill the existing workforce to deal with CCAM needs?

4. How can socio-economic considerations be embedded in mobility planning and policy so that deployment is efficient, inclusive and publicly legitimate?

The white paper focuses on the material contained in the supplied documents. Other project outputs reported in the technical progress report, including the innovation radar, the stakeholder and population-groups impact analysis, dissemination activities and exploitation planning, are acknowledged where they help explain the overall architecture, but are not assessed in the same depth because their full deliverables were not part of the source corpus.

3 From project ambition to an integrated evidence chain

3.1 The original problem definition

CCAM- ERAS identified three linked problems: uncertain employment and socio-economic effects; short-, medium- and long-term demand for new and updated skills; and the absence of a coordinated response connecting government, industry, education, social partners and the research community.

The proposed approach of CCAM-ERAS considered the full value chain and recognised that connected and automated mobility changes the allocation of tasks between humans and systems, the organisation of transport services, the composition of supply chains, the responsibilities of public authorities, and the skills needed to design, operate, maintain and regulate increasingly software-defined mobility systems.

The project was designed around six mutually reinforcing results: a stakeholder community; an innovation radar; a quantitative employment model; a social-impact assessment capability; educational plans and schemes; and a socio-economic transition roadmap. The attached technical report shows how these elements were developed through linked work packages rather than as isolated studies. The stakeholder community and workshops informed the scan and use cases; the use cases anchored the economic and skills analyses; the modelling and foresight work informed occupational and educational instruments; and the accumulated evidence fed into planning and policy analysis.

2.2 A multi-method research design

The strength of the work lies in methodological triangulation. No single method can adequately estimate the labour-market implications of a technology whose adoption remains uneven and contingent on regulation, infrastructure, business models and public acceptance. The project therefore combined:

- stakeholder mapping, interviews and workshops to identify real-world barriers, expectations and emerging practices;
- desk research and PESTLE analysis to structure external drivers and constraints;
- use-case analysis to connect general trends to actual operating environments;
- supply-chain mapping of NACE sectors to identify direct, indirect and induced effects from the deployment of CCAM in the economy;
- scenario design and macro-econometric modelling to quantify plausible employment effects;
- skills foresight to anticipate changes across time horizons and sectors;
- co-creation and occupational profiling to translate broad skills findings into job-level learning outcomes; and
- policy and planning review to test whether governance frameworks are equipped to manage distributional and institutional effects.

This sequence matters. The numerical model does not stand alone: its assumptions were informed by literature, industry input and validation, while its occupational interpretation was linked to qualitative foresight. Conversely, the qualitative work was disciplined by explicit use cases, sectors, time horizons and modelled pathways. The result is a more realistic account of transition than either a purely technology-led forecast or a purely descriptive stakeholder study.

3.2 Stakeholder community and implementation progress

CCAM-ERAS established and engaged a substantial stakeholder community engagement strategy, a first community meeting in Brussels in November 2024, and a consultation process designed to support work across the project. Stakeholders represented industry, education and training, public authorities, research, professional bodies and social partners, although the report also acknowledged underrepresentation of some groups, including trade unions, and the need for more targeted engagement.

The first community meeting organised structured discussions on the transport value chain, societal effects, and regulation and policy. This engagement was not only a dissemination activity. It supplied evidence and validation for subsequent analytical work and created a mechanism for testing whether emerging results were relevant to organisations responsible for implementation.

The technical report also describes the development of an innovation-radar methodology based on data and text mining, key performance indicators, scoring and innovation profiles. The radar was intended to keep the skills and employment analysis connected to a rapidly evolving technology landscape. This is a significant design choice: skills anticipation cannot be a one-off forecast when software, sensors, connectivity, regulation and business models evolve continuously.

4 Mapping the transition: external conditions, use cases and value chains

4.1 What the PESTLE scan established

An evidence base of 28 interviews conducted between October and December 2024 accompanied by two workshops created the first scan of external factor shaping CCAM deployment.

Politically and legally, the analysis found that fragmented national rules hinder cross-border scaling and increase compliance costs. Stakeholders called for greater harmonisation of testing, liability, data sharing and approval procedures, together with regulatory sandboxes that support experimentation without weakening safety and accountability. Public-private partnerships were seen as necessary because governments influence infrastructure, procurement and legal certainty, while industry holds technical and operational expertise.

Economically, uncertain returns on investment and high up-front costs create a difficult adoption environment, especially for small and medium-sized operators. The benefits of automation may accrue over long operating periods through lower labour costs, higher asset utilisation, fuel efficiency and improved logistics, while infrastructure and technology costs are incurred early. This timing mismatch strengthens the case for targeted grants, tax incentives, public procurement and risk-sharing mechanisms rather than undifferentiated subsidies.

Socially, the evidence pointed towards transformation of jobs rather than a uniform elimination of employment. The main risks concern uneven access to reskilling, polarisation between high-skilled technical roles and lower-skilled service work, public concern about safety and surveillance, and the possibility that rural areas, small operators, women and other underrepresented groups do not share equally in the benefits. Stakeholders repeatedly stressed lifelong learning, micro-credentials, inclusive recruitment and stronger cooperation with trade unions and workers.

Technologically, interoperability, connectivity and cyber-resilience emerged as system requirements. The vehicle cannot be treated independently from road infrastructure, telecommunications, cloud and edge services, energy supply, data platforms and operational control centres. Legally, unresolved liability, certification, labour-law and data-governance questions remain critical. Environmentally, the potential contribution to decarbonisation depends on integration with electrification, renewable energy, efficient fleet use and circular-economy practices; automation alone does not guarantee environmental improvement.

The scan therefore established a cross-cutting principle that runs through the later deliverables: deployment is governed by the alignment of technology, institutions, markets and human capabilities. Where one component lags, it can become the binding constraint.

4.2 Six use cases as an analytical bridge

The six selected use cases cover both passenger and freight mobility and a range of operational environments. They provide a bridge between general trends and concrete tasks:

Table 1 Six use cases and their main workforce implications

Domain	Use case	Operational focus	Indicative workforce implications
Freight	Last-mile delivery	Autonomous middle/last-mile vehicles integrated with couriers and urban logistics	Remote supervision, vehicle preparation, incident intervention, digital dispatch and customer hand-off.
Freight / operations	Bus depot	Automated movement, charging, washing and positioning of buses in a controlled depot	Teleoperation, automation maintenance, sensor calibration, fleet analysis and emergency response.
Freight	Ports and terminals	Automated trucks, cranes and guided vehicles in complex logistics hubs	Remote control, fleet coordination, V2X integration, predictive analytics and systems interoperability.
Passenger	Public shared transport	Demand-responsive shuttles and automated services integrated with public transport	Remote operations, service management, mobility analysis, accessibility support and public communication.
Passenger	Private shared transport	Robotaxi or private-hire services supported by digital platforms	Fleet orchestration, app interfaces, cybersecurity, user-data management and rapid incident response.
Passenger / inclusion	Services for specific groups	Shared automated services for older people, disabled users and underserved areas	Stewards and ambassadors, empathy, inclusive service design, human-machine interaction and local support.

Source: consortium synthesis .

The use-case approach revealed that differences in human-capital demand are often driven more by the development phase and operating environment than by the service label itself. Controlled environments such as depots, warehouses and terminals can automate more quickly because routes, access and interactions are easier to manage. Open-road passenger services introduce more complex requirements for public interaction, vulnerable-road-user safety, customer assistance, incident management and regulatory oversight.

Across the six cases, remote monitoring, technical maintenance and digital coordination appear repeatedly. Customer-facing and inclusion-oriented roles become more prominent in passenger services, while fleet orchestration, logistics integration and systems maintenance are particularly visible in freight and controlled environments. Safety drivers and similar fallback roles remain important during testing and early deployment, although stakeholders differ on whether they are transitional or enduring functions.

4.3 How the supply chain changes

CCAM-ERAS mapped the selected use cases onto NACE sectors and compared traditional transport and logistics supply chains with their CCAM-enabled counterparts. In the traditional logistics and warehousing supply chain, warehousing and support activities account for 44 per cent of inputs and land transport for 22 per cent. In traditional land transport, warehousing and transport operations also form the core, while energy and vehicle manufacturing remain substantial inputs.

The introduction of CCAM does not remove this core. Instead, it adds and enlarges several enabling layers:

- computer, electronic and optical products, including cameras, radar, lidar, processors and communication modules;

- computer programming, software integration, cloud services, data processing and platform management;
- telecommunications and V2X connectivity;
- electricity supply, charging and digital energy management;
- intelligent infrastructure, road-side systems and back-office integration;
- cybersecurity, certification, testing, insurance and legal-technical services; and
- training, remote operations and continuous lifecycle support.

This expanded value chain explains why employment effects extend beyond transport operators. Investment can generate demand in electronics, computing services, engineering and infrastructure even when labour-saving automation reduces demand in driving, handling or routine warehouse tasks. It also explains why the location of jobs may change. Employment may shift from operational sites to software firms, control centres, technical services, public authorities and specialised suppliers.

The mapping also highlighted the importance of electrification and digital infrastructure. Automated fleets are likely to be heavily dependent on electricity, charging, reliable communications and data services. The employment and skills implications of CCAM therefore intersect with the energy transition and the wider digital economy. Workforce planning that focuses only on vehicle operators will miss a large part of the transition.

Table 2 How the CCAM value chain changes

Pattern	Illustrative activities	Labour-market implication
Continuity	Vehicle manufacturing, transport operations, warehousing, infrastructure and maintenance remain central.	Established sectors persist, but their work becomes more dependent on software, data and connected systems.
Expansion	Electronics, software and cloud services, telecommunications and V2X, electricity and charging, cybersecurity, assurance and insurance gain weight.	Investment and lifecycle support create demand beyond transport operations, especially for technical and regulatory services.
Relocation	Remote operations centres, data platforms, specialised suppliers, technical services and public oversight assume more tasks.	Some work moves away from vehicles and operational sites, changing the geography, organisation and qualification profile of jobs.

Source: consortium synthesis.

5 Quantifying employment effects

5.1 Scenario assumptions and the E3ME framework

CCAM-ERAS translated the use-case and supply-chain work into explicit modelling assumptions. It established a business-as-usual baseline and differentiated pathways for warehousing, road freight and passenger transport. The main drivers were technology uptake, additional investment, cost savings, productivity gains and changes in input demand. The analysis also distinguished early-, mid- and late-adopter Member States to represent differences in regulatory readiness, infrastructure, market conditions and deployment speed.

The baseline already contains some adoption, which is important for interpretation. The alternative scenarios measure how employment and GDP differ from that baseline; they are not a comparison between automation and a world with no automation. In the final employment analysis, warehousing reaches 75 per cent uptake in the baseline by 2050, with low and high alternatives of 60 and 100 per cent. Highly automated road freight reaches 10 per cent in the baseline and 15 or 20 per cent in medium and high pathways. Public passenger transport reaches 10 per cent in the baseline and 15 or 20 per cent in medium and high pathways, while private commercial passenger transport remains lower.

Investment assumptions assign additional spending to relevant supply-chain sectors. Productivity and cost-saving assumptions reduce labour requirements or operating costs in directly affected activities. Occupational effects are obtained by combining sectoral changes with historical occupational structures and qualitative foresight. The E3ME model captures direct, indirect and induced effects across the economy and does not assume that all markets automatically clear, allowing investment and demand expansion to generate additional output where capacity exists.

This methodology provides a disciplined way to compare pathways, but it does not remove uncertainty. Results depend on the assumed timing and magnitude of uptake, investment and savings. The model also does not explicitly incorporate existing labour shortages, such as the shortage of long-haul drivers, which may reduce the social cost of automation in some settings.

5.2 Results by use case

The graph below summarizes the expected effect of the application of CCAM in each use case investigated within the project.

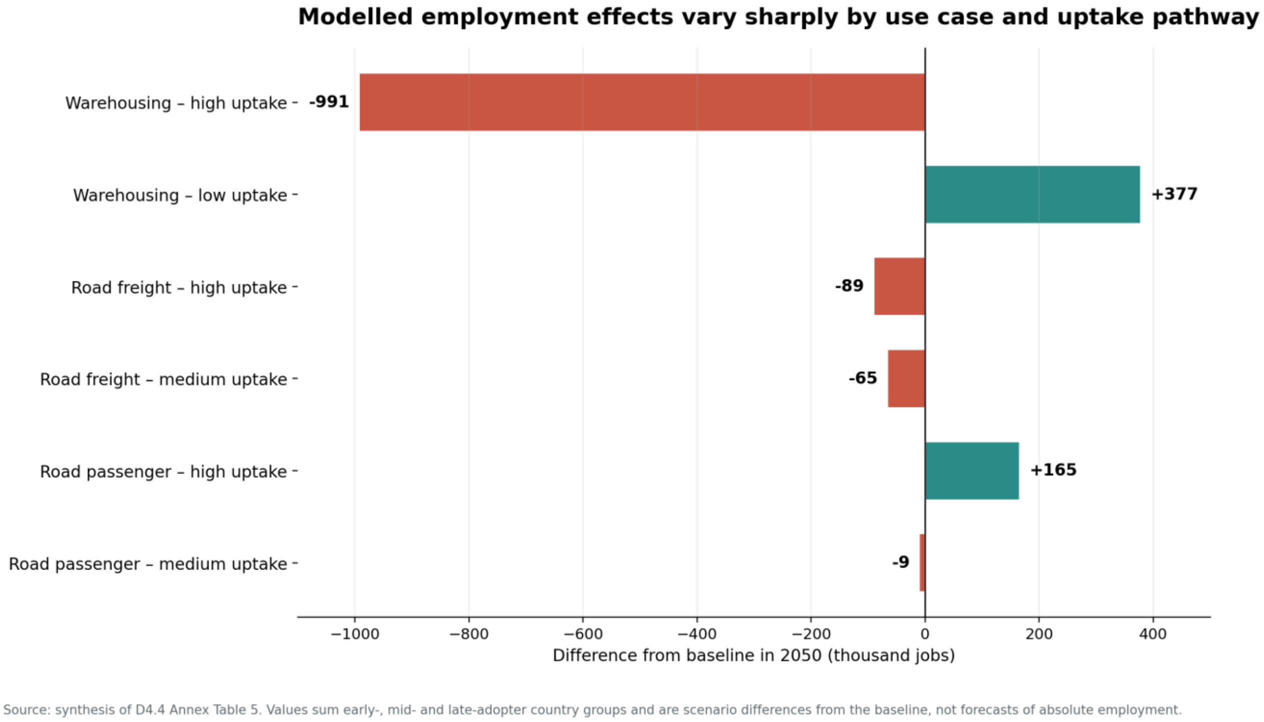


Figure 2. Employment differences from baseline in 2050 vary by use case and uptake pathway.

Source: consortium synthesis.

5.2.1 Warehousing

Warehousing produces the largest modelled employment effects. Under the high-uptake pathway, the total EU-27 employment difference from baseline in 2050 is approximately -991 thousand jobs. About 934 thousand of this difference occurs in land transport and warehousing, and the occupational effects are concentrated among drivers and mobile plant operators, labourers and clerical occupations. Early-adopter countries experience the largest absolute effect, followed by late adopters where warehousing and transport represent a relatively large share of employment.

The low-uptake pathway produces the opposite result: approximately +377 thousand jobs compared with the baseline in 2050, with around 361 thousand concentrated in transport and warehousing. The reason is not that lower automation is inherently job-creating, but that slower productivity displacement allows investment effects to dominate relative to the more automated baseline. This result demonstrates the sensitivity of employment outcomes to the sequencing of investment and labour-saving effects.

The policy implication is not simply to slow automation. It is to recognise that rapid deployment in highly automatable environments can produce concentrated transition pressure and therefore requires early workforce mapping, redeployment pathways and regional adjustment measures. Warehousing is also a strong candidate for job-to-job mobility because many emerging roles build on existing logistics knowledge while adding digital monitoring, maintenance or coordination competences.

5.2.2 Road freight

Employment effects in road freight are smaller at the EU level. Summing country-adopter groups, the high-uptake pathway produces a difference of about -89 thousand jobs from baseline by 2050, while the medium pathway produces about -65 thousand. The land-transport sector bears most of the reduction: the report estimates approximately 91 thousand fewer land-transport jobs in the high scenario and 70 thousand fewer in the medium scenario, partially offset by indirect and induced effects elsewhere.

Driving occupations are the most exposed. Investment in electronics and computing services creates some additional demand, but not enough to fully offset productivity-driven reductions in freight operations. The effect is stronger and earlier in countries that adopt faster, although late adopters can still face large absolute effects where freight employment is structurally important.

These findings should be interpreted alongside labour shortages. In some segments, automation may fill vacancies or reduce pressure rather than displace incumbent workers one-for-one. The transition challenge nevertheless remains significant because the skills required to supervise highly automated fleets, manage exceptions and maintain software-enabled vehicles differ from conventional driving skills.

5.2.3 Road passenger transport

Passenger transport produces a more differentiated outcome. The high-uptake pathway yields an estimated +165 thousand jobs compared with baseline by 2050 across the three adopter groups. The increase is driven by investment, additional demand for passenger services, and strong gains in computing services, electronics and land transport. ICT professionals and technicians gain, and the model also shows a positive difference for drivers and mobile plant operators because overall service demand expands faster than automation reduces labour requirements in this pathway.

The medium-uptake pathway remains close to baseline, at approximately -9 thousand jobs across the EU-27 adopter groups. Here, positive investment effects are largely offset by reductions in driving and other occupations. The contrast between the two pathways illustrates that adoption can alter service demand as well as labour productivity. A technology pathway that expands accessible, shared and demand-responsive services may create employment along the value chain even as individual vehicles become less labour intensive.

5.3 What the model does and does not say

The scenario results should not be reduced to a single headline number. Five interpretive principles are essential:

- Results are differences from a baseline that already contains adoption, not absolute forecasts of job creation or destruction.
- Effects are use-case specific. Controlled, highly automatable environments differ fundamentally from passenger services that may expand mobility demand.
- The speed of adoption matters. Early adopters experience stronger and earlier effects and need earlier transition measures.
- Sectoral gains and losses do not imply frictionless worker mobility. A job lost in warehousing is not automatically replaced by a computing-services job for the same person or region.
- Labour shortages, regulation, public acceptance and business models can alter real-world outcomes relative to model assumptions.

The model is therefore best used as an early-warning and planning instrument. It identifies where transition pressure may concentrate and which assumptions are decisive. It should be combined with occupational analysis, regional labour-market data and stakeholder consultation when designing policy.

6 Skills transformation and occupational profiles

6.1 From job replacement to task reconfiguration

The skills foresight and use-case analyses converge on a common conclusion: CCAM is more likely to reconfigure tasks within existing occupations than to generate immediate, wholesale replacement of jobs. Mechanics increasingly work with sensors, software diagnostics and over-the-air updates. Drivers and dispatchers move towards monitoring, exception handling and fleet coordination. Customer-service staff need basic understanding of automated systems and accessibility protocols. Engineers require stronger systems integration, safety and cybersecurity competences. Public officials must assess software-driven systems, data governance, operational design domains and safety evidence.

This creates hybrid profiles. Domain expertise remains necessary because workers must understand vehicles, logistics, mobility services, user needs or regulation. But it is no longer sufficient. It must be combined with digital capability, system awareness, communication and judgement. The most important skills are often not advanced programming; they are the ability to interpret system outputs, recognise limits, respond to anomalies, coordinate with other actors and make safe decisions under uncertainty.

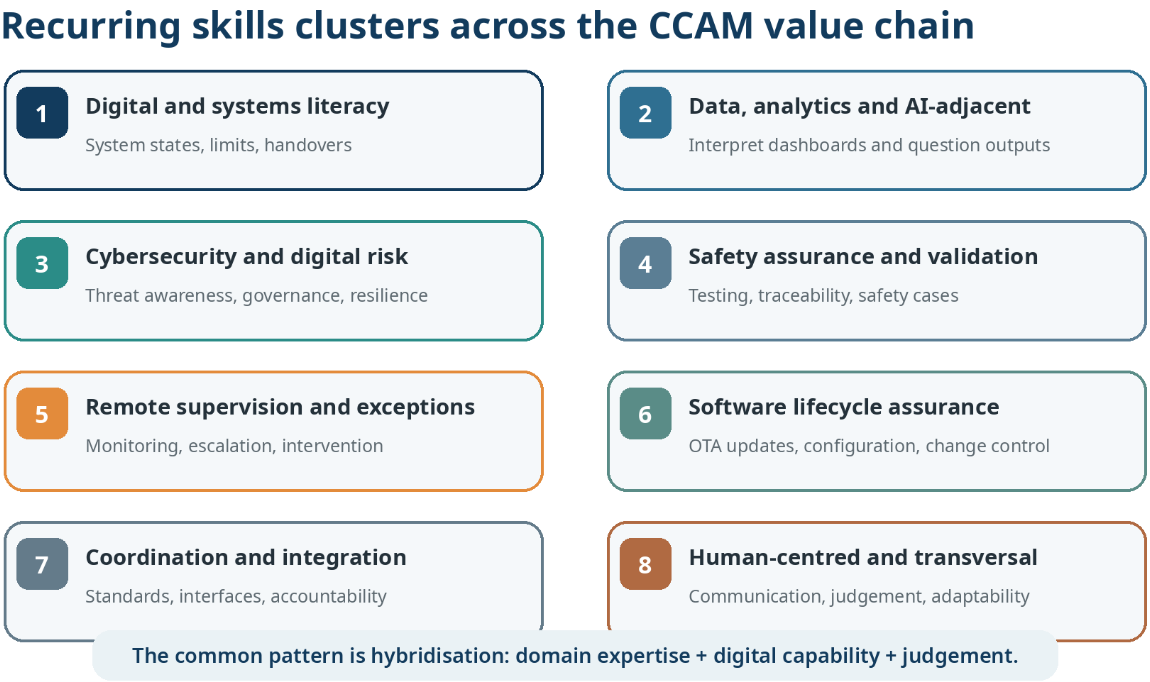
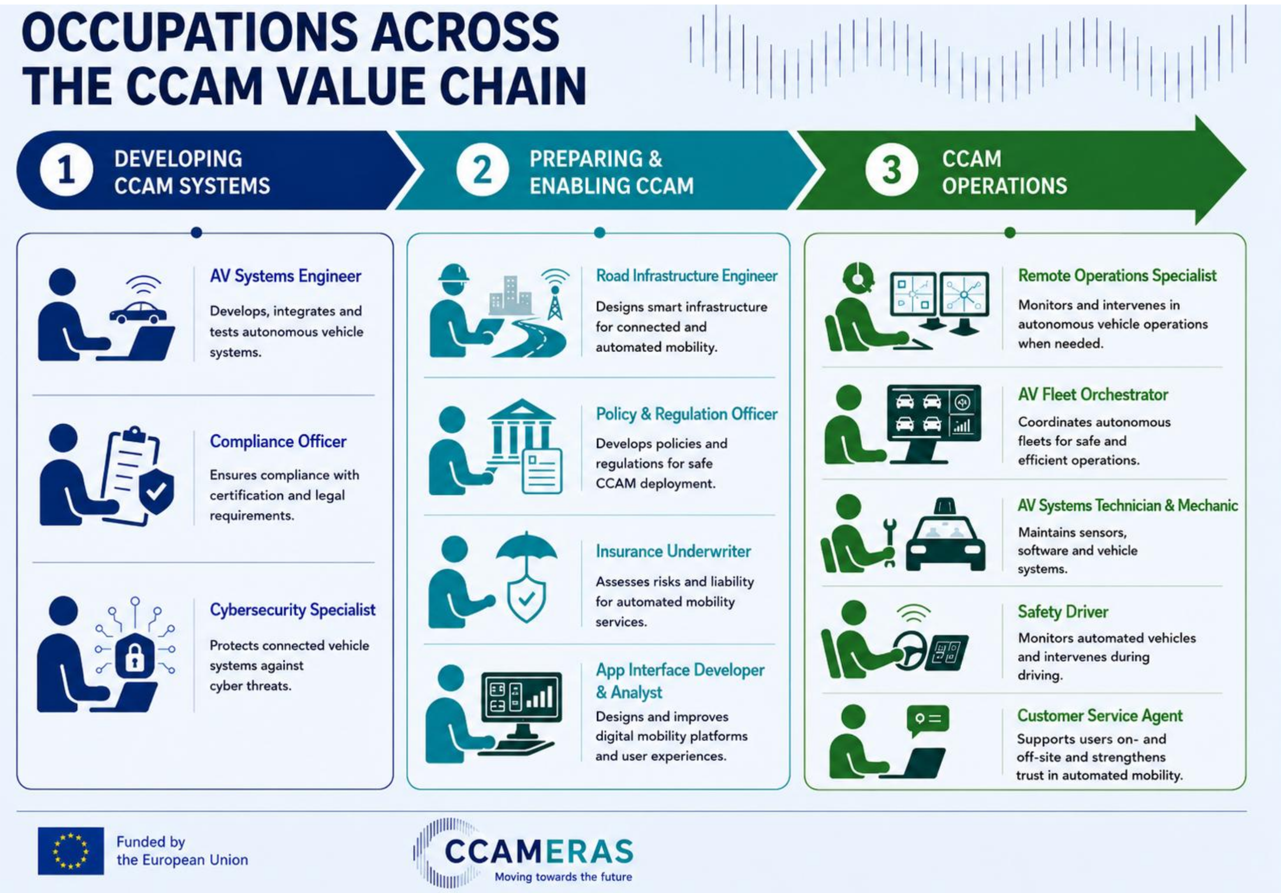


Figure 3 Eight recurring skills clusters identified across the CCAM value chain. Source: consortium synthesis.

The foresight work identifies several structural bottlenecks. Technology and software change faster than formal curricula and certification. Emerging roles lack standard definitions, making recruitment and qualification design difficult. Education providers face limited access to equipment, current systems and industry-experienced trainers. Small operators have less capacity to release staff for training or purchase specialised provision. Public authorities often cannot match private-sector salaries for scarce technical talent. These constraints interact and are likely to be most acute in the medium term, when deployment expands but institutional adaptation is incomplete.

6.2 Occupational profiles

The figure maps key occupations across three stages of the CCAM value chain: developing automated-vehicle systems, preparing the infrastructure and regulatory environment, and operating CCAM services. It shows that successful deployment requires not only engineering and cybersecurity expertise, but also policy, insurance, maintenance, fleet coordination, safety monitoring and customer-support roles.



The profiles show that future work spans qualification levels and is not limited to engineering. Technical occupations require deeper integration of mechanical, electronic and digital competences, while non-technical occupations require a CCAM layer added to existing expertise in customer service, law, policy, insurance, planning or administration. This distinction has direct implications for education.

For technicians, mechanics and engineers, formal technical education remains the foundation. Curricula need to include software-enabled systems, sensors, diagnostics, systems integration, cybersecurity and safety assurance, complemented by continuous short courses as technologies change. For customer-service, regulatory and other less technical roles, short courses, work-based learning and structured learning-by-doing may be more effective than redesigning entire initial qualifications.

The diversity of backgrounds also means that one standard pipeline will not work. Remote operations specialists may come from driving, dispatch, customer service, gaming or technical support. Policy and regulation officers may come from law, public administration, transport planning, data science or engineering. Learning outcomes therefore provide a more durable basis than prescribing a single course sequence: they define what a person must be able to do while allowing multiple routes to competence.

Table 3 Occupational profiles identified for CCAM deployment and their explanation.

Cluster	Occupation	Primary contribution	Indicative learning approach
Operations	Customer service agent	Passenger assistance, incident handling, accessibility support and feedback to service improvement.	On-the-job training, short AV courses and role-play.
Operations	Remote operations specialist	Monitor multiple vehicles, interpret data, manage anomalies and coordinate interventions.	Accredited modular training, simulation and workplace learning.
Operations	Fleet orchestrator	Coordinate routes, multi-operator fleets, traffic interfaces and data-driven operations.	Cross-disciplinary training, soft skills and work-based learning.
Operations	AV technician or mechanic	Maintain sensors, calibrate systems and combine mechanical, electronic and software diagnostics.	Formal technical education plus continuous upskilling.
Operations	Safety driver	Monitor automated-driving behaviour, perform manual takeovers and report anomalies.	Advanced driving and supplier/software training.
Enabling	Road-infrastructure engineer	Design AV-ready infrastructure, integrate ITS and train public-sector professionals.	Formal engineering plus targeted in-house training.
Enabling	Policy and regulation officer	Develop rules, permits and strategies and integrate CCAM into wider mobility systems.	Formal education, scenario-based training and continuous learning.
Enabling	Insurance underwriter	Apply data-driven risk models and interpret liability, cybersecurity and system evidence.	Formal foundations plus applied workplace learning.
Enabling	App-interface developer or analyst	Design secure mobility applications and integrate user, booking and operational data.	Applied problem-solving and AV-specific security training.
System development	AV systems engineer	Develop and integrate AI, robotics, sensors, control logic and system architecture.	Engineering education plus in-company applied training.
System development	Compliance officer	Oversee safety, cybersecurity, audits, integrity and regulatory compliance.	Legal-technical education plus AV-specific training.
System development	AV cybersecurity specialist	Threat modelling, hardening, vulnerability monitoring and incident response across the ecosystem.	Specialised cybersecurity modules and on-the-job learning.

Source: consortium synthesis

6.3 Priority profile: Remote Operations Specialist

The Remote Operations Specialist was selected as a pivotal operational occupation and elaborated at EQF level 3. The role is not continuous remote driving. It involves real-time monitoring of multiple vehicles, remote assistance and mission-level supervision, intervention when automation reaches its limits, passenger or customer support, coordination with technicians and emergency services, and contribution to service improvement.

The profile organises the role around three core responsibilities:

1. keeping autonomous fleets running safely and continuously;
2. ensuring quality and compliance with regulations and procedures; and
3. contributing to operational optimisation and innovation.

Competence requirements include situational awareness across multiple data feeds, understanding of system boundaries and operational design domains, incident prioritisation, adaptive problem solving, communication under time pressure, inclusive passenger support, basic cybersecurity awareness, accurate reporting and the disciplined use of escalation and fallback procedures. The role also requires sustained attention and good judgement because intervention is infrequent but potentially safety critical.

The educational implication is a modular, practice-oriented pathway combining accredited training, simulation, supervised workplace learning and periodic reassessment. Training should be linked to actual control-room tools and operational procedures but grounded in transferable concepts so that workers are not tied to a single vendor platform.

6.4 Priority profile: Policy and Regulation Officer

The Policy and Regulation Officer was elaborated at EQF level 6 because public-sector capacity emerged as a critical deployment bottleneck. The profile distinguishes three functions that may be performed by one person in a small authority or distributed across specialised teams in larger organisations: regulator; policy maker; and integration or authorisation officer.

The regulator interprets and develops rules, processes permits, oversees compliance and uses operational evidence to improve procedures. The policy maker develops long-term mobility strategy, integrates accessibility and socio-economic objectives, and aligns funding and market design. The integration or authorisation officer assesses site-specific deployment, safety, cybersecurity, type approval and operational conditions and maintains close links with operational staff.

The profile therefore combines legal and policy literacy with sufficient technical understanding to interrogate safety cases, software updates, data arrangements, operational performance and accountability across complex supply chains. It also requires stakeholder coordination, procurement and contract-management capability, multimodal planning, public communication and continuous learning. This is not a call to turn every official into an engineer. It is a call for public institutions to develop the knowledge needed to commission, assess and govern expert evidence rather than depend on it uncritically.

6.5 5.5 Educational principles emerging from the work

Across the profiles, five principles recur:

- **Modularity.** Short, stackable units are needed because workers require targeted additions to existing qualifications and must update skills over time.
- **Work-based learning.** Simulations, live systems, supervised practice and learning-by-doing are essential for operational and safety-critical competences.
- **Multiple entry routes.** Recognition of prior learning and bridging modules should support transitions from adjacent occupations.
- **Shared quality standards.** Vendor-led and in-company training will remain important, but common learning outcomes and assessment are needed for portability and trust.
- **Train-the-trainer capacity.** Education providers, workplace mentors and public-sector trainers need access to current systems, equipment and industry experience.

Table 4 A modular learning architecture for CCAM roles

Learning layer	Typical content	Best-suited formats	Main users
Foundation	Digital and systems literacy, safety culture, cybersecurity hygiene, human factors and the basic CCAM operating concept.	Short courses, blended modules and induction.	All CCAM-facing staff.
Occupational core	Role-specific tasks, standards, decision rights, evidence requirements and communication responsibilities.	Accredited VET/HE modules, micro-credentials and recognition of prior learning.	Operators, technicians, engineers, service staff and officials.
Operational or vendor layer	Actual tools, interfaces, operational design domains, standard procedures, incident escalation and local service context.	Simulation, supervised workplace learning and vendor training.	Staff assigned to specific systems or services.
Continuing assurance	Software updates, lessons from incidents, regulatory change, refresher practice and periodic competence checks.	Continuing professional development, drills and reassessment.	Safety-critical roles, supervisors, trainers and regulators.

Source: synthesis of D4.5 and D5.2 [7,9].

7 Socially sustainable deployment through planning and policy

7.1 Why planning frameworks matter

Employment and skills policy cannot be separated from mobility planning. Decisions about where, when and how CCAM is deployed determine which services expand, which occupations are exposed, who has access, what infrastructure is required, how data are governed and how costs and benefits are distributed.

The analysis in CCAM—ERAS used the Sustainable Urban Mobility Planning cycle as a process framework and nine factors as a substantive lens: accessibility and connectivity; affordability; equity and inclusion; employment, skills and labour conditions; public health and safety; public acceptance, trust and awareness; data governance, privacy and cybersecurity; digital coverage and connectivity; and funding, financing and procurement. It reviewed eleven recent policy and strategic documents and twenty local or regional mobility plans.

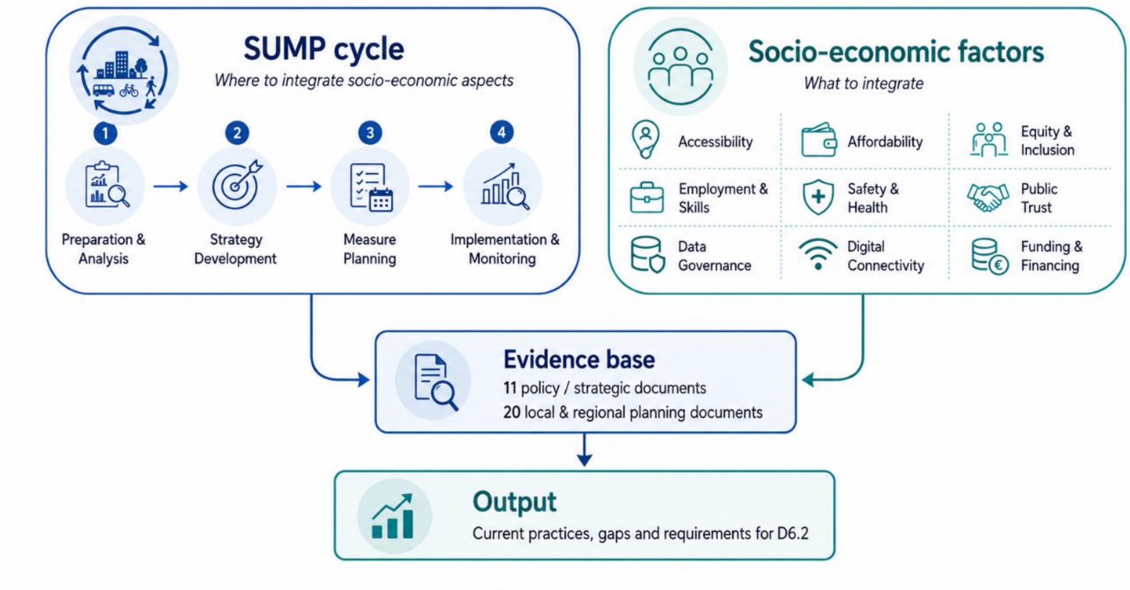


Figure 4 The SUMP Progress

7.2 The implementation gap

The review found that socio-economic issues are widely acknowledged but unevenly translated into decisions. Accessibility and safety are relatively mature because they already sit within conventional mobility planning. Affordability, equity, employment, digital inclusion, public trust and data governance are less consistently supported by indicators, measures, responsibilities and monitoring. They are often described as expected benefits rather than outcomes that must be actively governed.

A second gap lies between levels of governance. European and national strategies articulate broad ambitions but often provide limited operational guidance. Local and regional plans have established planning procedures but rarely include the full implications of automation, software and data. This creates a disconnect between strategic intent and implementation capacity.

A third gap concerns institutional scope. Traditional transport planning is centred on transport authorities, infrastructure departments and operators. CCAM requires sustained involvement from labour-market institutions, education providers, social policy actors, data-protection and cybersecurity authorities, emergency services, economic-development bodies, procurement teams and representatives of affected workers and users. Current governance arrangements do not consistently bring these actors into the same planning process.

7.3 Integrating socio-economic factors across the SUMP cycle

The value of the SUMP framework is that it turns broad principles into a sequence of decisions. In the preparation and analysis phase, authorities can map exposed occupations, training capacity, affordability, digital access, institutional capability and vulnerable groups alongside traffic and environmental conditions. In strategy development, alternative deployment pathways can be tested for distributional and employment effects, and objectives can be translated into measurable targets. In measure planning, workforce transition, training, accessibility, data governance and public engagement can be included in integrated packages with named responsibilities and budgets. During implementation and monitoring, indicators can track who uses the service, who benefits, which jobs change, whether training reaches target groups, how incidents are handled and whether costs remain affordable.

Table 5 Integrating socio-economic considerations across the SUMP cycle

SUMP phase	Common gap identified	Required addition for CCAM
1. Preparation and analysis	Limited diagnostics on labour markets, affordability, digital access and institutional capacity.	Map exposed occupations, training supply, vulnerable groups, data capability, affordability and governance readiness.
2. Strategy development	CCAM is weakly reflected in visions and scenarios; socio-economic objectives lack measurable indicators.	Compare deployment pathways, assess distributional effects and set targets for accessibility, employment, trust and inclusion.
3. Measure planning	Few integrated packages address workforce transition, affordability, digital inclusion and data governance.	Combine infrastructure and service measures with training, transition support, engagement, procurement and named responsibilities.
4. Implementation and monitoring	Monitoring focuses on transport and environmental performance, with partial socio-economic coverage.	Track users, costs, job changes, training participation, incidents, service quality, public trust and distributional outcomes.

Source: consortium synthesis .

Procurement is a particularly important level. Contracts can require operators and technology suppliers to provide workforce-transition plans, data for public-interest monitoring, accessible service design, cyber-resilience, training and knowledge transfer. Financing can be linked to socio-economic performance rather than technology installation alone. This helps align public expenditure with the wider outcomes that justify deployment.

Table 6 Socio-economic readiness questions before scaling a CCAM pilot

Dimension	Readiness question
Workforce exposure	Which tasks and occupations will expand, contract or move, and which groups or locations carry the transition risk?
Skills and training	Are role definitions, learning outcomes, trainers, equipment and paid learning time available before deployment scales?
Inclusion and access	Who gains access, who may be excluded by price, disability, geography or digital requirements, and how will this be measured?
Governance and accountability	Which public and private actors own safety, labour, data, service-quality and transition responsibilities?
Data, safety and trust	What evidence will be collected on incidents, cybersecurity, public acceptance, workload and system performance, and who may inspect it?
Procurement and finance	Do contracts and funding require accessible design, workforce-transition plans, knowledge transfer, monitoring data and corrective action?
Monitoring and adaptation	Which indicators trigger review, retraining, service redesign or additional support as the pilot moves into routine operation?

Source: synthesis of the draft D6.1 planning framework and WP5 workforce findings [8-10].

8 Strategic action agenda

CCAM-ERAS turns the project evidence into a roadmap for moving from recognition of socio-economic issues to operationalisation and enforcement. It treats CCAM as a public-value transition: planning should start from mobility needs, compare deployment pathways, translate objectives into funded and enforceable measures, and monitor outcomes throughout implementation. The actions below combine governance, workforce and skills, equity, funding, data and cybersecurity, public trust, procurement and SUMP integration rather than treating them as separate policy tracks.

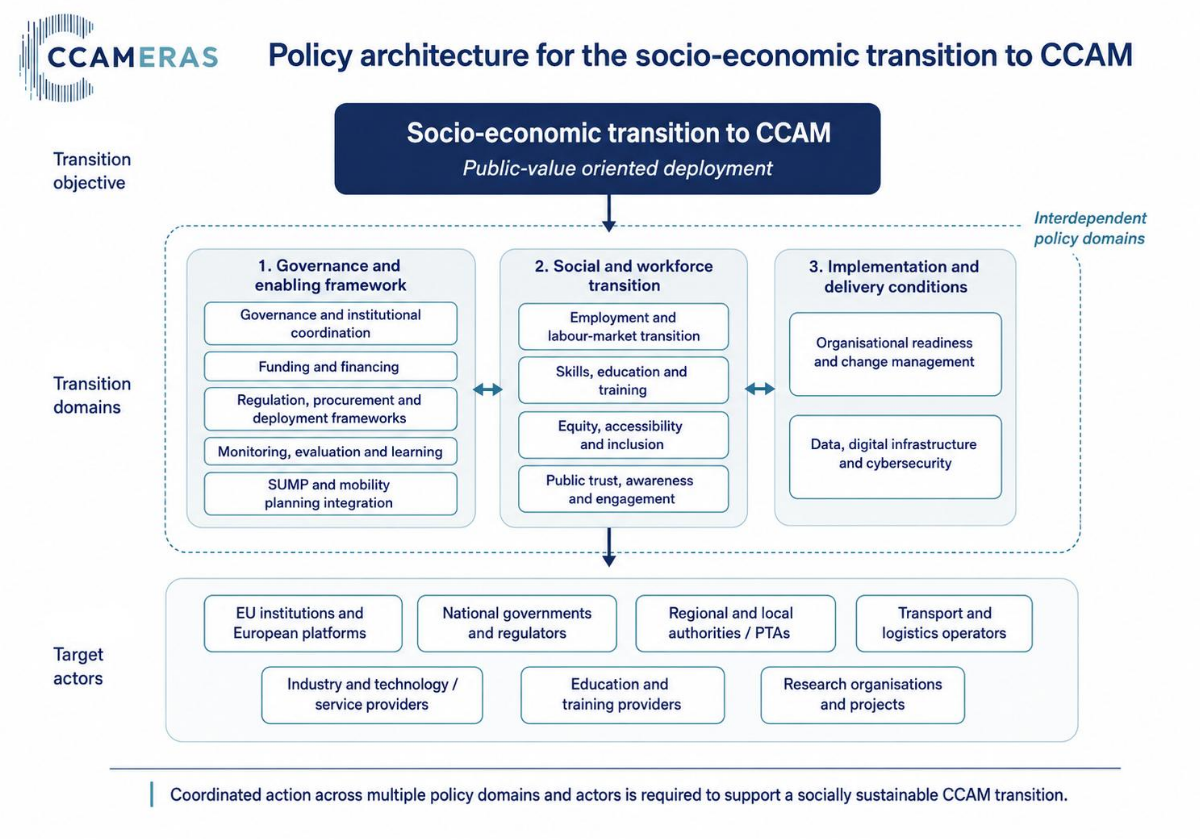


Figure 5 Strategic action agenda

European and national institutions

1. **Coordinate the transition across policy domains.** EU institutions, European platforms and national governments should align transport, labour, education, social, digital, industrial, funding and regional policy; define responsibilities; and provide legal clarity on testing, operational design domains, remote operation, fallback, liability, insurance, data and cybersecurity.
2. **Turn public-value objectives into common requirements.** Frameworks, model authorisations and funding rules should cover affordability, accessibility, public-transport integration, service coverage, data sharing, transparency, participation, safety reporting, cybersecurity and workforce-transition planning.
3. **Fund readiness before deployment scales.** Support should build public-sector capability, local planning capacity, SME participation, transition assistance, training infrastructure, paid learning, organisational change, evaluation and knowledge exchange, with funding tied to socio-economic objectives and reporting.
4. **Establish continuous employment and skills intelligence.** Combine scenario modelling, deployment data, labour-market indicators and stakeholder evidence; maintain shared occupational profiles, modular qualifications and mutual recognition; and update them as systems and roles evolve.

5. **Standardise evaluation and learning.** Major deployments and publicly funded pilots should have socio-economic evaluation plans. European and national frameworks should connect EU-CEM with employment, equity, trust and organisational-readiness indicators and publish comparable findings, including setbacks.

Regional and local authorities

1. **Integrate CCAM into every SUMP phase.** Begin with the mobility problem and public-value objective, then map affected groups, workforce and training capacity, affordability, digital access, organisational readiness and data capability before selecting a solution.
2. **Establish participative, cross-sector governance.** Bring transport and public-transport authorities together with labour, education, social policy, economic development, digital and cybersecurity, procurement and emergency services, as well as operators, workers, user groups and research organisations.
3. **Compare scenarios and set measurable objectives.** Assess trade-offs and unintended effects and define targets for accessibility, affordability, public-transport complementarity, service coverage, safety, employment and job quality, inclusion, public trust and data governance.
4. **Use procurement and authorisation as steering tools.** Contracts, concessions, permits and funding should require universal design, non-digital access, fare and service integration, secure data sharing and interoperability, workforce-transition plans, training, knowledge transfer, public reporting and corrective action.
5. **Monitor distributional outcomes and adapt.** Track users and non-users by geography, income, disability, age, gender and digital access, alongside safety, affordability, trust, service quality and workforce effects. Validate findings with stakeholders and adjust services, contracts, funding and support measures.

Employers, operators and technology providers

1. **Prepare organisations and workers early.** Carry out task-level impact and readiness assessments, develop organisational and workforce transition plans, and involve affected workers and their representatives before adoption decisions harden.
2. **Build credible job-to-job pathways.** Provide paid reskilling, upskilling and internal mobility from driving, dispatch, maintenance, customer service and logistics into remote operations, fleet orchestration, automated-vehicle maintenance, cybersecurity, compliance and technical-support roles.
3. **Design systems and work for safe human oversight.** Address workload, attention, escalation, psychological safety and decision rights; document operational design domains, system limitations, procedures and staff competence; and combine transferable learning outcomes with system-specific training.
4. **Deliver inclusive, interoperable and trustworthy services.** Apply universal design, fare and public-transport integration, non-digital access, user support and territorial coverage. Enable secure data sharing through documented interfaces and data definitions, avoid vendor lock-in and use cybersecurity-by-design.
5. **Share evidence and adapt operations.** Report service performance, safety events, accessibility, affordability, customer feedback, software updates and workforce and job-quality effects; co-invest in training and organisational adaptation; and cooperate with independent evaluation.

Education, training and research organisations

1. **Translate occupational profiles into modular, stackable learning.** Align micro-credentials, VET and higher-education provision with European qualification frameworks and combine role-specific learning with data governance, cybersecurity, safety, human factors, systems thinking, regulation, engagement and accessibility.
2. **Create accessible routes into emerging roles.** Use bridging programmes, recognition of prior learning, simulation, work-based learning, train-the-trainer programmes and industry placements, including for operator and public-authority staff.
3. **Build delivery partnerships and monitor outcomes.** Co-fund training infrastructure and specialist equipment with authorities, operators and industry; align provision with deployment schedules; and track participation, completion, job entry, employer relevance and curriculum currency.
4. **Strengthen the evidence base across the lifecycle.** Use scenario-based forecasting, distributional analysis and ex-ante and ex-post evaluation to distinguish enabling conditions, adoption and activity indicators, social outcomes and longer-term effects on occupations, organisations and society.
5. **Support open learning and societal readiness.** Develop shared methods, data definitions and tools; evaluate pilots, sandboxes and procurement; use co-design and stakeholder validation; communicate successes and failures; and transfer evidence into SUMP practice, regulation and curricula.

Social partners, worker and user representatives

1. **Engage before decisions harden.** Participate in baseline assessment, scenario design, role and workload definition, qualification development, procurement, implementation and evaluation rather than being consulted only after deployment.
2. **Negotiate fair transition arrangements.** Secure transparent information on automation plans, paid training, recognition of prior learning, redeployment and income support, sufficient learning time and practical job-to-job transition pathways.
3. **Protect job quality and safety.** Monitor workload, attention and psychological safety, surveillance and algorithmic management, safety and liability responsibilities, cybersecurity, outsourcing and the distribution of productivity gains.
4. **Make inclusion a deployment condition.** Represent users and non-users as well as workers at risk of exclusion; co-design universal access, non-digital options, assistance and complaint channels; and support recruitment and progression for groups underrepresented in technical transport roles.
5. **Validate evidence and sustain dialogue.** Use continuous participation to interpret employment effects, build trust, identify unintended effects and distinguish displacement from automation that addresses vacancies, reduces hazardous work or improves service coverage, with agreed triggers for corrective action.

8.1 Sequencing through the planning and deployment cycle

The order of action matters. Readiness should be assessed before solutions are selected; public-value objectives should shape scenarios and measures; contractual, funding and skills conditions should be in place before deployment; and monitoring should continue throughout operation.

Table 7 Sequencing priority action by roadmap phase

Roadmap phase	Priority actions	Primary actors
1. Preparation and analysis	Define the mobility problem and public-value case; establish governance; map affected groups, workforce, training, affordability, digital access and organisational readiness; clarify legal and data gaps; and agree the evaluation logic.	Regional and local authorities and PTAs lead, with national regulators, operators, social partners, user groups, education providers and researchers.
2. Strategy development	Compare deployment scenarios, trade-offs and unintended effects; define objectives, indicators and targets for accessibility, affordability, employment, inclusion, trust, data governance, safety and public-transport integration.	Authorities work within national and EU frameworks; operators, providers, workers, users and researchers test and validate the options.
3. Measure planning	Build integrated packages covering procurement, funding, authorisation, workforce transition, skills, inclusive service design, engagement, data sharing, cybersecurity and monitoring, with named owners, budgets, milestones and corrective clauses.	Authorities, procurement teams and funders work with operators, technology providers, education and training bodies, social partners and user representatives.
4. Implementation, monitoring and learning	Manage organisational and workforce change; collect contextual, activity and outcome indicators; report and validate results; adapt services, contracts, funding and training; and share lessons across regions.	All delivery partners, affected groups, independent evaluators, research organisations and permanent monitoring functions.

Source: Consortium Synthesis .

9 Limitations and next steps

The project has created a strong evidence base, but the findings should be used with appropriate caution.

First, the employment effects are assumption dependent. Uptake, investment, cost-saving and productivity parameters can change as regulation, prices, technology and business models evolve. The results are scenario differences from baseline and should be updated as better data become available.

Second, the use cases provide broad coverage but are not exhaustive. Evidence is strongest for pilots and early deployments, and some occupations may evolve differently when services scale. The balance between remote assistance, remote driving, on-board support and automated fallback remains particularly sensitive to regulation and system design.

Third, occupational transitions are not frictionless. Sectoral gains do not guarantee that affected workers can move into new roles without time, income support, geographic mobility and foundational education. Future work should connect the profiles to regional worker populations, wage structures, training costs and job-quality indicators.

Fourth, the skills evidence combines qualitative and consultative sources rather than a representative labour-market survey. This is appropriate for emerging occupations but should be complemented over time by vacancy data, administrative education data, certification records and employer surveys.

Fifth, the policy and planning analysis and the D6.2 roadmap draw on a finite set of documents, stakeholder inputs and early deployment evidence. The resulting framework is operational, but its effectiveness should be tested across different territorial, institutional and service contexts.

The next stage should therefore focus on applying and validating the roadmap: testing learning outcomes in real training programmes; validating profiles with employers and workers; updating the employment dashboard as adoption data improve; integrating socio-economic indicators into pilots and SUMP processes; and testing responsibilities, milestones, financing conditions and corrective mechanisms in procurement and deployment.

10Conclusion

The work synthesised here shows that Europe does not face a binary choice between automation and employment. The relevant choice is how the transition is organised. The same technology can produce different labour-market outcomes depending on the use case, adoption speed, investment pattern, service model, institutional readiness and availability of skills. The challenge is therefore one of coordination across time and systems.

Three findings are especially consequential. First, the transition operates through task change and hybridisation more often than immediate occupational disappearance. This creates realistic opportunities for reskilling and job-to-job mobility, but only when training is designed around actual tasks and offered before displacement occurs. Second, public authorities have a role in the skills problem. Authorities need to develop their own skills, combining technical and legal knowledge. But first, they must recognise that their own role is both crucial and urgent. . Safe deployment requires authorities capable of understanding and governing dynamic, software-driven systems. Third, socio-economic outcomes must be planned and measured. Accessibility, employment, affordability, inclusion, trust and data governance cannot be left as assumed benefits.

The integrated evidence chain developed by the project provides a practical basis for action. It connects technological change to sectors, sectors to employment, employment to tasks and skills, skills to learning outcomes, and learning outcomes to governance and planning. Its most important message is straightforward: investment in automated mobility must be matched by investment in people and institutions. When these investments are synchronised, CCAM can support safer, more efficient and more inclusive mobility. When they are not, skills shortages, regulatory delays and unequal transition costs can become as significant a barrier as the technology itself.

11References

References will be included once they are uploaded online so we can have links to project deliverables