From Fragmentation to Competitiveness:

A Europe-Wide Call for Collaboration to Scale Zero-Emission Freight

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Prepared in the context of the ZEFES project

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Abstract:

This white paper analyses zero-emission (ZE) road freight adoption in Europe, focusing on fragmentation in regulatory, technological, and operational domains that constrain cross-border deployment. It draws on a focused literature review and uses collaborative governance—joint decision-making among autonomous yet interdependent actors—as an analytical lens. Empirical evidence from the ZEFES stakeholder survey and documented stakeholder dialogues is used to characterize perceived barriers and governance preferences within the project's stakeholder sample. The paper concludes with pathways and recommendations intended to support harmonisation, incentive alignment, and the enabling conditions required to scale ZE freight corridors.

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1. Executive Summary

1.1 Purpose and scope

This white paper draws on the ZEFES project's stakeholder survey, written expert feedback from European associations and partner dialogues (including ZEFES K-Expert Talks) to examine how governance, collaboration, and fragmented rules are shaping the cross-border deployment of zero-emission road freight in Europe. It treats ZEFES not only as a technical demonstration, but also as part of a nascent zero-emission freight ecosystem in which OEMs, trailer manufacturers, logistics operators, infrastructure and energy providers, policymakers, and associations must act together. Building on this evidence base and on the governance literature, the paper outlines pathways and recommendations by synthesising the survey and stakeholder inputs into a prioritised set of harmonisation actions and governance options to support the standardisation of rules, alignment of incentives, and the enabling conditions required to scale zero-emission freight corridors. Informal exchanges with stakeholders during the ZEFES Stakeholder Symposium held in Zeebrugge in 2026 were broadly consistent with the themes discussed in this paper, including the importance of economic viability, corridor-based approaches, and cross-border operability.

1.2 Key findings on collaboration, regulation, and deployment barriers

Among respondents in this ZEFES stakeholder sample who had already operated or trialled ZE trucks and/or e-trailers (N = 28), almost all reported tangible operational benefits (see Section 5). Energy or fuel-cost reductions were cited by the large majority, with many also highlighting positive driver feedback, better access to low-emission zones and perceived safety or driving-performance improvements. Taken together, these responses indicate that where ZE vehicles are deployed under suitable conditions, most users experience concrete advantages rather than only costs or risks.

At the same time, the survey and expert feedback indicate that scaling these observed benefits across borders is constrained by several persistent coordination gaps. Regulatory fragmentation is widely perceived as a primary deployment barrier. In response to the survey statement "Regulatory fragmentation across Europe is a primary barrier to deploying zero-

emission (ZE) road freight at scale", 42 of 53 respondents selected Agree or Strongly agree on a five-point agreement scale (Strongly agree: 19; Agree: 23). Seven respondents were neutral and four disagreed; no one selected Strongly disagree. This pattern supports the interpretation that the fragmentation is perceived in this stakeholder sample as a major constraint.

The most frequently selected "top two" hindrances cluster around charging rules and vehicle approval. When respondents were asked to select their two most important hindrances to cross-border ZE deployment (multi-select; results reported as % of respondents selecting each item):

- Charging infrastructure rules: 32/53 (60%);
- Vehicle certification & approval: 31/53 (59%);
- Road access & EMS rules: 18/53 (34%);
- Tolling/ferry/intermodal access: 7/53 (13%);
- Data & digital interoperability: 5/53 (9%);
- Power availability & grid connection (as a coded top-two category): 3/53 (6%)
  In addition, 9 respondents (17%) provided write-in items coded as "Other/NA."
  Because the question required two selections, percentages are not expected to sum to 100%.

Importantly, this does not indicate low relevance of grid constraints: stakeholders frequently treat grid connection, permitting, and power availability as integral elements of "charging infrastructure rules", and grid-related frictions emerge consistently in open responses, K-Expert Talk evidence, and written association feedback.

Stakeholders prefer EU-level direction combined with multi-actor execution. On the question of who should lead harmonisation efforts (single-choice coding, N = 53), responses were distributed as:

- EU Commission/Agencies: 27/53 (51%);
- National governments: 6/53 (11%);
- Joint public–private taskforce: 13/53 (25%);
- Other / multi-actor: 7/53 (13%)

If the two multi-actor categories are combined (taskforce + other/multi-actor), 20/53 (38%) explicitly called for shared leadership or distributed coordination mechanisms. This supports a governance framing where EU-level leadership is valued, while a substantial minority requests more collaborative institutional arrangements.

Interpretation boundary: These results describe perceptions and preferences within a ZEFES-linked stakeholder sample; they do not constitute population estimates for all European freight actors.

1.3 Priority recommendations for policymakers, industry, and associations

Importantly, fragmentation is not only a compliance barrier, but it can also threaten Europe's industrial competitiveness if coordination across borders and sectors remains weak (McKinsey & Company, 2025). EU-level research and innovation strategy similarly frames the green-and-digital transition as a competitiveness and sovereignty imperative, calling for collective and coordinated action to move from traditional value chains towards broader ecosystems built on electrification, software/data/AI, resilient supply chains, and circularity (European Commission et al., 2026). Taken together, these perspectives support treating regulatory and operational fragmentation in ZE freight not only as an administrative burden but as a strategic risk to Europe's ability to scale and capture value from the transition.

Within this context, the ZEFES stakeholder survey results provide a more granular view on how governance could evolve. Stakeholders in this sample express a clear preference for EU-level direction combined with multi-actor execution, with EU institutions expected to set the overall framework while public- and private-sector actors collaborate on implementation along specific corridors. This aligns with collaborative and polycentric governance models discussed in the literature.

The recommendations below are derived from the barrier and governance patterns reported in this ZEFES-linked stakeholder sample and are framed as evidence-informed levers with plausible causal links to deployment acceleration. They are not exhaustive or prescriptive, but indicate where joint action by policymakers, industry and associations could most effectively reduce observed frictions.

For EU and national policymakers

1. Target harmonisation where survey respondents report the highest friction.
   Prioritise alignment of cross-border requirements related to vehicle certification/approval and charging infrastructure rules and reduce variability in road-access / EMS rules that directly affect payload and operational feasibility.

2. Treat charging-rule clarity as deployment infrastructure.
   Standardise, as far as possible, permitting processes, access conditions and predictable corridor deployment rules for charging, so as to reduce regulatory uncertainty that discourages fleet investment.

3. Institutionalise joint problem-solving mechanisms.
   Given that 38% of respondents explicitly prefer multi-stakeholder leadership models, establish structured EU-level public–private working arrangements (e.g. taskforces or corridor platforms) that translate corridor lessons and stakeholder evidence into regulatory convergence.

For industry (OEMs, trailer manufacturers, operators, energy/charging actors)

1. Pursue pre-competitive alignment on interfaces and compliance pathways. Invest in interoperable technical and procedural solutions that reduce the "approval burden" across jurisdictions and lower transaction costs for cross-border ZE operations.

2. Operationalise corridor learning into replicable playbooks. Convert demonstrator and early-operator learnings into standardised operational guidance for charging strategy, route planning and cross-border compliance preparation that can be reused by additional operators and corridors.

For associations and cross-industry platforms

1. Bridge evidence to policy.
   Act as neutral conveners that synthesise demonstrator evidence, survey signals and written feedback (e.g. from ESTA, ETB and others) into concise, implementable harmonisation proposals for EU and national decision processes.

2. Maintain an auditable trace from claim to data.
   Where feasible, publish or annex survey coding rules, summary tables and evidence registers so that key claims in the main text remain transparent and verifiable for policymakers and other stakeholders.

Overall, the evidence points to a constructive pathway: Europe already has working ZE deployments and engaged stakeholders; coordinated governance and targeted harmonisation can now help turn these promising pilots into scalable, cross-border solutions

2. Introduction: ZEFES in the Zero-Emission Freight Ecosystem

Recent competitiveness analyses argue that Europe's challenge is no longer ambition but speed and scale, requiring reforms that improve the investment environment and targeted large-scale projects where industry and the public sector collaborate strategically. This provides a wider competitiveness lens for the ZEFES question: if zero-emission freight corridors are to scale, Europe must reduce fragmentation and create interoperable, investment-ready deployment conditions (McKinsey & Company, 2026).

The Urgency of Aligning for Zero-Emission Freight

Transitioning the European freight ecosystem to zero-emission technologies is not only urgent due to climate targets, but increasingly complex due to its multi-actor, cross-border, and high-capital nature. While the European Green Deal sets an ambitious policy trajectory, implementation lags due to regulatory fragmentation, disparate infrastructure readiness, and diverging market signals. Recent EU registration data indicates that uptake is still at an early stage: electrically chargeable trucks above 3.5t accounted for 4.2% of new registrations in 2025 (up from 2.3% in 2024), while diesel still represented 93.2% of new truck registrations (ACEA, 2026).

The ZEFES project brings together manufacturers, logistics providers, and policymakers, yet early findings underscore the need for deeper alignment mechanisms.

2.1 ZEFES objectives and work package context

ZEFES is an EU-funded collaborative programme addressing the deployment of zero-emission freight through modular vehicle powertrain innovation, trailer integration, and real-world operational validation. The project's work packages create an evidence base that is relevant not only to technology readiness but also to the enabling conditions required for cross-border operation, including infrastructure interfaces and regulatory constraints.

2.2 From technical demonstrations to system-level transition

A central premise of this white paper is that ZE freight deployment is a system transition, not a single-technology substitution. Vehicle performance, charging access, grid readiness,

operational rules, and certification regimes interact to determine whether fleets can deploy at scale. ZEFES demonstrations are therefore treated here as “system probes”: they generate operational evidence about what is feasible under current conditions and where constraints arise.

2.3 Why collaboration and harmonised rules matter for cross-border ZE freight

The survey data provides a quantitative basis for prioritising harmonisation and collaboration. First, 79% (42/53) of respondents agreed that regulatory fragmentation is a primary barrier to scaling ZE road freight. Second, when asked to select top hindrances, respondents most frequently selected charging infrastructure rules (60%) and vehicle certification & approval (59%), followed by road access & EMS rules (34%). These results indicate that perceived constraints sit at the intersection of infrastructure governance and regulatory operability—areas that require multi-actor coordination. Governance preferences further support this: while 51% favour EU institutions as lead drivers, 38% call for multi-stakeholder leadership models, suggesting that effective harmonisation may require both EU-level direction and structured public–private execution. Alongside the survey-based evidence presented in this paper, informal exchanges during the ZEFES Stakeholder Symposium held in Zeebrugge in 2026 provided additional contextual perspective on current sector discussions. These exchanges suggested that, beyond technological readiness, stakeholders are increasingly attentive to economic viability, investment predictability, and practical cross-border deployment conditions, in line with the paper’s focus on collaboration and harmonised rules.

2.4 Intended audience and how to read this white paper

This paper is written for (i) policymakers and regulators working on transport, energy, and cross-border enabling frameworks; (ii) industry actors responsible for deploying ZE freight solutions; and (iii) associations and platforms supporting alignment across sectors. Readers seeking evidence should begin with the survey results and coding summary tables; readers seeking action can go directly to the recommendations and return to the evidence sections to verify the basis for each recommendation.

The Problem: Fragmentation Across the Freight Ecosystem

The road to zero-emission freight is fragmented in at least three key ways:

1. Regulatory Fragmentation: Differing national regulations on weights, dimensions, and type approvals obstruct cross-border deployment.
2. Technological Fragmentation: OEMs pursue different architectures for ZE trucks and trailers (e.g. depot vs. dynamic charging, central vs. distributed intelligence).
3. Operational Fragmentation: Users face difficulties in scaling pilots due to charging uncertainty, route restrictions, and limited interoperability across OEMs.

As a result, even highly motivated actors cannot act effectively or at scale. These interdependencies are not well-managed through existing coordination mechanisms.

- **Collaborative Governance as an Explanatory Lens**

Fragmentation is not a new phenomenon in public policy or complex systems. As outlined in Emerson et al. (2012), collaborative governance is “the processes and structures of public policy decision making and management that engage people across boundaries of public agencies, levels of government, and/or the public, private and civic spheres.”

The Emerson framework identifies key drivers:

- Uncertainty or Crisis (in our case, climate targets and policy pressure),
- Interdependence (actors cannot reach outcomes alone), and
- Consequential Incentives (e.g., funding opportunities, mandates, risk exposure).

These conditions are present in the ZE freight landscape.

The framework also posits that collaborative governance emerges and evolves through shared motivation, capacity for joint action, and principled engagement. This triad can be used to evaluate initiatives like ZEFES:

- Shared Motivation: Is there a common understanding of goals among partners?
- Capacity for Joint Action: Are there institutional and operational mechanisms (e.g., shared platforms, joint pilots, mutual KPIs)?
- Principled Engagement: Are stakeholders engaging in inclusive, transparent, and adaptive ways?

- **Decentralised Coordination through Polycentric Governance**

In addressing the governance of multi-actor, cross-border decarbonisation projects such as ZEFES, the concept of polycentric governance provides a compelling foundation. As introduced by Ostrom (2010), polycentric governance refers to systems in which multiple centers of decision-making operate with some degree of autonomy but are mutually adjusting through rules, trust, and information-sharing. This approach acknowledges the limitations of both purely market-based and purely hierarchical governance structures in managing complex socio-technical systems. In the context of ZEFES, which spans OEMs, operators, DSOs, ministries, and corridor authorities across several EU member states, such a polycentric architecture is not only descriptive but also prescriptively useful. It allows for experimentation, local adaptation, and shared learning all of which are essential for managing technological and regulatory uncertainty in the deployment of zero-emission freight. Ostrom’s emphasis on adaptive learning and mutual monitoring aligns with the distributed nature of ZEFES, reinforcing the need to design governance models that enable coordination without excessive centralisation.

- **Contributions from Network Governance Theory**

Wang & Ran’s work on network governance (2023) further supports this lens. It highlights the need for both coordination (aligning plans, standards, data) and control (ensuring performance and compliance) in distributed systems. In ZEFES, this might translate to:

- Coordination through common protocols (e.g., interoperable interfaces, shared data definitions).

- Control via performance dashboards, partner assessments, and stage-gated funding.

- **Team dynamics and psychological safety**

While structural governance frameworks (Emerson et al., 2012) and network architectures (Wang & Ran, 2023) form the backbone of multi-actor alignment, the success of such initiatives also depends critically on the internal dynamics of participating teams.

Edmondson's (1999) empirical work on psychological safety demonstrates that when teams believe they can engage in interpersonal risk-taking, learning behaviour increases, which in turn enhances performance.

In the context of ZEFES, pilot teams across OEMs, logistics operators and infrastructure partners must cultivate such conditions to ensure that collaboration translates into innovation and deployment

- **Framing the Way Forward**

Building on the foundational work of Jacobides, Cennamo, and Gawer (2018), it becomes evident that zero-emission freight should be understood not merely as a sectoral or infrastructural challenge, but as the emergence of a complex industrial ecosystem. In this framing, no single actor—whether OEM, infrastructure provider, or regulator—can deliver system-wide change independently. Instead, interdependent roles must be coordinated around shared value creation and aligned technical interfaces. The ZEFES project, by spanning manufacturers, operators, grid actors, and public authorities, exemplifies the early architecture of such an ecosystem. As emphasised in the literature, ecosystem orchestration depends on both *modular complementarities* (e.g., vehicle–charging interface standards) and *strategic alignment* (e.g., harmonized deployment corridors). Recognizing ZEFES as part of an emergent ZE-freight ecosystem thus helps reframe fragmentation not as failure, but as a coordination gap — one that may be addressed through ecosystem-wide governance strategies rather than isolated technical fixes.

- **The Urgency of Ecosystem Coordination**

Recent industry analysis further reinforces the urgency of coordinated, cross-sectoral action. A 2025 McKinsey & Company report titled *"Europe's ZE Truck Transition: Key for Decarbonization and Competitiveness"* (McKinsey & Company, 2025) emphasises that achieving Europe's decarbonization goals requires a step-change in collaboration across the value chain, including vehicle manufacturers, charging infrastructure providers, logistics operators, and policymakers. The report estimates that fleet-wide compliance with the 2040 CO_2 targets will necessitate over €400 billion in infrastructure and vehicle investments, making siloed approaches unviable. McKinsey & Company explicitly frames zero-emission trucking as an "ecosystem challenge," mirroring the ZEFES perspective that no single actor can deliver the transition alone. These insights provide further empirical support for the white paper's call to move beyond fragmented pilot projects toward system-level orchestration and networked governance of the ZE freight transition.

3. Collaborative Governance for ZE Freight

Scaling zero-emission (ZE) road freight across Europe is not only a technology and infrastructure challenge; it is a coordination challenge across interdependent actors and jurisdictions. In this paper, collaborative governance is used as an analytical lens to explain how shared rules, joint execution capacity, and learning mechanisms can reduce cross-border operability frictions and make ZE corridor deployment repeatable.

3.1 Collaborative governance and ecosystem orchestration

ZE freight is an ecosystem problem: trucks, trailers, charging, grid connection, digital interfaces, and corridor rules are complementary components that must align for cross-border operations to work in practice (Jacobides, Cennamo, & Gawer, 2018). Collaborative governance helps explain how autonomous actors can jointly design and operate these complements—through shared objectives, joint decision routines, and execution mechanisms that translate evidence into harmonised, usable rules (Emerson, Nabatchi, & Balogh, 2012).

Fragmentation is not a new phenomenon in public policy or complex systems. As outlined in Emerson et al. (2012), collaborative governance is “the processes and structures of public policy decision making and management that engage people across boundaries of public agencies, levels of government, and/or the public, private and civic spheres.”

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Polycentric coordination across borders

In addressing the governance of multi-actor, cross-border decarbonisation projects such as ZEFES, the concept of polycentric governance provides a compelling foundation. As introduced by Ostrom (2010), polycentric governance refers to systems in which multiple centers of decision-making operate with some degree of autonomy but are mutually adjusting through rules, trust, and information-sharing. This approach acknowledges the limitations of both purely market-based and purely hierarchical governance structures in managing complex socio-technical systems. In the context of ZEFES, which spans OEMs, operators, DSOs, ministries, and corridor authorities across several EU member states, such a polycentric architecture is not only descriptive but also prescriptively useful. It allows for experimentation, local adaptation, and shared learning elements all of which are essential for managing

technological and regulatory uncertainty in the deployment of zero-emission freight. Ostrom's emphasis on adaptive learning and mutual monitoring aligns with the distributed nature of ZEFES, reinforcing the need to design governance models that enable coordination without excessive centralisation.

Network governance and structured coordination

Wang & Ran's work on network governance (2023) further supports this lens. It highlights the need for both coordination (aligning plans, standards, and data) and control (ensuring performance and compliance) in distributed systems. In ZEFES, this can be translated to:

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Control via performance dashboards, partner assessments, and stage-gated funding.

3.2 Enablers of collaboration: trust, learning, psychological safety

Beyond formal governance arrangements, collaboration depends on relational conditions that make cross-actor coordination workable in practice. Collaborative governance research highlights trust-building, shared understanding, and iterative learning as core enablers of sustained joint action (Ansell & Gash, 2008; Emerson, Nabatchi, & Balogh, 2012). In ZE freight, these enablers matter because early deployment involves uncertainty in technology performance, infrastructure readiness, cost evolution, and cross-border enforcement realities.

Practically, trust grows when stakeholders can test solutions together, share constraints candidly, and generate "small wins" that reduce perceived risk. Project-based settings such as ZEFES stakeholder dialogues and K-Expert Talks can therefore function as learning infrastructure—helping partners compare assumptions, surface operability bottlenecks early, and converge on feasible execution routines that can be reused across corridors.

Edmondson's (1999) work on psychological safety shows that when people believe they can speak up, ask questions, and admit uncertainty without fear of blame, learning behaviors increase—improving problem-solving and performance under uncertainty.

In cross-organisational programmes like ZEFES, psychological safety supports the quality of evidence that feeds harmonisation: it enables partners to report operational failures, permitting delays, grid-connection realities, and compliance frictions early—so that coordination efforts focus on the real bottlenecks rather than optimistic assumptions.

3.3 Implications for cross-border ZE freight

For cross-border ZE freight, governance questions are operational questions. Even when EU-level objectives are clear, deployment outcomes depend on how quickly the ecosystem can align rules-of-use, approvals evidence, infrastructure access assumptions, and data practices across borders. Network governance theory is useful here because it focuses on the network as the unit of delivery—i.e., whether the corridor ecosystem can produce repeatable, investable operating conditions.

Provan & Kenis (2008) describe three basic modes of network governance—shared governance, lead-organisation governance, and a Network Administrative Organisation (NAO). Their central insight for ZE freight is that scale requires an explicit coordination structure that can sustain legitimacy and keep execution moving as the network grows. In the

ZE transition, EU institutions can provide external legitimacy and direction (targets, minimum requirements, and standard-setting), while corridor-level public–private taskforces and trusted intermediaries (including associations) can provide the joint execution capacity needed to resolve practical blockers and turn evidence into reusable templates.

Three recurring tensions identified by Provan & Kenis are directly visible in the ZE freight transition:

• Efficiency vs. inclusion: broad participation builds buy-in and surface-level realism, but delivery needs decision-capable teams and clear ownership to avoid stalling.

• Internal vs. external legitimacy: partners must believe the collaboration is fair and useful (internal legitimacy), while policymakers, investors, and the wider market must see credible progress and accountability (external legitimacy).

• Flexibility vs. stability: the system must adapt as technology and energy markets evolve, but investment and operations require stable, repeatable rules and processes over time.

Implication for EU-wide ZE corridor scaling: governance should be designed to balance these tensions rather than leaving them to ad-hoc negotiation. Practically, this supports (i) corridor execution mechanisms with named owners and escalation routes; (ii) a small, comparable KPI set and minimum data definition to enable learning across routes; and (iii) an evidence-to-rules feedback loop so that demonstrated solutions can inform harmonisation and standardisation efforts.

4. Evidence and Method

4.1 Data sources (survey, written feedback, K-Expert Talks, project material)

Survey (primary source). We conducted a cross-sectional stakeholder survey within the ZEFES consortium and wider stakeholder network to identify regulatory and operational barriers to cross-border deployment of zero-emission (ZE) road freight and to elicit preferences for governance and harmonisation pathways.

Additional qualitative sources (triangulation). Survey findings are triangulated with evidence from (i) insights captured through ZEFES stakeholder engagement activities, including documented discussions and thematic takeaways, and (ii) insights from ZEFES K-Expert Talks (IAA 2024, Transport Logistic 2025, Solutrans 2025). This enables us to connect perceived hurdles and requested actions to concrete operational examples and stakeholder experiences discussed in the project context, without treating the survey results as standalone.

Informal stakeholder exchanges during the ZEFES Stakeholder Symposium held in Zeebrugge in 2026 were used solely as contextual background to sense-check themes emerging from the survey and dialogue corpus and do not constitute a separate evidence source.

Written key-informant feedback (triangulation). Written feedback from two European associations (ESTA and ETB) was used as key-informant triangulation evidence and coded against the same barrier framework used for the survey open responses. For traceability, written feedback items are referenced as WF-01 and WF-02 (WF = Written Feedback; see Annex F).

4.2 Survey sample, fieldwork, limits

Participants and sampling. The sampling frame comprised organisations active in the European road-freight ecosystem: OEMs, logistics operators/shippers/LSPs, infrastructure and charging providers (including grid and distribution system operators, DSO; charge point operators, CPO), policymakers/authorities, research organisations, associations and complementary service providers (e.g. parking and IT/digital platforms). Participation was voluntary and unpaid.

The survey recorded 54 submissions in total. One internal test entry was removed, leaving 53 valid responses in the analytic dataset. Fieldwork ran from 21 October 2025 to 1 December 2025. The distribution of organisation types and operating regions is reported in the Results section. Findings reflect stakeholder perceptions within this ZEFES-linked sample and are interpreted descriptively rather than as population estimates.

Instrument. The structured online questionnaire (Microsoft Forms) included four blocks:

1. Respondent profile – organisation type and main corridors/countries of operation.
2. Perceptions of regulatory fragmentation – closed multi-select items on perceived barriers to cross-border ZE deployment (e.g. vehicle certification and approval; road access and EMS rules; charging-infrastructure rules and availability; grid connection and permits; toll/ferry/intermodal access; data and digital interoperability), a core Likert statement on fragmentation as a barrier, and an open question inviting a concrete example of misalignment.
3. Governance and EU initiatives – a single-choice item on preferred leadership for harmonisation over the next two years (EU institutions, national governments, research consortia, joint public–private taskforce, other), and Likert-type items on the perceived effectiveness of EU-level initiatives (AFIR, TEN-T, CO_2 standards, 2ZERO) and of cross-industry forums such as ZEFES K-Expert Talks.
4. Experience with ZE trucks and e-trailers – multi-select items on which ZE solutions respondents have already operated or trialled, and closed/open questions on observed benefits and operational or regulatory hurdles, including the question “What is the single most important step Europe should take to accelerate ZE deployment in 2026?”

Procedure. The survey link was distributed via the ZEFES partner mailing list and Stakeholder Group and amplified through ZEFES social channels and partner associations (e.g. ESTA, IRU, ETB). Reminder messages were issued during the fieldwork period. Responses were anonymous by default; respondents could optionally provide their name, role and email address in a separate field if they wished to participate in a short follow-up interview or allow attribution of specific quotes.

4.3 Coding and triangulation approach

Closed items. Primary quantitative outcomes are the proportions of respondents selecting each barrier to cross-border ZE deployment. Secondary outcomes include the distribution of leadership preferences, the prevalence of ZE field experience (ZE trucks and e-trailers), and the frequency of reported benefits and hurdles among those with experience. For all closed

questions we use the predefined response options from the questionnaire; multiple selections were allowed for the barrier list and experience items.

Open question on current hurdles. For the open text on “main regulatory or operational hurdles”, we focused on respondents with any ZE field experience (operated or trialled ZE trucks and/or e-trailers) who provided a non-empty answer. These answers were coded using a directed content-analysis approach with a codebook aligned to the barrier framework:

- Certification / Type-approval
- Road access / EMS
- Toll / Ferry / Intermodal
- Charging & Grid (siting, power availability, DSO lead times)
- Data / Interoperability
- EU–national misalignment
- Total cost of ownership (TCO) / Cost
- Range / Performance
- Payload / Weight
- Other (specified)
  Each answer could receive more than one code.

Open question on the “single most important step” for 2026. For the question “What is the single most important step Europe should take to accelerate ZE deployment in 2026?” 45 respondents provided a substantive textual answer. These were coded using a parallel, solution-oriented codebook:

- Infrastructure & Grid / Charging (including H_2 refuelling and corridor/terminal infrastructure)
- Funding, Incentives & Prices (subsidies, tolls, de-risking, electricity prices, CO_2 charging schemes)
- Regulation, Standards & Harmonisation (EU–national alignment, legal clarity, data and interoperability standards)
- Vehicle-specific Standards (e.g. Weights and Dimensions, allowances for 4-ton overweight, legalisation of longer/heavier combinations such as EMS/Duo trailers)
- Market-pull & Mandates (fleet mandates, targeted incentives/disincentives shaping demand)

Multiple codes per answer were allowed. For comparison in the Results, detailed codes are also grouped into overarching themes of infrastructure & energy, regulation & harmonisation, economics & TCO, vehicle performance & payload and market pull & mandates.

Data analysis. For closed-ended questions we computed counts and percentages for each response option. Where relevant, we present simple cross-tabulations by stakeholder type or ZE-experience status and interpret these descriptively; no formal hypothesis tests or

confidence intervals were calculated. For open-ended questions, we report the number of responses in which each code appears and the corresponding percentage of respondents who provided a non-empty answer to that question. Because multiple codes can apply to a single answer, percentages across codes do not sum to 100%. Given the modest sample size, these results are interpreted as indicative patterns, not precise prevalence estimates.

K-Expert Talk content analysis (triangulation detail). In addition to the stakeholder survey, we analysed the K-Expert Talk series as a qualitative corpus of multi-actor expert dialogue (IAA 2024; Transport Logistic 2025; Solutrans 2025). Using directed content analysis, statements were coded against a predefined codebook aligned to the survey themes (e.g., charging & grid, type approval/certification, weights & dimensions, intermodal constraints, data interoperability, and TCO). The unit of analysis was a “meaningful claim” (1–3 sentences) expressing a barrier, enabler, or recommended action. Each claim was also tagged by actor type and governance target (EU, Member State, or joint public–private coordination). The coded corpus was used for triangulation to corroborate survey patterns and clarify underlying mechanisms. K-Expert Talk evidence is used as explanatory triangulation and illustrative support rather than representative sampling. The same directed coding logic was applied to the written association expert feedback to support triangulation (WF-01; WF-02).

Ethics and confidentiality. No personal or sensitive data were required for participation. Responses were stored on secure institutional platforms. Reporting in this white paper is at an aggregate and anonymised level, unless explicit consent for attribution was provided via the survey. The activity forms part of routine programme evaluation and stakeholder engagement within ZEFES; no intervention or vulnerable populations were involved.

AI-assisted editorial support. Generative AI tools (ChatGPT) were used only to support editorial and analytical tasks under human control—for example, to suggest possible code categories, polish language, and help restructure sections drafted by the authors. AI tools were not used to generate data, fabricate or “discover” sources, or produce stakeholder quotes. All coding decisions, numerical results, and factual claims in this section are based on the underlying survey dataset and were implemented, checked and approved by the authors, who remain fully responsible for the final content.

4.4 Limitations

This study has several limitations that should be considered when interpreting the findings. First, the survey used a non-probability, ZEFES-linked sampling frame, so results describe perceptions within this stakeholder group and cannot be treated as statistically representative of all European freight actors. Second, the sample size (N = 53) and heterogeneous respondent mix limit the scope for disaggregated analysis by actor type or corridor, and all quantitative results are interpreted descriptively rather than through formal inference. Third, the evidence relies on self-reported perceptions of barriers, governance preferences and observed benefits; we did not independently verify regulatory conditions, infrastructure availability or operational performance. Fourth, open-ended responses, K-Expert Talk transcripts and written association feedback were analysed using directed content analysis with a predefined codebook, which supports comparability but may under-represent themes that fall outside this framework. Finally, triangulation across survey, dialogue and written feedback sources aims to enhance interpretive robustness, but the qualitative materials are purposively selected and should be read as illustrative rather than exhaustive.

5. Findings I – Coordination Gaps Across the Freight Ecosystem

We briefly summarise benefits to underline that the key issue is scale and operability and not lack of value.

Early responses in this ZEFES-linked sample suggest that zero-emission (ZE) vehicles already deliver concrete operational benefits where they are deployed, but that these positive examples remain unevenly distributed and difficult to scale across borders. This section first summarises reported benefits from early ZE truck and e-trailer operations, and then examines the main frictions that stakeholders perceive when attempting to extend such deployments across countries and corridors. The emphasis is on how these observed frictions can inform joint efforts by policymakers and industry to reduce deployment barriers.

Among respondents who had already operated or trialled ZE trucks and/or e-trailers (N = 28), and answered the benefits question, almost all reported tangible operational benefits. Energy savings or fuel reduction were mentioned by close to 90% of these early adopters, and around two-thirds highlighted positive driver or user feedback. Roughly half noted improved access to low-emission zones or other permits, while around one-third pointed to improved safety or driving performance. A smaller group mentioned greater operational flexibility or other benefits such as reputational gains and learning effects. Because respondents could select multiple benefits, these proportions do not sum to 100%, but together they suggest that where ZE vehicles are actually deployed, most users experience concrete advantages rather than only costs or risks.

5.1 Regulatory fragmentation

Fragmentation in cross-border rules remains a persistent barrier to scaling zero-emission freight. Stakeholders point to misalignment in access conditions, approvals, and operational rules that increases administrative burden and creates uncertainty for corridor planning and investment.

Triangulation from K-Expert Talks. Dialogue evidence indicates that fragmentation is experienced as non-uniform national implementation and inconsistent local enforcement, which forces route adjustments and undermines cross-border operability even when EU-level revisions exist. As one participant noted: “In every country, we have to discuss with local authorities… a lot of authority say, ‘Ah, I don’t know about this, and I don’t care.’” (K-Expert Talk, Transport Logistic 2025 transcript).

Taken together, the survey and K-Talk evidence suggest that the primary barrier is not technology readiness but cross-border operability under fragmented implementation and enforcement. This pattern is consistent with association feedback on cross-border operability frictions (WF-01; WF-02).

5.2 Infrastructure and grid constraints

Stakeholders identify infrastructure readiness—particularly charging availability and grid connection lead times—as a critical constraint for scaling zero-emission road freight beyond

pilots. Fragmentation in permitting processes, site requirements, and cross-border access conditions increases uncertainty for corridor planning and slows investment decisions.

Triangulation from K-Expert Talks. Transcript evidence indicates that infrastructure deployment is constrained not only by charger availability but also by grid connection and implementation lead times that affect corridor reliability. As one participant noted: “it takes at least like six to nine months to roll out a charging infrastructure.” (K-Expert Talk, Solutrans 2025 transcript).

Taken together, the survey and K-Talk evidence suggest that accelerating deployment requires not only more charging sites, but predictable and faster grid connection and permitting pathways, aligned across Member States to reduce corridor-level uncertainty.

5.3 Operational challenges (range, payload, routing, intermodal interfaces)

Stakeholders report that operational feasibility remains constrained by vehicle limitations and corridor conditions, particularly range/performance considerations, payload impacts, and routing constraints. Intermodal interfaces are also raised as a practical scaling issue, as corridor performance depends on the availability and readiness of transfer nodes and operational coordination across modes.

Triangulation from K-Expert Talks. Dialogue evidence suggests that intermodal feasibility depends on enabling nodes in the network (terminals and combined transport sites) that can consolidate freight flows and connect road and rail efficiently. As one participant noted: “we need terminals… combined transport sites that allow to consolidate trucks… and put them on the train.” (K-Expert Talk, Solutrans 2025 transcript).

Taken together, the survey and K-Talk evidence indicate that operational constraints are shaped not only by vehicle capability, but also by network interfaces and node readiness, making corridor performance infrastructure- and coordination-dependent.

5.4 Data and digital interoperability issues (fleet data, charging data, interfaces)

Stakeholders also highlight data and digital interoperability as an enabling condition for scale. Fragmented interfaces across vehicles, charging infrastructure, fleet systems, and corridor stakeholders increase planning complexity and reduce operational confidence—particularly for cross-border operations where consistent reporting and coordination are needed.

Triangulation from K-Expert Talks. Dialogue evidence indicates that scaling zero-emission freight corridors requires operational and demonstrator data to be translated into shared standards and rule-making, enabling interoperability across actors and borders. As one participant noted: “Our use cases… will enable data. We need to use this data… for the rule makers to bring more standardization and harmonisation.” (K-Expert Talk, Solutrans 2025 transcript).

Taken together, the survey and K-Talk evidence suggest that data interoperability is not only a technical issue, but also a governance challenge requiring EU-level standard-setting and multi-actor coordination.

5.5 Economic constraints and the ZE business case (TCO, pricing, risk sharing)

Stakeholders frequently emphasise that total cost of ownership (TCO) and business-case uncertainty remain central barriers to wider deployment. Respondents point to higher upfront costs, exposure to energy-price variability, and unclear residual values, noting that without predictable operating economics and risk-sharing mechanisms, corridor-scale investment decisions are delayed.

Triangulation from K-Expert Talks. Dialogue evidence clarifies that charging location and pricing structures can materially affect TCO, particularly where public fast charging is significantly more expensive than depot charging. As one participant noted: “Public fast charge… beware of the total cost of ownership, because prices are about like twice or three times higher than at the depot.” (K-Expert Talk, Solutrans 2025 transcript).

Taken together, the survey and K-Talk evidence suggest that scaling ZE freight requires not only infrastructure rollout, but also cost predictability and business-model viability, supported through aligned incentives, transparent charging pricing, and risk-sharing mechanisms. These economic constraints are not independent market failures but the cumulative result of fragmented regulation, infrastructure governance, and corridor execution. Delivered charging-price variability across locations, depot–public price spreads, and grid-connection timelines therefore function as governance gaps (affecting bankability and investment timing), not purely commercial risks. This explains why stakeholders increasingly frame TCO drivers—such as delivered electricity prices, grid lead times, and utilisation—as priorities for coordinated EU and corridor-level action.

6. Findings II: Governance Preferences and Leadership

Survey findings reveal both a strong preference for EU-level leadership (51%) and a substantial call for broader collaborative governance models (38%). When asked who should lead harmonisation efforts over the next two years, a majority of respondents (51%) chose the European Commission or its agencies as the preferred driver. This indicates clear support for a Europe-wide coordination mechanism.

This finding echoes the ACEA (2025) report, which highlights that the uptake of ZE trucks remains “highly fragmented” and concentrated in just a few member states. Notably, non-EU countries like Switzerland and Norway outperform EU states due to more favourable enabling conditions and coherent policies. This points to the need for more aligned regulatory frameworks and support mechanisms across the EU to accelerate progress and reduce fragmentation.

At the same time, a significant minority (25%) explicitly favoured the creation of a joint public–private taskforce, and another 13% proposed more distributed leadership models involving combinations of EU, national, and industry actors. Taken together, around 38% of respondents expressed a preference for shared, multi-actor governance, rather than a purely top-down approach.

These findings suggest that Europe’s zero-emission freight transition cannot rely solely on centralised authority. Instead, there is a clear mandate for EU-led collaboration, in which the Commission provides structure and legitimacy, but works in tandem with taskforces, corridor-level platforms, and trusted intermediaries across the freight ecosystem. This aligns with (Sørensen & Torfing, 2010) insight that collaboration involves more than coordination—it requires the co-creation of ideas and practices, the exchange of resources, and the exercise of metagovernance to sustain momentum and remove barriers. In the ZEFES context, such

hybrid approaches can enhance trust, enable adaptive learning, and reflect the complex interdependencies among freight actors.

Related themes also surfaced in informal stakeholder exchanges during the ZEFES Stakeholder Symposium held in Zeebrugge in 2026, where participants acknowledged the role of EU-level direction while emphasising the need for practical, execution-oriented implementation approaches. Corridor-based collaboration and the visibility of the economic case were recurring points of reference in these discussions.

Written association feedback aligns with this hybrid logic, pointing to the need for EU-level direction alongside practical corridor-level execution mechanisms (WF-01; WF-02).

To make these governance preferences more concrete, we also asked stakeholders (N = 45) to name the single most important step Europe should take in 2026.

When asked an open question to name the single most important step Europe should take in 2026 to accelerate ZE deployment, respondents converged on three main levers. First, around 44% called for faster deployment of infrastructure, grid capacity and charging or refuelling corridors, often emphasising planning security and megawatt-charging capability along core freight routes.

“Planning security by introducing a long-term incentive on free road toll and invest in charging along motorways.”

“Accelerate the charging infrastructure and the grid investments.”

“Develop a Combined Transport rail-road terminals network connections.”

“I think… chargers in the roads [are needed] since there are not enough in many regions.”

Second, roughly 40% stressed regulatory and standardisation measures, including weights-and-dimensions revisions and harmonised rules for approvals, permits and cross-border operations.

- “Remove regulatory misalignment that creates delays or additional cost.”
- “Issue the revised W&D directive to give legal certainty to cross border operations.”
- “Standardization of data exchange, and standardization of regulations.”
- “Allow 4 tons overweight across all countries.”
- “The approval of a new Weights and Dimensions directive… should create infrastructures and clear corridors for this kind of vehicles.”

Third, about 38% pointed to funding, incentives and price signals, such as toll exemptions, electricity-price regulation for ZE truck charging, or stronger implementation of Eurovignette-style CO_2-differentiated road pricing.

- “Improve TCO by comprehensive implementation of similar incentive measures such as Eurovignette, ETS2 and financial de-risking for customers and CPOs.”
- “The energy price is the key factor for logistics companies to switch to zero-emission vehicles without subsidies.”
- “Energy must be cheaper than diesel. Once that is achieved, everything else will follow naturally.”
- “Reduce electricity prices for e-trucks on public and private charging points; implement EU-wide CO_2 charging schemes on toll roads.”

Smaller but important shares highlighted vehicle-specific standards (e.g. legalising EMS/duo-trailer concepts or allowing additional ZE weight across borders) and market-pull mandates, such as fleet or shipper obligations. Overall, the responses do not point to a single silver bullet; instead, stakeholders call for a coordinated package that simultaneously addresses infrastructure, rules and economics.

Taken together, the benefits question and the “single most important step” question point in the same direction. Where ZE solutions are already in use, stakeholders see real operational gains, but they do not believe the current framework is sufficient to scale these benefits across borders. Their priorities cluster around getting the basics right on infrastructure and grid access, predictable and fair price signals, and coherent EU–national rules, rather than inventing entirely new instruments.

7. Towards a collaborative governance model for ZE freight corridors

Active EU-wide collaboration is now a competitive requirement. When rules, approvals, and charging conditions diverge across borders, Europe pays in delay, cost, and slower scale—undermining investment confidence and the ability to replicate ZE operations across corridors. The EU should therefore lead an execution-focused harmonisation agenda, starting with corridors where cross-border operability can be made measurable, repeatable, and scalable.

The survey results and expert feedback do not simply criticize existing arrangements; they point towards a preferred governance trajectory. Within this ZEFES-linked sample, stakeholders tend to favor EU-level direction on high-level objectives and rules, combined with shared implementation responsibility across Member States, industry and associations. This section uses these preferences, together with the collaborative and polycentric governance literature, to sketch key features of a more coordinated governance model for ZE freight corridors.

7.1 Proposed governance blueprint (EU direction + corridor execution + evidence loop)

A workable model needs to separate convergence (agreeing what should be aligned) from execution (making it work on real routes). A three-layer blueprint helps:

Layer A — EU convergence pipeline (priority topics and common outputs). EU institutions maintain a visible “convergence pipeline” for the operability topics identified as most critical in the evidence, including charging rules-of-use, approvals and certification, W&D/EMS operability, minimum data and KPI definitions, and cross-border compliance frictions such as PTI mutual recognition where relevant. The aim is not to introduce new bureaucracy, but to clarify priorities, define a limited set of common outputs (such as templates, evidence packs or guidance), and sequence topics according to what can be addressed in the short term versus what requires longer legislative lead times.

Layer B — Corridor execution taskforces (public–private implementation). Stakeholder inputs repeatedly highlight that even where goals are shared, execution fails on “small” operational blockers: inconsistent interpretations, unclear processes, and misaligned timelines. Corridor taskforces provide capacity for joint action by creating a practical forum with named owners, time-bound actions, and escalation routes. Their role is to translate convergence ambition into deployable corridor conditions (permit steps, charging access assumptions, enforcement guidance, operational KPIs). This implementation logic is

consistent with the collaborative governance emphasis on “capacity for joint action” (Emerson et al., 2012) and with polycentric governance as a model for coordinated problem-solving across multiple centers of decision-making (Ostrom, 2010).

Layer C — Evidence loop (learning → templates → convergence). Corridor learning must be captured in a form that can travel: a small set of repeatable outputs (evidence packs, process maps, KPI definitions, and documented “resolved blockers”). This closes the loop from pilots and early deployment back to harmonisation and standardization.

7.2 Roles across the value chain (who does what)

To avoid “everyone owns it, nobody executes it,” roles should be explicit:

- EU level (Commission / agencies): set the convergence pipeline; promote common templates; enable comparability via minimum KPIs; ensure that validated corridor outputs can feed into EU standardization and legislative update processes where needed.
- Member States (ministries, permitting and enforcement authorities): nominate corridor-level owners; provide clarity on processes, timelines and evidence requirements; enable corridor permissions where EU-wide alignment requires longer lead times.
- Infrastructure & energy actors (CPOs, DSOs/TSOs, site owners): increase transparency on grid-connection lead times; align “rules-of-use” assumptions and access conditions suitable for heavy-duty operation; support corridor reliability.
- Industry (OEMs, trailer manufacturers, operators, shippers, leasing): contribute structured operational evidence; participate in corridor taskforces with decision-capable representatives; support interoperability-by-design where feasible.
- Associations and platforms: convene neutral, pre-competitive alignment; translate operational evidence into implementable asks; maintain continuity and traceability across cycles.

7.3 Associations as neutral conveners and “translators to policy”

Stakeholder dialogues and written feedback underline the value of trusted intermediaries. Associations can add value by: (i) convening multi-actor problem-solving in a psychologically safe way; (ii) translating operational frictions into policy-usable templates and prioritised asks; and (iii) maintaining continuity beyond project timelines through an evidence register that links claims in the paper to coded inputs and supporting materials.

7.4 Minimum conditions for execution (mandate, KPIs, data-sharing, escalation)

Across the evidence base, four minimum conditions recur:

- Mandate and scope: which topics are in/out and what can be decided at corridor level.
- Named owners: accountable leads per topic and per corridor.
- Comparable KPIs: a minimum corridor KPI set so progress is measurable across routes.

- Data-sharing rules: minimal datasets and confidentiality rules that enable monitoring and learning without unrealistic reporting burdens.
  A practical escalation mechanism is essential so unresolved corridor blockers can be elevated to the convergence pipeline with clear ownership and timelines.

8. Standardisation and harmonisation pathways

The survey and expert feedback do not only highlight where fragmentation is felt most strongly; they also point towards where alignment efforts could have the greatest impact. Within this ZEFES-linked stakeholder sample, respondents most frequently cite charging-infrastructure rules, vehicle certification and approval, and road-access/EMS provisions as the main cross-border deployment frictions, while written feedback from ESTA and ETB underlines the operational consequences of divergent PTI regimes and access conditions. Taken together, this evidence suggests a set of priority domains where targeted standardisation or mutual recognition could substantially lower transaction costs and uncertainty for zero-emission (ZE) freight operations.

- Rather than calling for uniformity in all areas, the findings support a more corridor-based and sequenced approach to harmonisation. In such an approach, EU institutions, Member States and industry actors would focus first on aligning or mutually recognising those rules that directly shape cross-border operability and investment decisions using ZE freight corridors as structured testbeds for common templates, procedures and key performance indicators (KPIs). The following subsections outline indicative pathways in these priority domains, drawing on stakeholder preferences, association feedback and the collaborative governance literature to identify options for practical, evidence-informed alignment.

9. Recommendations and Roadmap

Collaboration is now a competitiveness capability. In a networked transition like zero-emission freight, performance depends not only on technology, but on how quickly the ecosystem can coordinate across borders—aligning rules, interfaces, processes, and execution timelines. When governance remains fragmented, Europe pays not only in administrative burden, but in slower replication, higher transaction costs, and weaker investment confidence. Competitiveness-oriented perspectives therefore point to a more strategic, execution-focused approach to public–private collaboration—especially where systemic reforms take time and corridor delivery can create near-term momentum. (McKinsey & Company, 2026). From this lens, the priority is speed and replicability: reducing approval friction and planning uncertainty so that cross-border ZE operations can scale with confidence.

9.1 EU and Member State actions (enable execution and reduce uncertainty)

- Establish a visible convergence pipeline for the top operability topics (charging rules-of-use, approvals/certification evidence, W&D/EMS operability, minimum data/KPIs, and cross-border compliance frictions such as PTI mutual recognition where relevant).

- Support corridor-level execution mechanisms (taskforces) that can resolve operational blockers with named owners and escalation routes.
- Accelerate practical alignment on charging rules-of-use, including permitting transparency, grid-connection lead-time visibility, and heavy-duty access assumptions (not only rollout targets).
- Reduce repeated approval friction by promoting common evidence packs and practical mutual-recognition approaches where feasible.
- Increase predictability on W&D/EMS cross-border operability, using corridor permissions where EU-wide alignment requires longer lead times.
- Define a minimum corridor KPI set so progress is measurable and comparable across routes.
- Where market uncertainty remains a major barrier, prioritise measures that increase planning security (stable frameworks, clearer cost signals, and reduction of process uncertainty) rather than short-lived announcements.

9.2 Industry actions

- Pursue pre-competitive alignment on interfaces and compliance pathways to reduce transaction costs.
- Operationalise corridor learning into reusable playbooks (charging strategy, route planning, compliance preparation).
- Share structured operational evidence (under confidentiality safeguards) to support common evidence packs and KPI tracking.
- Coordinate vehicle, infrastructure, and grid-connection timelines to reduce corridor-level execution risk.

9.3 Association / platform actions

- Convene and moderate corridor taskforces as neutral facilitators.
- Maintain an auditable evidence register linking barriers, operational impacts and proposed mechanisms (claim-to-data traceability).
- Translate corridor learning into implementable asks (templates, process maps, KPI definitions) to support EU and Member State convergence processes.

10. Implications for ZEFES and Future EU Projects

EU-funded projects are not only technical accelerators, but also governance and collaboration accelerators. In fragmented cross-border systems, progress often depends on whether stakeholders can meet repeatedly, compare constraints, and build shared implementation logic across the value chain. EU projects provide a structured setting for this: a neutral space where OEMs, operators, infrastructure and energy actors, authorities, and associations can align on practical barriers and test workable solutions.

ZEFES illustrates this convening value: beyond demonstrations, it has created a platform where stakeholders can surface operability frictions (approvals, charging rules-of-use, W&D/EMS constraints, interoperability) and translate them into reusable learning. The implication for future programmes is to treat this convening function as a core deliverable—paired with explicit evidence → template → standardisation pathway—so that stakeholder alignment turns into measurable corridor progress and replicable cross-border deployment.

Overall, the evidence assembled in this white paper suggests that Europe already has working ZE solutions, engaged stakeholders and emerging governance ideas; the remaining task is to organise these assets more effectively so that promising pilots can evolve into interoperable, cross-border ZE freight corridors.

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12. Annexes (A–F)

Annex A. Survey method and instrument summary

Instrument. A structured online questionnaire (Microsoft Forms) captured stakeholder perceptions of cross-border regulatory and operational fragmentation affecting zero-emission (ZE) road freight, governance preferences, and experience with ZE trucks/e-trailers.

Question blocks (4).

1. Respondent profile – organisation type and main countries/corridors of operation.
2. Fragmentation and barriers – Likert statement on fragmentation as a barrier; “select up to two” key hindrances; open example of misalignment.
3. Governance and EU initiatives – preferred leadership for harmonisation; perceived effectiveness of selected EU initiatives; usefulness of cross-industry forums (incl. K-Expert Talks).
4. ZE experience – operated/trialled ZE solutions; observed benefits; operational/regulatory hurdles; priority step for 2026.

Fieldwork and cleaning. The survey closed with 54 submissions. One internal test entry was excluded; results are based on N = 53 valid responses.

Reporting boundary. Results are descriptive and interpreted as stakeholder signals within the ZEFES-linked sample (not population estimates). Multi-select items may sum above 100%.

Annex B. Evidence sources and triangulation summary

This white paper synthesises three evidence streams:

- Primary evidence: stakeholder survey results (Annex A).

- Written stakeholder feedback: coded and logged in the evidence register (e.g., association feedback and expert comments).
- Dialogue-based triangulation: insights from ZEFES K-Expert Talks (IAA 2024; Transport Logistic 2025; Solutrans 2025) used to clarify mechanisms behind survey patterns (e.g., charging economics, corridor operability frictions).

Attribution rule. Quotes are included only where traceable and approved; otherwise inputs are reported in aggregated form.

Annex C. Conceptual lens used in the paper (one-page map)

The paper treats harmonisation as an execution and coordination challenge in a multi-actor transition.

How the lens is used:

- Collaborative governance → why structured public–private coordination is required to reduce cross-border friction.
- Network governance → why EU-level direction must be paired with corridor-level delivery routines (roles, KPIs, feedback loops).
- Ecosystem orchestration → why interfaces (rules, approvals, charging conditions, data) matter as much as technology.

This lens supports the paper's focus on "what makes cross-border ZE freight repeatable at scale."

Annex D. External policy and industry anchors used for framing

Selected EU policy and industry sources are used as contextual anchors to frame urgency and feasibility, including:

- EU infrastructure and corridor logic (AFIR; TEN-T)
- EU HDV decarbonisation policy and enabling conditions (CO_2 standards and related frameworks)
- EU R&I ecosystem framing (e.g., 2ZERO and relevant strategy documents)
- Industry analyses used only for framing, not as primary empirical evidence

Primary claims and recommendations are grounded in the survey and stakeholder inputs described in Annexes A–B.

Annex E. Glossary (short)

AFIR Alternative Fuels Infrastructure Regulation
CPO Charge Point Operator
DSO / TSO Distribution / Transmission System Operator
EMS European Modular System
HDV Heavy-Duty Vehicle
KPI Key Performance Indicator
LEZ Low-Emission Zone
LSP Logistics Service Provider

PTI Periodic Technical Inspection
TCO Total Cost of Ownership
TEN-T Trans-European Transport Network
VECTO EU HDV energy/CO_2 tool
W&D Weights & Dimensions
ZE Zero-Emission

Annex F. Written feedback evidence register (WF = Written Feedback)

(WF-01 and WF-02 summarise coded written feedback from two European associations; source documents available on request.)

F1. Code families used (directed coding)

Codes aligned to the survey barrier framework:

1. Regulatory operability (Weights & Dimensions / road access / EMS; approvals & certification; PTI mutual recognition)
2. Infrastructure readiness (charging & grid connection; hydrogen availability)
3. Operational impacts (delay, cost, empty kilometres, emissions)
4. Governance mechanisms & KPIs (EU templates/recognition; joint execution arrangements; corridor KPIs)

F2. Evidence items (coded source summaries)

- WF-01 (ETB written feedback): PTI mutual recognition; operational inefficiency (empty km / CO_2); EU-level mutual recognition mechanism; TCO + grid-connection timelines as decision KPI.
- WF-02 (ESTA written feedback): access/W&D alignment and approvals; charging + H_2 availability; coalition-style implementation logic; corridor KPIs (route access + installed energy capacity).

F3. Coded evidence summary (presence by source)

Code family	WF-01 (ETB)	WF-02 (ESTA)
Regulatory operability (PTI/access/approvals/W&D/EMS)	✓	✓
Infrastructure readiness (charging/grid; H_2)	✓	✓
Operational impacts (cost/delay/inefficiency/emissions)	✓	✓ (implied*)
Governance mechanisms & KPIs	✓	✓

“*Implied” indicates the theme is referenced without a quantified metric or worked example in the written feedback.

F4. Illustrative coded extracts (paraphrased)

WF-01 (ETB) – illustrative mechanisms

- PTI mutual recognition (regulatory operability): lack of cross-border recognition can require assets to return to the registration country for inspection.
- Operational impact: this creates avoidable empty kilometres, cost, and emissions.
- Governance mechanism: proposes EU-level mutual recognition (or bilateral interim arrangements).
- KPI logic: highlights relevance of TCO together with grid-connection timelines for charging hubs.

WF-02 (ESTA) – illustrative mechanisms

- Access/W&D + approvals (regulatory operability): unfinished alignment of access conditions and harmonised approvals remain sticking points for cross-border deployment.
- Infrastructure readiness: charging availability and hydrogen refuelling along corridors are framed as prerequisites.
- Implementation logic (governance): pragmatic coalition-style approach—two or more countries run joint public–private initiatives and scale through demonstrated success.
- KPIs: corridor-oriented measures such as enabled route access and installed energy capacity.