



## Deliverable D6.3

### Overall Impact Assessment of Project Results and Cross-Analysis of Pilots

Dissemination level		
PU	Public — fully open (automatically posted online)	X
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<sup>1</sup> **DATA** = data sets, **DEC** = Websites, patent filings, videos, etc; **DEM** = Demonstrator, pilot, prototype, **ETHICS**; **OTHER**; **R** = Document, report.

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## Abbreviations

Abbreviation	Full Term
<b>ADMIRAL</b>	Advanced Multimodal Marketplace for Low Emission and Energy Transportation
<b>AI</b>	Artificial Intelligence
<b>AHP</b>	Analytic Hierarchy Process
<b>API</b>	Application Programming Interface
<b>BAU</b>	Business-As-Usual
<b>CINEA</b>	European Climate, Infrastructure and Environment Executive Agency
<b>CO<sub>2</sub></b>	Carbon Dioxide
<b>CSAT</b>	Customer Satisfaction
<b>DEA</b>	Data Envelopment Analysis
<b>D</b>	Deliverable
<b>eCMR</b>	electronic Convention on the Contract for the International Carriage of Goods by Road
<b>EC</b>	European Commission
<b>ETA</b>	Estimated Time of Arrival
<b>EU</b>	European Union
<b>GA</b>	Grant Agreement
<b>GHG</b>	Greenhouse Gas
<b>KPI</b>	Key Performance Indicator
<b>LMI</b>	Logistics Maturity Index
<b>LSI</b>	Logistics Sustainability Index
<b>LTI</b>	Logistics Transferability Index
<b>MCDA</b>	Multi-Criteria Decision Analysis
<b>MS</b>	Milestone
<b>OA</b>	Overall Assessment
<b>PO</b>	Project Officer
<b>SUMP</b>	Sustainable Urban Mobility Plan
<b>TRL</b>	Technology Readiness Level
<b>TMS</b>	Transport Management System
<b>WP</b>	Work Package
<b>WPL</b>	Work Package Leader

## Publishable Executive Summary

ADMIRAL (Advanced Multimodal Marketplace for Low Emission and Energy Transportation) was established to accelerate the transition towards more sustainable, efficient, and digitally connected freight transport systems in Europe.

Through a combination of pilot demonstrations, digital solution development, and stakeholder-oriented validation activities, the project aimed to demonstrate how interoperable logistics tools and collaborative marketplace models can reduce emissions, improve operational performance, and strengthen resilience across multimodal supply chains.

Deliverable D6.3 - Overall Impact Assessment of Project Results and Cross-Analysis of Pilots, provides the final synthesis of project outcomes under WP6.

Building on the evidence generated in Deliverables D6.1 (Impact Assessment Framework, KPIs and Prioritization) and D6.2 (Energy consumption, user experience and socio-economic impact assessment), as well as pilot implementation and evaluation results from Work Package 5, the present report consolidates the impacts observed across the four ADMIRAL pilot environments in Portugal–Spain, Slovenia–Croatia, Lithuania, and Finland. It also assesses the relative performance and transferability of the individual solutions developed and demonstrated during the project.

Thus, the assessment also considers the compliance of pilot implementation with the framework and specifications defined in D5.1 (Pilot Implementation Plan).

The assessment applies a harmonised multi-criteria framework structured around three strategic dimensions:

- Logistics Sustainability Index (LSI): measuring environmental and operational sustainability outcomes, including also acceptance, socioeconomic and equity analysis;
- Logistics Maturity Index (LMI): measuring technological readiness and operational deployment maturity;
- Logistics Transferability Index (LTI): measuring scalability, interoperability, and replication potential in wider European contexts.

These three indexes were combined into an overall project impact model using previously validated project weighting priorities, where sustainability was assigned the highest relative importance.

The validation of the weighting scheme was performed through two rounds of consortium workshops during the Project General Assembly event (May 2024), incorporating input from project partners and domain experts.

The pilot-level analysis confirms that ADMIRAL delivered differentiated but complementary results across the four demonstration sites, and aligned with the plan.

The Slovenia–Croatia pilot achieved the strongest balanced performance, combining high sustainability gains, mature operational deployment, and strong potential.

The Finland pilot demonstrated the highest sustainability performance, supported by fuel substitution and AI-enabled cargo flow optimisation.

The Portugal–Spain pilot showed strong maturity and integration performance with ADMIRAL Marketplace, particularly through multimodal service catalogue development and platform connectivity in a cross-border corridor context.

The Lithuania pilot demonstrated the highest transferability performance through digitally integrated tools such as eCMR, ETA services, and interoperable transport management functionalities.

At solution level, the assessment indicates that ADMIRAL generated two complementary categories of innovation outcomes. First, operational impact solutions such as planning, optimisation, and emissions tools delivered direct environmental and efficiency benefits, with key contributions emerging particularly from the Finland pilot (AI-based cargo planning and fuel optimisation) and the Slovenia–Croatia pilot (operational deployment of planning and efficiency tools). Second, ecosystem transformation solutions such as the Marketplace, integration tools, eCMR services, and data exchange structures created the digital backbone necessary for long-term scaling and cross-organisational collaboration, with major developments driven by the Portugal–Spain pilot (Marketplace and corridor integration) and the Lithuania pilot (eCMR, ETA services, and interoperable digital tools).

Across the full project portfolio, ADMIRAL achieved an estimated overall impact score of 72.1/100, indicating a strong final performance across sustainability, maturity, and transferability dimensions. The project performed particularly strongly in maturity (88.8/100) and transferability (82.1/100), demonstrating that several solutions reached advanced deployment stages and possess clear replication potential beyond the original pilot settings. Sustainability performance was also positive (59.2/100), reflecting measurable emissions reductions, improved route efficiency, enhanced asset utilisation, and increased visibility of greener transport options.

The transferability analysis shows that the most scalable ADMIRAL results are the digital backbone solutions, particularly the Integration Tool, eCMR / Digital Bill of Lading, Data Exchange Structures, and the ADMIRAL Marketplace.

These solutions can be adapted to multiple logistics contexts, provided that enabling conditions such as API accessibility, stakeholder cooperation, data governance, and regulatory alignment are in place. Operational optimisation tools also demonstrated strong replication potential, although their performance is more dependent on local workflows, data quality, and organisational readiness.

Beyond quantitative outcomes, the project also generated broader socio-economic benefits. Thus, stakeholder surveys conducted during the project were used as a structured data source to capture user perceptions, acceptance, and socio-economic impacts, and were integrated into the methodological framework alongside quantitative pilot data and qualitative interviews.

Evidence from stakeholder engagement and pilot implementation indicates improved coordination between supply-chain actors, reduced administrative burden, stronger decision-support capabilities, and enhanced readiness for digital and low-emission logistics operations. No significant negative employment effects were identified; instead, the transition primarily creates changing skill requirements in areas such as digital operations, data management, and emissions reporting.

The assessment also acknowledges the potential contribution of ADMIRAL solutions to Sustainable Urban Mobility Plans (SUMPs), considering their role in upscaling scenarios and the system-level interactions that influence their wider application.

The principal legacy of ADMIRAL lies not in any single pilot or individual tool, but in the integrated portfolio of mature, transferable, and scalable logistics innovations that it has delivered. These outcomes provide a strong foundation for future exploitation, replication, and policy support in the transition towards low-emission and digitally enabled multimodal freight transport across Europe.

Overall, the ADMIRAL project demonstrates that European freight transport systems can be improved through a coordinated combination of digitalisation, optimisation, and collaboration. The project confirms that sustainability gains, operational efficiency, and system interoperability are mutually reinforcing when implemented through practical pilot environments and market-oriented digital solutions.

# 1 Purpose & Structure

## 1.1 Purpose of the Deliverable

Deliverable D6.3-*Overall Impact Assessment of Project Results and Cross-Analysis of Pilots*, constitutes the final synthesis of the evaluation activities carried out under Work Package 6 of the ADMIRAL project. The deliverable consolidates the evidence generated throughout the project lifecycle and provides a structured assessment of the extent to which ADMIRAL achieved its intended technical, environmental, operational, and strategic objectives.

The report builds directly on the foundations established in previous Work Package 6 deliverables. Deliverable D6.1 developed the impact assessment framework, including the key performance indicators (KPIs), methodological principles, and weighting logic for final evaluation. Deliverable D6.2 provided the interim and pilot-level evidence base through quantitative measurements, stakeholder assessments, and initial impact calculations. The present deliverable uses those validated inputs, together with final pilot implementation results and solution maturity evidence, to produce the overall ex-post project assessment.

Accordingly, D6.3 has four principal objectives:

1. **To provide the final overall impact assessment of ADMIRAL results** across sustainability, maturity, and transferability dimensions;
2. **To conduct a cross-pilot synthesis** comparing the outcomes of the four ADMIRAL demonstration environments;
3. **To assess solution-level performance** to identify the most impactful and scalable innovations developed within the project;
4. **To determine the transferability of results**, including the conditions, barriers, and opportunities for wider European uptake.

The deliverable therefore serves as the principal evaluation document demonstrating the added value and legacy of ADMIRAL.

## 1.2 Scope of the Assessment

The report has a set of closely connected core objectives. First, it provides the final overall impact assessment of ADMIRAL results by examining performance across sustainability, technological maturity, and transferability dimensions. Second, it presents a cross-pilot synthesis of the four demonstration environments to identify common success factors, differences in outcomes, and complementary strengths. Third, it assesses the transferability of project results by determining which solutions are most suitable for replication in other European contexts, under which enabling conditions such replication can occur, and what barriers may still limit wider deployment.

The scope of the assessment covers both pilot-level and solution-level outcomes. The scope of the assessment covers both pilot-level and solution-level outcomes. At pilot level, the report evaluates the demonstrators implemented in Portugal–Spain, Slovenia–Croatia, Lithuania, and Finland, taking into

account their implementation as defined in Deliverable 5.1 (Pilot Implementation Plans). At pilot level, the report evaluates the demonstrators implemented in Portugal–Spain, Slovenia–Croatia, Lithuania, and Finland.

At solution level, it examines the principal ADMIRAL innovations developed during the project, including marketplace services, planning and optimization tools, integration components, digital documentation solutions, data exchange services, and emissions-related tools. In addition to direct operational results, the report also considers maturity, readiness for deployment, interoperability, and long-term continuation and survival potential.

Wherever possible, the analysis relies on validated quantitative evidence collected during the project. This includes pilot KPI results, emissions and efficiency outcomes, technology readiness progression, and implementation evidence generated during demonstration activities. In areas where complete numerical comparability was not available across all cases, a transparent evidence-based scoring approach was applied, based on predefined qualitative criteria and structured expert judgement. This approach combined documented evidence (e.g. pilot reports, implementation templates, and stakeholder inputs) with a standardised scoring scale to ensure consistency and traceability. While not based on external frameworks such as GRADE or SORT, the method follows similar principles of systematically assessing the strength and consistency of available evidence. This ensures methodological consistency while allowing all relevant project outcomes to be considered.

### 1.3 Structure of the Deliverable

The structure of the deliverable follows a logical progression from methodology to findings and from detailed analysis to strategic conclusions.

Chapter 2 presents the final methodological framework used for the assessment, including the index structure, weighting logic, data treatment, and scoring principles. Chapter 3 provides the pilot-level impact assessment and compares the performance of the four ADMIRAL pilots. Chapter 4 develops the cross-pilot comparative analysis and identifies common patterns, differences, and complementary strengths across the demonstration portfolio. Chapter 5 focuses on the comparative evaluation of the individual solutions developed during the project.

Chapter 6 presents the overall impact assessment outcomes at project level and synthesises ADMIRAL's final contribution across the principal strategic dimensions. Chapter 7 examines the transferability of results, including the conditions required for replication, the barriers to wider uptake, and the solutions with the strongest European scaling potential. Finally, Chapter 8 summarises the principal conclusions of the report and proposes recommendations for exploitation, replication, and future development.

### 1.4 Intended Audience and Use

This deliverable has been prepared for several audiences. For the European Commission and project reviewers, it provides a clear evidence-based account of ADMIRAL's final achievements and added value. For consortium partners, it supports exploitation planning by identifying the most mature and transferable project assets.

For logistics operators, technology providers, and public authorities, it offers practical insights into how digitalisation, multimodal coordination, and interoperable tools can support more sustainable and efficient freight transport systems.

More broadly, the report contributes to the digital and green transition, including the ongoing European discussion on how digital innovation can accelerate the decarbonisation and modernisation of freight transport. The lessons derived from ADMIRAL are therefore relevant not only to the consortium itself, but also to external stakeholders seeking scalable and market-relevant logistics solutions.

## 1.5 Concluding Remarks

Ultimately, the purpose of this deliverable is not only to measure what ADMIRAL achieved during the project period, but also to demonstrate the longer-term relevance of its results. The findings presented in the following chapters show how the combination of pilot experimentation, digital innovation, and collaborative logistics models can contribute to the transition towards low-emission, resilient, and digitally enabled freight transport across Europe.

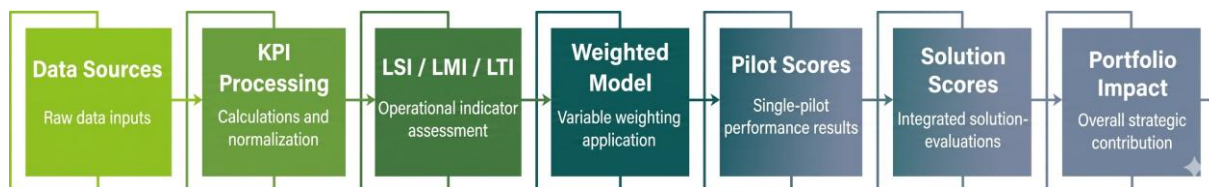


Figure 1: Overall Assessment Framework

As shown in Figure 1, the integrated methodological structure applied in Deliverable D6.3 for the final evaluation of ADMIRAL results. The framework combines evidence from Deliverables D6.1 and D6.2, pilot datasets, stakeholder interviews, templates, and consolidated project databases. These inputs are processed through the three-index model: Logistics Sustainability Index (LSI), Logistics Maturity Index (LMI), and Logistics Transferability Index (LTI), and subsequently aggregated using the validated weighting system to generate pilot-level, solution-level, and overall portfolio impact scores. Source: own elaboration based on ADMIRAL WP6 methodology and project datasets.

## 2 Methodological Basis

### 2.1 Purpose of the Methodological Framework

The purpose of this chapter is to describe the methodological basis used to produce the final overall impact assessment of ADMIRAL. As Deliverable D6.3 represents the concluding evaluation report of Work Package 6, its role is not to establish a new methodology, but rather to apply, consolidate, and extend the framework previously developed during the project. The final assessment therefore builds directly on the methodological foundations defined in Deliverable D6.1 and the empirical evidence generated in Deliverable D6.2, while also incorporating the final pilot implementation results, as presented in Deliverable D5.3 (Pilot evaluation summary report), stakeholder feedback, interview findings, and the complete set of available project datasets.

The methodological approach adopted in D6.3 follows a cumulative logic. Deliverable D6.1 established the conceptual framework, including the key impact dimensions, the index architecture, the KPI selection process, and the weighting system used to prioritise evaluation criteria, building on the KPI definitions and sustainability indicators developed in Work Package 2. Deliverable D6.2 then operationalised that framework by collecting and analysing pilot-level evidence under Tasks 6.2 and 6.3, including quantitative performance indicators, stakeholder-oriented assessments, and interim impact findings. The present deliverable integrates those earlier outputs with the final implementation evidence under Task 6.4 in order to provide the ex-post overall assessment of project outcomes.

### 2.1.1 Integration of Previous Deliverables and Work Package Tasks

The methodological basis of D6.3 combines evidence and analytical outputs generated across multiple activities of Work Package 6, as shown in the Figure 2 below.

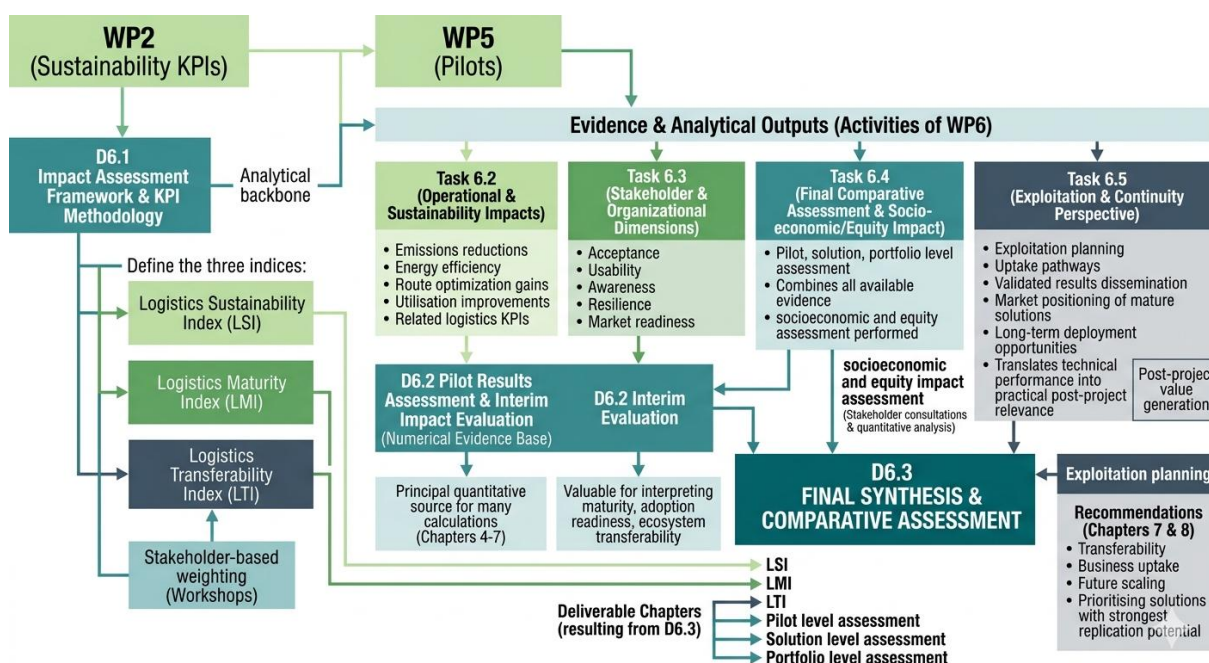


Figure 2: Deliverable D6.3 Logic through integration with project WPs

In addition, the data collection activities in Rome Milestone (MS8 - Initial versions of T6.2-4 results are in use) has been done through ALMA tool provided a supplementary evidence stream for the final assessment. The milestone dataset contributed practical information regarding user interaction, operational use cases, local deployment conditions, and performance observations within the Italian context. ALMA was used as a structured support instrument for data gathering, organisation, and interpretation of implementation evidence. These inputs were particularly useful for validating usability aspects, local adoption dynamics, and the practical applicability of selected solutions in real logistics environments. As such, they enriched the broader evidence base used for maturity assessment, transferability interpretation, and final recommendations.

In addition to the formal deliverables, the final methodology also draws on structured interviews, pilot result templates, milestone evidence, internal reporting files, and consolidated datasets provided by the consortium. These complementary sources were used at different stages of the assessment.

First, they supported the calculation and validation of KPI values, particularly in cases where pilot datasets from Deliverable D6.2 were incomplete or required contextual interpretation. Second, they contributed to the evaluation of the Logistics Maturity Index (LMI) and Logistics Transferability Index (LTI), where qualitative dimensions such as implementation readiness, interoperability, stakeholder acceptance, and replication potential cannot be fully captured through quantitative indicators alone. Third, they were used to triangulate and interpret the final results, ensuring consistency between numerical outcomes and real-world implementation evidence. The integration of these sources strengthens the robustness of the assessment by complementing the quantitative evidence from previous deliverables with qualitative insights, thereby providing a more comprehensive and reliable evaluation of ADMIRAL results.

### 2.1.2 Three-Index Assessment Model

The final ADMIRAL assessment is based on a multi-criteria evaluation model structured around three strategic dimensions.

The Logistics Sustainability Index (LSI) captures the measurable environmental and operational sustainability effects generated by ADMIRAL solutions and pilot activities. This includes emissions reductions, efficiency gains, resource utilisation improvements, and related operational benefits.

The Logistics Maturity Index (LMI) evaluates the degree to which ADMIRAL solutions progressed from concept stage towards operational readiness. It considers Technology Readiness Level (TRL) progression, implementation maturity, validation in real operational environments, and evidence of deployability.

The Logistics Transferability Index (LTI) evaluates the extent to which project results can be replicated in other contexts. It captures interoperability, standardisation, integration capability, scalability, and the suitability of solutions for adoption beyond the original pilot settings.

These three indices were retained from D6.1 and used as the common structure for all final comparisons in the present report.

### 2.1.3 Weighting Logic from the D6.1 Stakeholder Workshop

A central feature of the ADMIRAL methodology is that the final evaluation weights were not assigned arbitrarily, but derived through a structured stakeholder prioritisation process described in Deliverable D6.1. The validation was conducted through two rounds of consortium workshops, including a dedicated session held during the General Assembly meeting in May 2024, involving project partners and domain experts representing different roles within the logistics ecosystem (e.g. technology providers, logistics operators, researchers, and policy-oriented stakeholders).

During these workshops, participants assessed the relative importance of the three strategic dimensions—Logistics Sustainability Index (LSI), Logistics Maturity Index (LMI), and Logistics Transferability Index (LTI)—as well as the individual KPIs contributing to each dimension. The assessment followed a structured multi-criteria approach, where stakeholders provided importance ratings (e.g. through scoring and ranking exercises) based on their expertise and perspective on project objectives and expected impacts.

The collected inputs were subsequently aggregated and normalised to derive a consistent weighting system, ensuring that the final weights reflect a balanced consensus across stakeholders rather than individual preferences. This process ensured that the evaluation framework aligns with both the priorities of the ADMIRAL consortium and the broader objectives of sustainable, deployable, and scalable logistics solutions.

The workshop results indicated that sustainability should receive the highest relative importance in the final project assessment. Consequently, the agreed index weights were:

- Logistics Sustainability Index (LSI): 51%
- Logistics Maturity Index (LMI): 24%
- Logistics Transferability Index (LTI): 25%

These values were subsequently applied in the final overall impact calculations, in Figure 3.

At KPI level, the workshop also identified the relative importance of the core indicators. Among the most highly ranked KPIs were Unit Emission of Delivery, Existing-to-Achieved Technology Readiness Level, and Solution Integration and Standardization.

This confirms that ADMIRAL stakeholders considered measurable sustainability performance, deployment readiness, and interoperability as the most important dimensions of project success.

#### 2.1.4 Data Sources & Analysis

The present deliverable combines several categories of evidence just to maximise robustness and avoid overreliance on any single dataset. First, quantitative pilot datasets generated during demonstrations were used to assess measurable outcomes such as emissions reductions, operational efficiency improvements, planning gains, or utilisation effects. Second, solution implementation datasets were used to assess maturity and readiness, particularly through start and achieved TRL values, operational deployment evidence, and validation status. Third, stakeholder datasets generated were used to interpret usability, awareness, resilience, acceptance, and organisational readiness. Fourth, qualitative interview evidence and pilot templates were used to assess transferability conditions, implementation barriers, and contextual factors that cannot always be captured through numerical KPIs alone. These interviews, conducted with pilot stakeholders and solution providers, provided insights into real-world implementation aspects such as operational constraints, user acceptance, interoperability challenges, and organisational readiness. This qualitative evidence was systematically analysed and used to complement the quantitative assessment, particularly for the Logistics Maturity Index (LMI) and Logistics Transferability Index (LTI), where several dimensions rely on experiential and context-specific knowledge.

The integration of interview-based evidence is important for ensuring that the assessment reflects not only measured performance, but also practical feasibility and deployment conditions, thereby strengthening the robustness and realism of the evaluation.

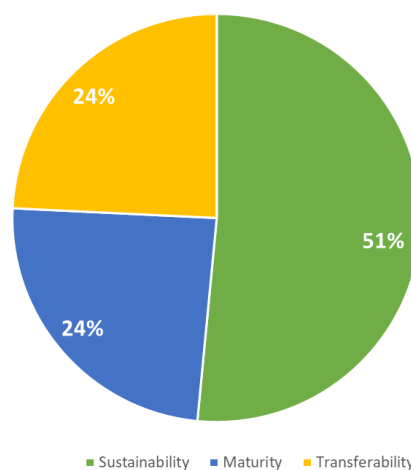


Figure 3 : Index Weights

Finally, consolidated overall datasets prepared by the consortium were used to cross-check consistency across pilots and solution families, ensuring alignment between individual pilot results, solution-level evidence, and the aggregated project-level outcomes (see Figure 4).



Figure 4 : Evidence Sources Integrated

Given the diversity of ADMIRAL pilots and solutions, the methodological challenge of D6.3 was to convert heterogeneous evidence into a harmonised comparative framework. This was achieved through three analytical steps.

First, available raw indicators were transformed into standardised scores on a common 0–100 scale using a Min–Max normalisation approach. This enabled the comparison of metrics originally expressed in different units, such as percentages, TRL values, or categorical assessments, by rescaling all values relative to the observed minimum and maximum within the relevant dataset. Second, where multiple indicators contributed to the same dimension, weighted aggregation was applied in line with the D6.1 prioritisation logic, ensuring that the contribution of each KPI reflects stakeholder-defined importance. Third, pilot-level and solution-level results were triangulated with qualitative evidence, including stakeholder surveys and structured interviews, to ensure that the final interpretation reflects both numerical performance and real-world implementation conditions. Survey results were particularly used to capture user acceptance, perceived effectiveness, and socio-economic aspects, contributing to the assessment of maturity and transferability dimensions.

Where complete numerical comparability was not available for all cases, conservative evidence-based scoring rules were applied based on documented qualitative evidence and predefined scoring criteria, and clearly documented. No unsupported values were introduced.

### 2.1.5 Reliability and Limitations

The methodology adopted in D6.3 is robust because it combines previously validated frameworks with multiple independent evidence sources. Nevertheless, some limitations remain typical of innovation projects involving heterogeneous pilots.

Not all pilots generated identical KPI sets, primarily due to differences in operational scope, data availability, and local implementation priorities across the four demonstration environments. In addition, some solutions were demonstrated under different operational conditions (e.g. terminal operations, corridor-based logistics, or digital service deployment), which influenced the type and extent of measurable outcomes. Furthermore, certain dimensions, particularly those related to transferability, stakeholder acceptance, and organisational readiness, are inherently qualitative and context-dependent, and therefore cannot be fully captured through purely technical or numerical KPIs.

For these reasons, the final results should be interpreted primarily as comparative strategic evidence rather than as deterministic engineering benchmarks. These limitations do not reduce the value of the assessment; rather, they reflect the real-world complexity of evaluating innovation in logistics.

The mixed-method approach used in this report is therefore appropriate because ADMIRAL evaluates a complex, multi-pilot Innovation Action where impacts are both quantitative and qualitative in nature. While measurable indicators (e.g. emissions reductions, efficiency gains, TRL progression) capture direct performance outcomes, other critical dimensions—such as interoperability, stakeholder acceptance, organisational readiness, and transferability—depend on context-specific and experiential evidence that cannot be fully quantified. In addition, the diversity of pilot environments, ranging from terminal operations to cross-border corridors and digital service ecosystems, requires a flexible methodological approach capable of integrating heterogeneous data sources. By combining quantitative KPI-based analysis with qualitative evidence from surveys, interviews, and implementation reports, the methodology ensures a more comprehensive, realistic, and policy-relevant assessment of ADMIRAL’s overall impact and scalability.

## 2.2 Overall assessment model

The final impact assessment of ADMIRAL is based on an integrated Overall Assessment Model designed to evaluate heterogeneous pilot results and solution outcomes within a single coherent framework. Given that the project combined multiple pilot environments, different logistics use cases, and a diverse portfolio of technological solutions, a single-indicator evaluation would not have been sufficient to capture the full value generated by the project.

For this reason, the methodology established in Deliverable D6.1 proposed a multi-criteria structure capable of combining environmental, operational, technological, and strategic dimensions into a harmonised assessment system. The model was subsequently supported by the datasets collected under Deliverable D6.2 and the final implementation evidence generated during the closing phase of the project. The present deliverable applies that framework in its final ex-post form.

The purpose of the model is threefold. First, it enables a consistent comparison of the four ADMIRAL pilots despite their different operational contexts. Second, it allows the individual solutions developed during the project to be assessed on a common basis. Third, it supports a portfolio-level synthesis of ADMIRAL’s overall impact and long-term legacy.

### 2.2.1 Structure of the Overall Assessment Model

As previously mentioned (section 2.1.2), the model is based on three complementary strategic indices reflecting the principal objectives of ADMIRAL (see Figure 5).

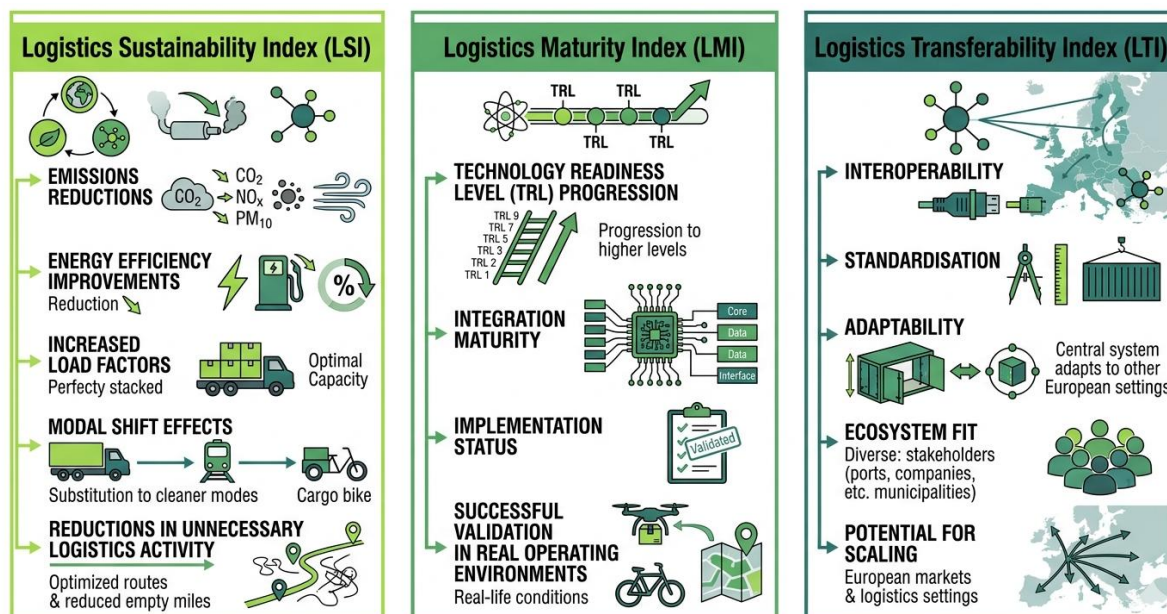


Figure 5 ADMIRAL Solutions – Sustainable, Mature, and Scalable

Taken together, the three indexes provide a balanced representation of short-term impact, implementation success, and long-term strategic value.

### 2.2.2 Weighting Logic & Priorities, and Overall Formulation

The relative importance of the three indices was established through the stakeholder prioritisation exercise reported in Deliverable D6.1. During this process, project partners and relevant experts assessed the importance of each strategic dimension for determining overall project success.

The results of the exercise indicated that sustainability should receive the highest weighting, reflecting the project’s decarbonisation and efficiency objectives. Maturity and transferability were also identified as critical dimensions, as the value of innovation depends not only on performance, but also on deplorability and replication potential.

The final index weights adopted for the ADMIRAL assessment are shown in Table 1.

Table 1 : Final weights of the overall assessment model

Index	Weight
Logistics Sustainability Index (LSI)	51%
Logistics Maturity Index (LMI)	24%
Logistics Transferability Index (LTI)	25%

These weights were retained throughout the final calculations presented in this deliverable.

For each assessed entity  $x$ , where  $x$  may represent either a pilot or a solution, the final overall score is calculated as:

$$OA_x = 0.51 \cdot LSI_x + 0.24 \cdot LMI_x + 0.25 \cdot LTI_x$$

where:

- $OA_x$  is Overall Assessment score of entity  $x$
- $LSI_x$  is Logistics Sustainability Index
- $LMI_x$  is Logistics Maturity Index
- $LTI_x$  is Logistics Transferability Index

Accordingly, pilot-level and solution-level scores are expressed as:

$$OA_p = 0.51 \cdot LSI_p + 0.24 \cdot LMI_p + 0.25 \cdot LTI_p$$

$$OAs = 0.51 \cdot LSIs + 0.24 \cdot LMIs + 0.25 \cdot LTIs$$

This formulation ensures methodological consistency across all analytical layers of the report.

### 2.2.3 Hierarchical Construction of the Indexes

Each of the three indices is composed of a set of relevant Key Performance Indicators (KPIs). For each entity  $x$ , the indices are calculated as weighted sums of normalised KPI values.

The Logistics Sustainability Index is defined as:

$$\sum_{k \in K_{LSI}} w_k^{LSI} = 1$$

subject to:  $LSI_x = \sum_{k \in K_{LSI}} w_k^{LSI} \cdot N_{xk}$

The Logistics Maturity Index is defined as:

$$\sum_{k \in K_{LMI}} w_k^{LMI} = 1$$

subject to:  $LMI_x = \sum_{k \in K_{LMI}} w_k^{LMI} \cdot N_{xk}$

The Logistics Transferability Index is defined as:

$$\sum_{k \in K_{LTI}} w_k^{LTI} = 1$$

subject to:  $LTI_x = \sum_{k \in K_{LTI}} w_k^{LTI} \cdot N_{xk}$

where:

- $K_d$  is set of KPIs belonging to dimension  $d$
- $w_k^d$  is normalized weight of KPI  $k$  within dimension  $d$
- $N_{xk}$  is normalized score of entity  $x$  on KPI  $k$

This hierarchical structure allows heterogeneous indicators to be integrated transparently into a common comparative framework.

### 2.2.4 Derivation of Weights & Normalisation of KPI Values

Within each index, KPI weights were derived from the stakeholder importance ratings reported in Deliverable D6.1. If the raw importance rating assigned to KPI  $k$  within dimension  $d$  is  $r_k^d$ , the normalized KPI weight is calculated as:

$$w_k^d = \frac{r_k^d}{\sum_{j \in K_d} r_j^d}$$

This procedure ensures that the contribution of each KPI reflects stakeholder priorities while maintaining a total weight of one within each index.

The use of stakeholder-derived weights is particularly relevant for ADMIRAL, as it links the final evaluation directly to the priorities identified by project partners and sector experts during the methodological phase.

Because ADMIRAL indicators are expressed in different units (e.g. percentages, TRLs, emissions intensities, categorical scores), all KPI values were transformed to a common 0–100 scale before aggregation.

For **benefit indicators**, where a higher value represents better performance, the following min-max normalization was applied:

$$N_{xk} = 100 \cdot \frac{X_{xk} - X_k^{min}}{X_k^{max} - X_k^{min}}$$

For **cost or burden indicators**, where a lower value represents better performance, the inverse normalization was used:

$$N_{xk} = 100 \cdot \frac{X_k^{max} - X_{xk}}{X_k^{max} - X_k^{min}}$$

where:

- $X_{xk}$  = observed value of entity  $x$  on KPI  $k$
- $X_k^{min}$  = minimum observed value in the relevant comparison set
- $X_k^{max}$  = maximum observed value in the relevant comparison set

For pilot comparisons, minimum and maximum values were derived from the pilot dataset, while for solution comparisons they were derived from the solution dataset. The KPIs used for these calculations were selected and defined in Deliverable D6.1, where the full set of indicators and their classification across the three assessment dimensions are presented. This ensures consistency between the normalization process applied in D6.3 and the KPI framework previously established and validated within the project.

### 2.2.5 Treatment of Improvement-Based Indicators & Practical KPI Families

Wherever baseline and post-implementation values were available, the methodology prioritised improvement scores rather than static final-state values. This approach better reflects the real contribution of the project.

$$\Delta X_{xk} = X_{xk}^{post} - X_{xk}^{pre} \quad \text{for benefit-type indicators.}$$

$$\Delta X_{xk} = X_{xk}^{pre} - X_{xk}^{post} \quad \text{for cost-type indicators.}$$

The improvement values  $\Delta X_{xk}$  were then normalised using the procedures described above with formulas.

This approach was particularly relevant for pilot sustainability indicators such as emissions reductions, delivery efficiency gains, or operational performance improvements reported in Deliverable D6.2.

In operational terms, the final calculations used KPI families aligned with the ADMIRAL framework and the evidence available in Deliverable D6.2. For the Logistics Sustainability Index, the main KPI families included emissions intensity, energy efficiency, delivery performance, load factors, and resource utilisation. For the Logistics Maturity Index, the main KPI families included TRL progression, deployment status, system integration, user readiness, and operational uptake. For the Logistics Transferability Index, the main KPI families included interoperability, standardisation, scalability, policy fit, stakeholder readiness, and ease of replication.

The specific KPIs composing each of these families were defined and detailed in Deliverable D6.1, where the full indicator set and their categorisation across dimensions are presented. The exact KPI mix applied in D6.3 varied slightly depending on data availability at pilot and solution level, while preserving the conceptual consistency of each index.

### 2.2.6 Combined Final Formulation & Remarks

Substituting the three indices into the overall equation yields the full hierarchical ADMIRAL model:

$$OA_x = 0.51 \left( \sum_{k \in K_{LSI}} w_k^{LSI} N_{xk} \right) + 0.24 \left( \sum_{k \in K_{LMI}} w_k^{LMI} N_{xk} \right) + 0.25 \left( \sum_{k \in K_{LTI}} w_k^{LTI} N_{xk} \right)$$

This equation represents the complete analytical logic used in the present deliverable.

The model provides a robust basis for comparative assessment because it combines stakeholder-validated priorities, quantitative evidence, and transparent normalization rules. It is particularly suitable for complex multi-pilot innovation projects where impacts are multidimensional and not directly comparable through a single KPI. At the same time, some indicators remain context-dependent, and certain transferability dimensions require structured expert interpretation in addition to numerical evidence. For this reason, the model should be interpreted as a strategic decision-support framework rather than a deterministic engineering benchmark.

The Overall Assessment Model forms the analytical core of Deliverable D6.3. It converts the diverse evidence generated across ADMIRAL into a coherent and scientifically transparent framework capable of comparing pilots, evaluating solutions, and determining the overall legacy of the project. The following chapters apply this model to derive pilot-level scores, solution-level rankings, overall project outcomes, and transferability conclusions.

### 3 Pilot-by-pilot Final Results

This chapter presents the final comparative assessment of the four ADMIRAL pilot demonstrations carried out in Portugal–Spain, Slovenia–Croatia, Lithuania, and Finland. The objective of the analysis is to evaluate pilot performance through a harmonised framework that allows different operational contexts and solution portfolios to be compared in a consistent manner.

As described in Chapter 2, the final assessment applies the ADMIRAL Overall Assessment Model, which combines three strategic dimensions: the Logistics Sustainability Index (LSI - environmental and operational sustainability performance), the Logistics Maturity Index (LMI - technological and operational readiness of deployed solutions), and the Logistics Transferability Index (LTI - potential for replication, scaling, and deployment in other logistics contexts).

These indexes capture complementary forms of project value. Sustainability reflects measurable environmental and operational improvements, maturity reflects the readiness of demonstrated solutions for real deployment, and transferability reflects the potential to replicate pilot outcomes in other logistics contexts.

The pilot assessment follows a multi-criteria decision analysis (MCDA) structure, in which heterogeneous pilot outcomes are transformed into normalized comparable scores and then aggregated through weighted indexes.

The pilot-level comparison is particularly important because ADMIRAL was intentionally designed as a multi-pilot research and innovation project. Each pilot addressed different market conditions, infrastructure settings, and logistics challenges. Consequently, the purpose of this chapter is not only to rank pilots, but also to identify the distinct strengths generated by each demonstration environment and the contribution of each pilot to the wider ADMIRAL portfolio.

For each pilot  $p$ , the final overall score was calculated using the weighted combination of the three indices:

$$OA_p = 0.51 \cdot LSI_p + 0.24 \cdot LMI_p + 0.25 \cdot LTI_p$$

where:

- $LSI_p$  is Logistics Sustainability Index
- $LMI_p$  is Logistics Maturity Index
- $LTI_p$  is Logistics Transferability Index

The weighting structure follows the stakeholder prioritisation exercise previously validated in Deliverable D6.1, where sustainability received the highest relative importance (51%), followed by transferability (25%) and maturity (24%).

This means that pilot rankings are influenced most strongly by measurable sustainability outcomes, while still recognising the importance of deployable solutions and replication potential.

### 3.1 Data Sources & Pilot-Level Indexes

The pilot-level calculations were derived exclusively from validated project evidence generated during the implementation of ADMIRAL. The principal data sources were the quantitative pilot results consolidated in Deliverable D6.2, the pilot result templates (including operational deployment evidence, integration status, and pilot implementation maturity) completed by consortium partners, implementation evidence related to technology readiness progression, and qualitative information obtained through interviews and pilot reporting, regarding emissions reductions, energy efficiency improvements, route/load optimization outcomes, and pilot performance indicators.

The D6.2 datasets were particularly important for the Logistics Sustainability Index, as they provided measurable outcomes such as emissions reductions, route and load optimisation gains, energy efficiency improvements, and related operational indicators. Pilot templates and implementation reports provided evidence for deployment maturity, system integration, and operational usability. Transferability evidence was derived from documented interoperability features,

API integration, marketplace connectivity, modularity of solutions, and wider replication potential, covering technology readiness evidence (start TRL and achieved TRL values from pilot solution reports) and pilot implementation descriptions (interoperability evidence, API integration, marketplace connectivity, and cross-stakeholder usability).

The indicators presented below are derived from the KPI framework defined in Deliverable D6.1 and operationalised using data collected in Deliverable D6.2.

To provide a structured overview of the pilot-level assessment, Table 2 summarises the main data sources, KPI families, and methodological components used for the calculation of each index.

Table 2: Summary of Pilot-Level Assessment Framework

Index	Main KPI Families	Data Sources	Assessment Approach
<b>LSI (Sustainability)</b>	Emissions intensity, energy efficiency, performance, resource utilisation, load factors, delivery factors	D6.2 pilot datasets, KPI measurements	Quantitative (Min–Max normalised KPIs)
<b>LMI (Maturity)</b>	TRL progression, deployment status, system integration, user readiness, operational uptake	Pilot templates, implementation reports, TRL evidence	Quantitative + qualitative (aggregated scores)
<b>LTI (Transferability)</b>	Interoperability, standardisation, policy fit, readiness, ease of replication, scalability, stakeholder	Interviews, pilot integration evidence, surveys, reports	Qualitative scoring + structured evidence-based assessment

Only indicators explicitly evidenced in project documentation were used in the final calculations.

### 3.1.1 Logistics Sustainability Index (LSI)

The Logistics Sustainability Index measures the environmental and operational sustainability performance achieved by each pilot. It was based primarily on verified pilot-level improvements reported in Deliverable D6.2, including greenhouse gas reductions, carbon intensity improvements, route optimisation effects, and fuel substitution impacts where applicable (Table 3).

Table 3: Indicators for Logistics Sustainability Index (LSI)

KPI Family	Example Indicators	Data Source	Treatment
Emissions	GHG emissions reduction (%)	D6.2 pilot KPIs	Direct or Min–Max
<b>Carbon intensity</b>	CO <sub>2</sub> per tonne-km	D6.2 datasets	Min–Max
<b>Energy efficiency</b>	Energy consumption per operation	Pilot reports	Min–Max
<b>Operational performance</b>	Delivery time / reliability	Pilot templates	Min–Max
<b>Resource utilisation</b>	Load factor (%)	Pilot datasets	Direct or Min–Max

Where indicators were expressed as percentage improvements (e.g. emissions reduction), values were directly transformed into the 0–100 assessment scale. For other indicators, Min–Max normalisation was applied as described in Section 2, ensuring comparability across pilots.

### 3.1.2 Logistics Maturity Index (LMI)

The Logistics Maturity Index evaluates the technological and operational readiness of the solutions deployed within each pilot. It is primarily based on indicators defined in Deliverable D6.1 and supported by implementation evidence collected through pilot templates, technical reports, and

stakeholder inputs. Key indicators include Technology Readiness Level (TRL) progression, deployment status, system integration, user readiness, and operational uptake.

TRL values were obtained from solution-level reporting (start and achieved TRL), while complementary evidence on deployment and integration was derived from pilot documentation and validation activities.

**Table 4: Indicators for Logistics Maturity Index (LMI)**

KPI Family	Example Indicators	Data Source	Treatment
TRL progression	Initial vs achieved TRL	Solution reporting	Scaled (0–100)
<b>Deployment status</b>	Pilot implementation level	Pilot templates	Qualitative → score
<b>System integration</b>	Integration with existing systems	Technical reports	Qualitative → score
<b>User readiness</b>	Stakeholder readiness	Surveys / interviews	Qualitative → score
<b>Operational uptake</b>	Usage level in pilots	Pilot data	Mixed

For pilots implementing multiple solutions, the final pilot maturity score was calculated as the arithmetic mean of the individual solution maturity scores, ensuring consistency across heterogeneous solution portfolios.

### 3.1.3 Logistics Transferability Index (LTI)

The Logistics Transferability Index evaluates the extent to which pilot outcomes can be replicated in other terminals, corridors, ports, or logistics ecosystems. As no single standardised scoring sheet was available across all pilots, the assessment applied a structured evidence-based scoring model aligned with the framework defined in Deliverable D6.1.

This model evaluates five core dimensions: external system integration, interoperability readiness, replicability, deployment readiness, and ecosystem fit. For each dimension, qualitative and semi-quantitative evidence was collected from pilot reports, stakeholder surveys, interviews, and implementation documentation (Table 5).

**Table 5: Indicators for Logistics Transferability Index (LTI)**

Dimension	Assessment Criteria	Data Source	Scoring Approach
Interoperability	Compatibility with external systems	Reports / Interviews	Qualitative (0–100)
<b>Standardisation</b>	Use of standards (e.g. eCMR)	Technical Surveys	Qualitative
<b>Replicability</b>	Ease of replication	Pilot Surveys	Qualitative
<b>Deployment readiness</b>	Implementation effort required	Surveys	Qualitative
<b>Ecosystem fit</b>	Alignment with market/policy context	Stakeholder Survey	Qualitative

Scores were assigned using a standardised 0–100 scale based on predefined qualitative criteria (e.g. low–medium–high performance levels), supported by documented evidence. This ensured consistency and traceability across pilots despite differences in data availability. The final LTI score for each pilot was calculated as the average of the dimension scores.

### 3.2 Final Pilot-Level Results

The results confirm that all four pilots generated positive project value, although with clearly differentiated performance profiles. No single pilot dominated all dimensions. Instead, each demonstration environment contributed a distinct form of strategic value to the overall ADMIRAL portfolio (Table 6).

**Table 6 : Final comparative scores of ADMIRAL pilots**

Rank	Pilot	LSI	LMI	LTI	Overall Score
1	Slovenia–Croatia	74.0	100.0	79.1	<b>81.5</b>
2	Finland	91.0	50.0	65.8	<b>74.9</b>
3	Portugal–Spain	32.5	100.0	84.1	<b>61.6</b>
4	Lithuania	26.8	90.0	91.3	<b>58.1</b>

As presented in Table 6, the comparative overall assessment scores of the four ADMIRAL pilots are calculated through the weighted integration of the Logistics Sustainability Index (LSI), Logistics Maturity Index (LMI), and Logistics Transferability Index (LTI). All scores are expressed on a standardised 0–100 scale, where higher values indicate stronger performance. These values can be interpreted as percentage-equivalent scores derived from the normalisation and aggregation procedures described in Section 2. The table shows the differentiated contribution of each pilot to the project portfolio: Slovenia–Croatia achieved the highest overall score (81.5/100), followed by Finland (74.9/100), Portugal–Spain (61.6/100), and Lithuania (58.1/100). The index scores are based on the aggregation of multiple indicators within each KPI family (as defined in D6.1 and operationalised in D6.2), which were normalised and combined using the methodology described in Section 3.1. While Table 6 presents the aggregated results, the underlying indicator-level values and their normalised scores were used in the calculation of each index and are documented in the supporting datasets and analysis files of this deliverable.

**Slovenia–Croatia Pilot.** The Slovenia–Croatia pilot achieved the highest overall score, reaching 81.5/100. Its leading position reflects a balanced performance across all three dimensions—sustainability, maturity, and transferability—within the weighting scheme applied in this assessment. The pilot combined strong sustainability gains, full maturity of deployed solutions, and high transferability potential. While the final ranking is influenced by the relative weights assigned to each index, the results indicate that the pilot consistently performs well across all dimensions rather than relying on a single area of strength. This suggests that the pilot successfully moved beyond isolated experimentation and demonstrated a solution set that is both operationally credible and replicable. In portfolio terms, Slovenia–Croatia can therefore be considered the strongest all-round demonstrator within ADMIRAL under the adopted evaluation framework.

**Finland Pilot.** The Finland pilot ranked second overall with a score of 74.9/100 and recorded the highest sustainability score of all pilots (91.0/100). This performance was strongly influenced by substantial emissions reductions associated with renewable fuel substitution and AI-supported cargo planning. Its final ranking was moderated by the lower maturity score, indicating that some solution components had not yet reached the same final readiness stage as those in the highest-ranking pilots. Nevertheless, Finland stands out as the environmental performance leader of the project.

**Portugal–Spain Pilot.** The Portugal–Spain pilot obtained an overall score of 61.6/100. Its strongest dimensions were maturity and transferability, driven by marketplace integration, service-catalogue architecture, and cross-border interoperability in a corridor context. This pilot demonstrates the strategic value of platform-based logistics coordination and cross-border digital integration. Although its quantified sustainability score was lower than that of the top two pilots, it generated important structural benefits for long-term European scaling.

**Lithuania Pilot.** The Lithuania pilot obtained an overall score of 58.1/100 and recorded the highest transferability score of all pilots (91.3/100). This result was driven by strong digital interoperability, including eCMR integration, API-enabled services, marketplace connectivity, and modular solution architecture. Its final ranking was constrained by the weighting structure of the model, where sustainability carries the largest influence. Nonetheless, Lithuania can be considered the strongest pilot in terms of digital replication potential and future market scalability.

The distribution of scores confirms that ADMIRAL generated a heterogeneous but complementary pilot portfolio rather than a single dominant demonstration model. Slovenia–Croatia’s leading position reflects balanced performance across sustainability, maturity, and transferability dimensions, indicating that integrated operational deployment combined with advanced readiness can outperform pilots excelling in only one area. Finland’s second-place score was driven primarily by exceptional sustainability performance, particularly linked to renewable fuel substitution and optimisation measures, although lower maturity values reduced its final ranking. Portugal–Spain demonstrated stronger performance in maturity and corridor/platform transferability than in direct sustainability metrics, highlighting the importance of digital coordination solutions whose benefits may emerge progressively over time. Lithuania recorded the strongest transferability profile among the pilots but lower short-term sustainability evidence, illustrating how highly interoperable digital solutions may create substantial long-term strategic value even when immediate environmental impacts are more moderate.

To ensure full transparency and reproducibility of the assessment, the complete list of indicators, their corresponding normalised scores, and their contribution to each index are presented in Annex 1, allowing detailed verification of how the aggregated results were derived.

From a portfolio perspective, the score spread between the highest-performing pilot (81.5) and the lowest-ranked pilot (58.1) indicates meaningful differentiation without underperformance. All pilots remain within a positive impact range, suggesting that each demonstrator contributed a distinct pathway to logistics transformation. This pattern supports the interpretation of ADMIRAL as a diversified innovation portfolio in which overall project value derives from complementarity across pilots rather than uniformity of outcomes.

### 3.3 Cross-Pilot Comparative Analysis

The pilot comparison demonstrates that ADMIRAL generated a genuinely complementary demonstration portfolio. The Slovenia–Croatia pilot shows the value of balanced deployment, where sustainability, maturity, and transferability were all strong. Finland demonstrates that targeted environmental interventions can produce very high measurable sustainability gains. Portugal–Spain confirms the importance of cross-border collaboration for digital integration and marketplace-enabled coordination. Lithuania highlights the long-term strategic value of interoperable digital tools with high replication potential. This diversity should be interpreted as a strength rather than a weakness. Horizon Europe projects are expected to generate systemic innovation, and ADMIRAL achieved this by validating multiple pathways to logistics transformation rather than pursuing a single uniform model.

Several strategic conclusions emerge from the pilot-level results. First, sustainability alone does not determine overall pilot leadership. Finland achieved the highest environmental score, driven by strong performance in indicators such as greenhouse gas emissions reduction, energy efficiency improvements, and renewable fuel substitution. However, Slovenia–Croatia ranked first overall due to a more balanced performance across maturity and transferability, supported by high scores in indicators such as TRL progression, full deployment status, system integration, interoperability readiness, and replicability. Second, digital interoperability strongly supports long-term impact. Lithuania and Portugal–Spain show that pilots with strong performance in indicators related to system integration, standardisation, and interoperability can generate significant strategic value, even when short-term sustainability gains are more moderate. Third, deployment readiness matters significantly. Pilots whose solutions achieved higher TRL levels, demonstrated operational uptake, and reached full implementation status performed substantially better in the overall ranking, highlighting the importance of moving from pilot testing to real operational deployment.

The pilot-level assessment confirms that ADMIRAL successfully delivered four differentiated but complementary demonstration outcomes, each reflecting distinct solution types and strong collaboration with stakeholders across the logistics ecosystem. Rather than producing one dominant pilot and several weaker cases, the project created a balanced portfolio in which each pilot contributed a specific strategic strength through the co-development and validation of solutions with industry actors, technology providers, and operational partners. Slovenia–Croatia emerged as the strongest balanced demonstrator, Finland as the environmental leader, Portugal–Spain as the cross-border integration leader, and Lithuania as the transferability leader. Collectively, these results provide strong evidence that ADMIRAL succeeded in validating diverse, stakeholder-driven solutions and multiple scalable pathways towards more sustainable, digitally connected, and resilient freight transport systems.

## 4 Cross-Analysis of Pilots

While Chapter 3 assessed each ADMIRAL pilot individually, the purpose of the present chapter is to examine the pilot portfolio collectively and identify the broader patterns emerging across the four demonstration environments.

A cross-analysis is particularly relevant for ADMIRAL because the project was intentionally structured around heterogeneous pilots operating in different geographical, operational, and market contexts. Each pilot addressed distinct logistics challenges, deployed different combinations of solutions, and generated different forms of value.

Accordingly, the objective of this chapter is not merely to compare rankings, but to understand why pilots performed differently, which success factors were common across sites, which contextual conditions influenced results, and how the four pilots together contribute to the strategic legacy of the project.

The analysis draws on the final pilot scores presented in Chapter 3, the evidence base developed in Deliverables D6.1 and D6.2, pilot implementation reports, and the broader qualitative information gathered during the project.

The final pilot-level scores demonstrated clear differences in performance profiles across the three strategic dimensions of the ADMIRAL assessment model.

As seen in Figure 6 - Radar Chart by Pilot, comparative radar visualisation of the four ADMIRAL pilots across the three core dimensions of the final assessment model: Logistics Sustainability Index (LSI), Logistics Maturity Index (LMI), and Logistics Transferability Index (LTI).

The figure enables simultaneous comparison of pilot performance profiles by showing the relative balance, strengths, and weaknesses of each demonstration environment. Source: own calculations based on the D6.3 final assessment model using consolidated evidence from D6.2, pilot templates, maturity evidence, and transferability scoring matrices.

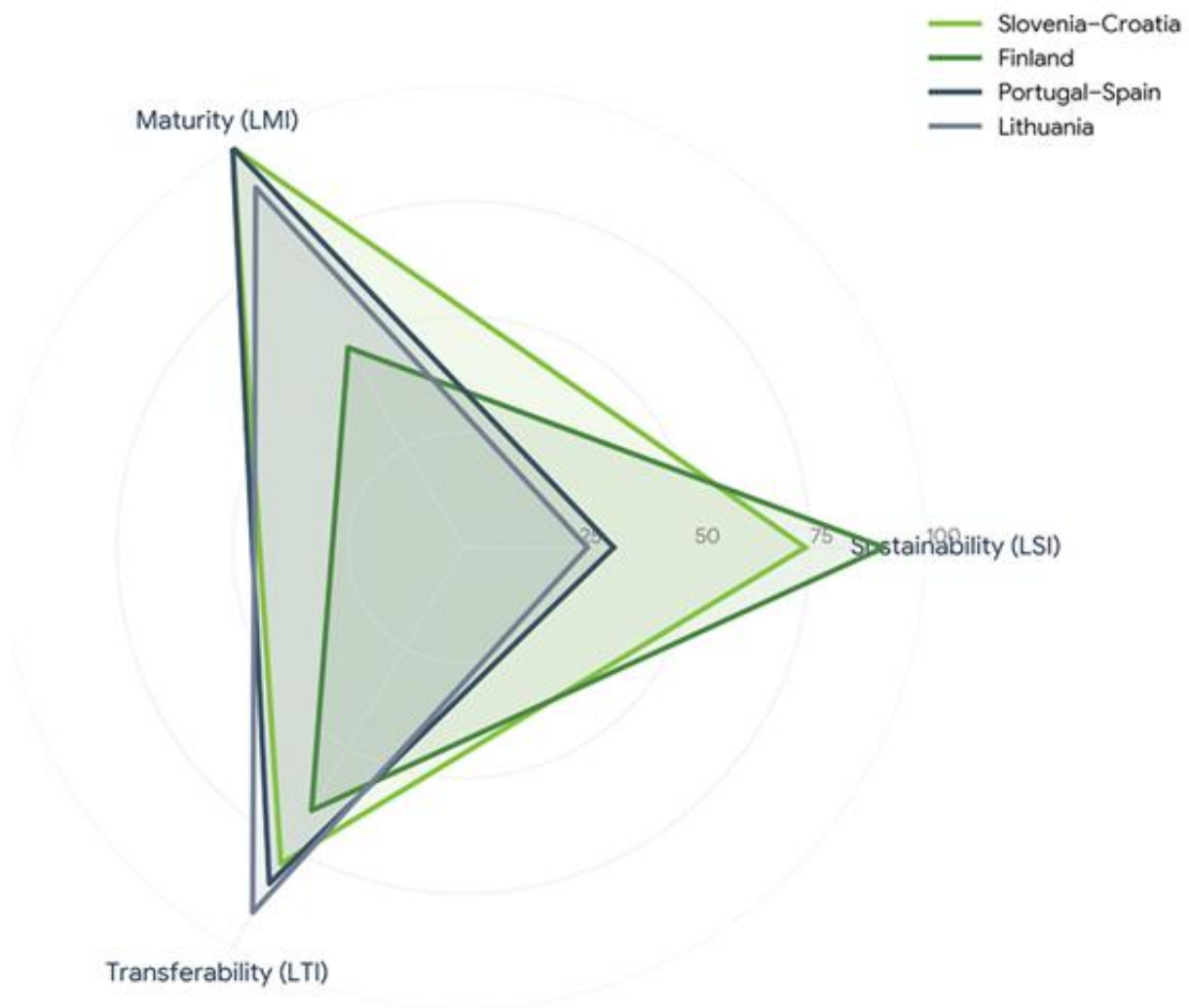


Figure 6 : ADMIRAL Pilot Performance Chart

The radar representation is particularly useful because overall scores alone may conceal different strategic performance structures. Two pilots with similar total scores may achieve them through very different combinations of sustainability, maturity, and transferability. The figure therefore supports a multidimensional interpretation of project results.

These results are derived from high scores in indicators such as TRL progression, full deployment status, system integration, interoperability readiness, and replicability, which were normalised and aggregated within the LMI and LTI indices as described in Section 2.

In contrast, the lower sustainability values reflect comparatively weaker performance in indicators such as greenhouse gas emissions reduction, energy efficiency improvements, and load factor optimisation, which form the basis of the Logistics Sustainability Index (LSI). This is consistent with the pilot's stronger focus on coordination and ecosystem integration rather than direct operational optimisation.

### Slovenia–Croatia Pilot

The Slovenia–Croatia pilot displays the most balanced radar profile of all four demonstrations. With strong scores in sustainability (74.0), maximum maturity (100.0), and high transferability (79.1), the pilot forms a near-symmetrical shape, indicating consistent performance across all dimensions. This balanced structure explains its first-place overall ranking. Scientifically, the result suggests that integrated real-world deployment combined with operational efficiency improvements and scalable solution architecture produces stronger portfolio outcomes than isolated excellence in a single dimension. Slovenia–Croatia therefore represents the most complete demonstration model within ADMIRAL (Figure 7).

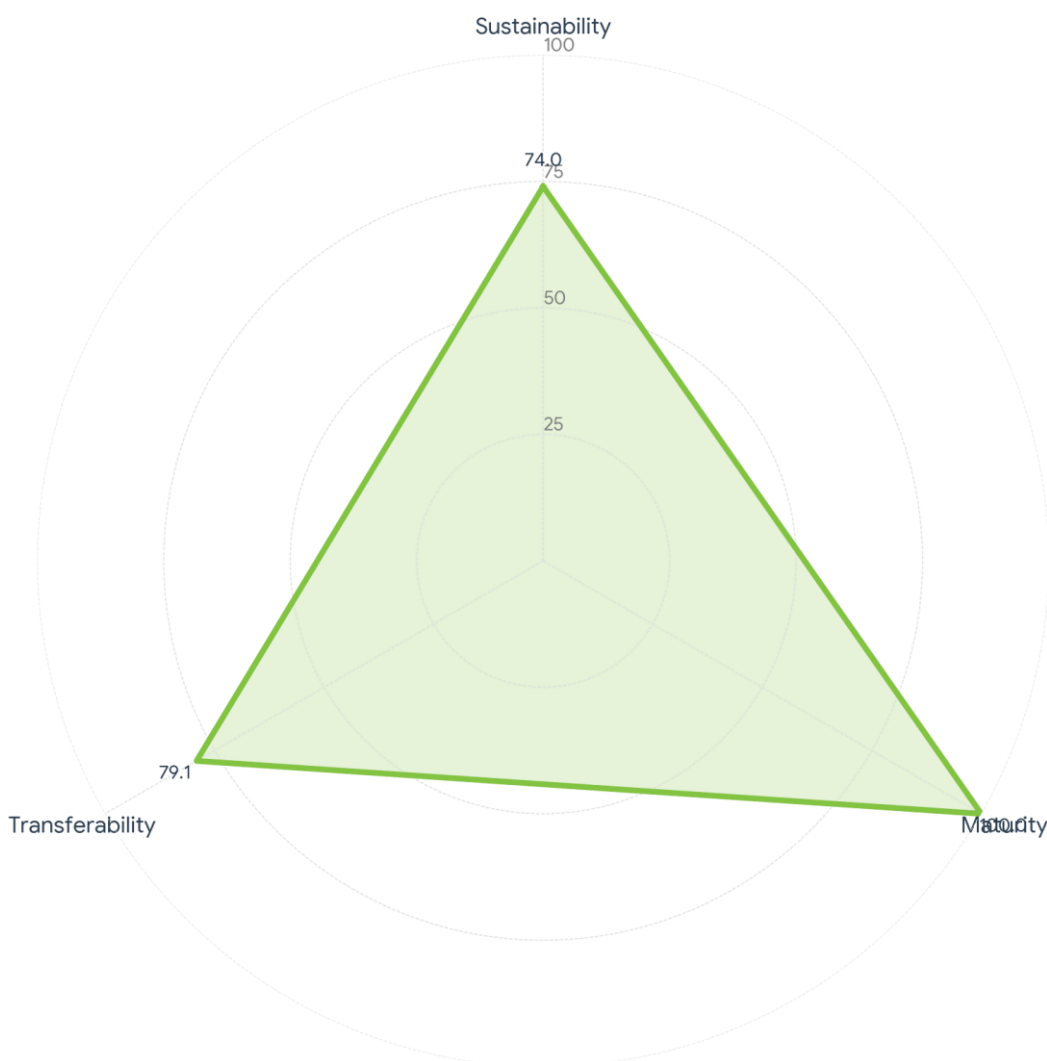


Figure 7 : Radar profile of the Slovenia–Croatia pilot

### Finland Pilot

The Finland pilot exhibits a highly distinctive radar shape characterised by exceptionally strong sustainability performance (91.0), moderate transferability (65.8), and lower maturity (50.0). This asymmetrical pattern indicates that Finland generated very strong environmental benefits, primarily associated with renewable fuel substitution and AI-supported optimisation, but with some solution components still at earlier deployment readiness stages. The pilot can therefore be interpreted as ADMIRAL’s environmental flagship, demonstrating that high-impact decarbonisation interventions can produce substantial results even before full maturity is reached (Figure 8).

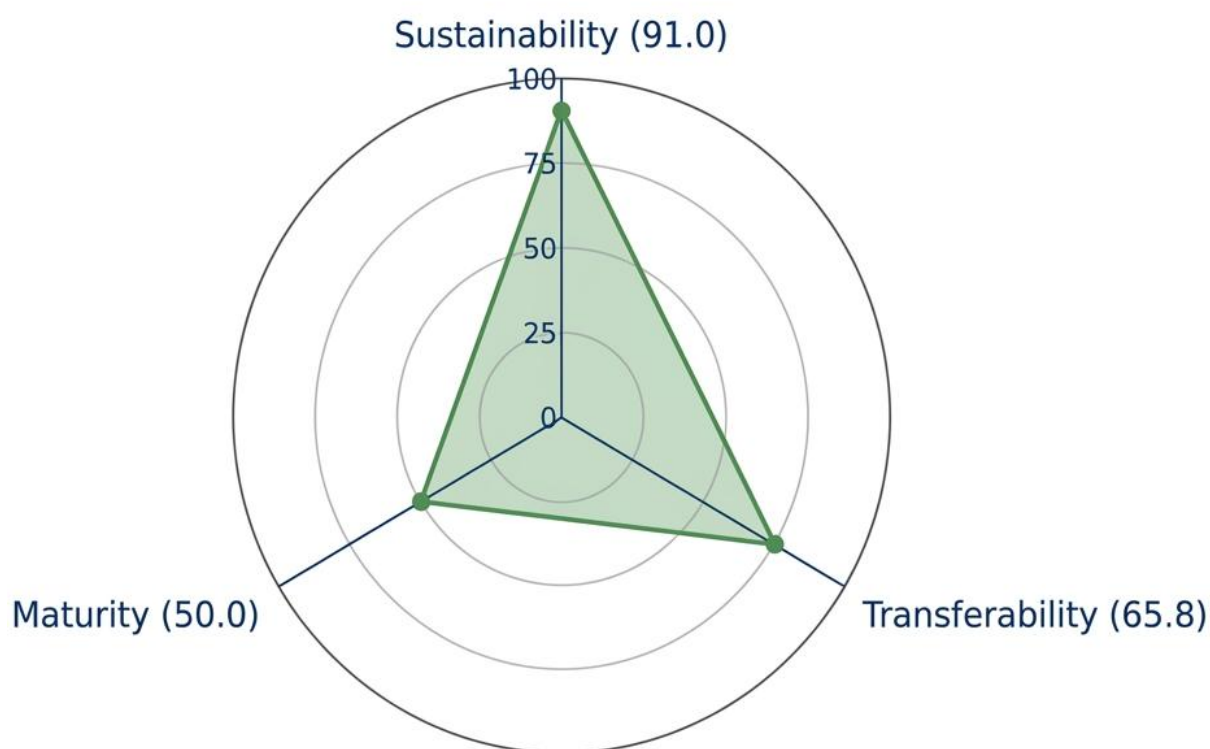


Figure 8 : Radar profile of the Finland pilot

Figure 7, the chart is characterised by exceptionally high sustainability performance, reflecting strong emissions reduction potential, while maturity and transferability remain more moderate. Finland therefore represents the environmental performance leader within ADMIRAL.

### Portugal–Spain Pilot

The Portugal–Spain pilot radar profile is dominated by maximum maturity (100.0) and high transferability (84.1), while sustainability performance is comparatively lower (32.5). This pattern reflects the strategic nature of the Portuguese-Spanish pilot, which focused strongly on marketplace integration, cross-border coordination, interoperability, and platform readiness. Rather than generating the largest immediate environmental KPI gains, the pilot created structural capabilities likely to support future efficiency and sustainability improvements through ecosystem coordination. Its radar shape therefore reflects a digitally mature and highly scalable corridor model.

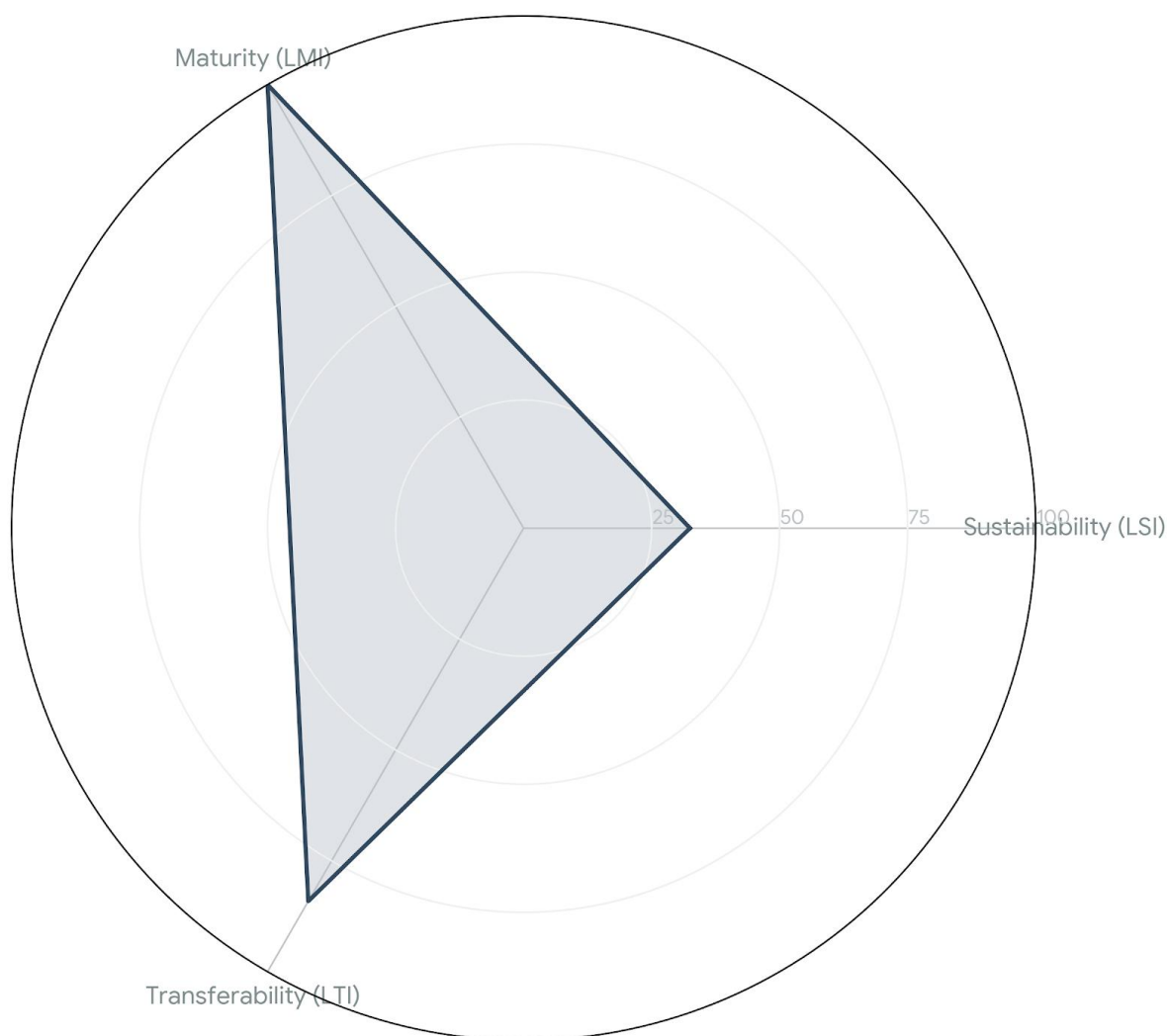


Figure 9 : Radar profile of the Portugal–Spain pilot

Figure 9, the chart highlights maximum maturity and strong transferability, indicating a highly deployable and scalable corridor/platform model. Lower direct sustainability values reflect the stronger focus on coordination and ecosystem integration.

### Lithuania Pilot

The Lithuania pilot presents the strongest transferability axis (91.3), very high maturity (90.0), and lower sustainability evidence (26.8), producing a radar shape concentrated toward digital scalability and readiness. This confirms Lithuania as ADMIRAL’s most replication-oriented pilot based on its consistently high scores across key transferability indicators. Specifically, the pilot achieved strong performance in dimensions such as interoperability readiness, standardisation, replicability, and deployment readiness, which were assessed through structured evidence collected from pilot reports, stakeholder inputs, and technical documentation. The use of widely applicable and modular digital solutions—including TMS integration, ETA services, eCMR functionality, CO<sub>2</sub> tools, and data exchange services—demonstrates a high degree of compatibility with existing logistics systems and regulatory frameworks, facilitating adoption in other contexts.

Furthermore, the reliance on standardised data formats, API-based integration, and platform-oriented service design supports scalability across different corridors and markets, as reflected in the high LTI score derived from the evidence-based scoring model. The lower sustainability axis should be interpreted not as weak performance, but as reflecting a stronger emphasis on digital enablement than on directly measurable short-term emissions reductions. However, these digital capabilities provide an enabling foundation for future sustainability gains when deployed at scale.

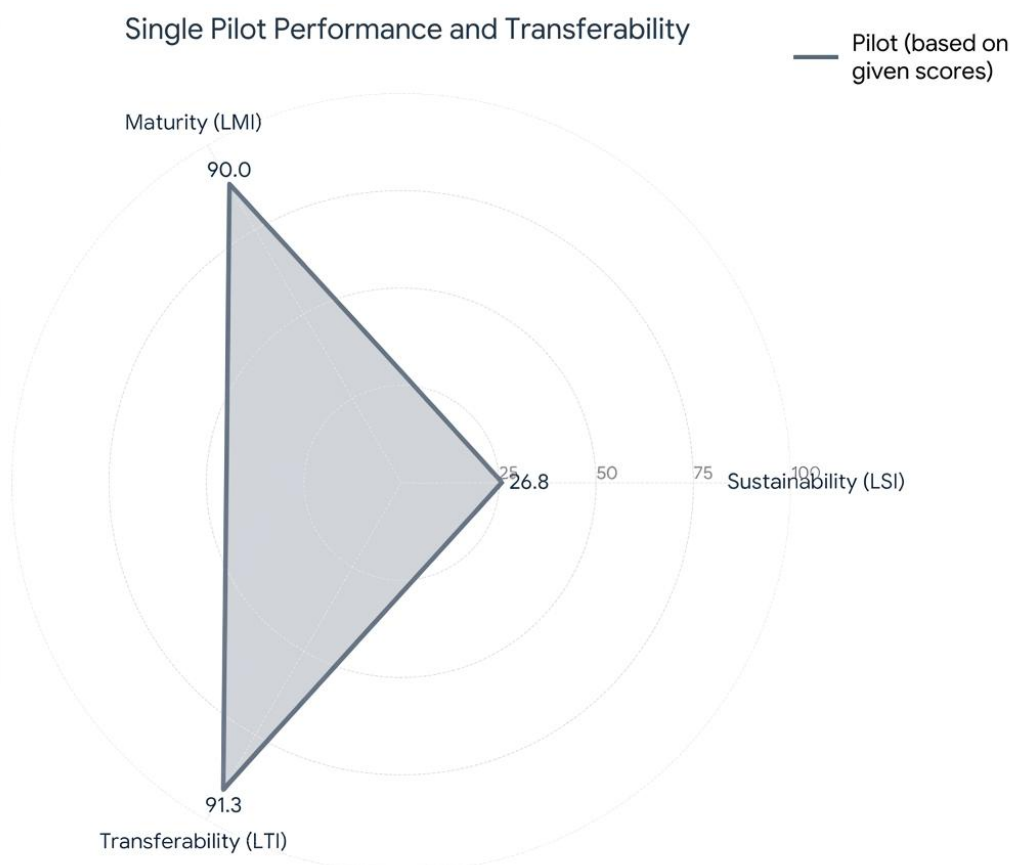


Figure 10 : Radar profile of the Lithuania pilot

Figure 10, the chart shows very high maturity and the strongest transferability performance of all pilots, confirming Lithuania as the leading digital replication model within ADMIRAL.

## Comparative Scientific Findings

Based on the pilot results, improvements in sustainability performance could be achieved by integrating optimisation functionalities (e.g. route and load planning), increasing the use of low-emission or alternative fuels, and enhancing real-time data utilisation to improve asset efficiency and reduce empty runs. These measures would strengthen the environmental dimension while leveraging the already strong digital and organisational capabilities of the pilot.

The combined radar chart demonstrates that no single pilot dominates all three dimensions. Instead, each pilot occupies a distinct strategic niche:

- **Slovenia–Croatia:** most balanced and highest all-round performer
- **Finland:** sustainability leader
- **Portugal–Spain:** maturity and corridor integration leader
- **Lithuania:** transferability and digital replication leader

This multidimensional differentiation is a positive outcome for a Horizon Europe innovation project. It indicates that ADMIRAL validated multiple transformation pathways rather than testing a single homogeneous model. The radar chart therefore visually confirms that project-wide impact arises from complementarity among pilots, not from uniformity of results, Figure 11.

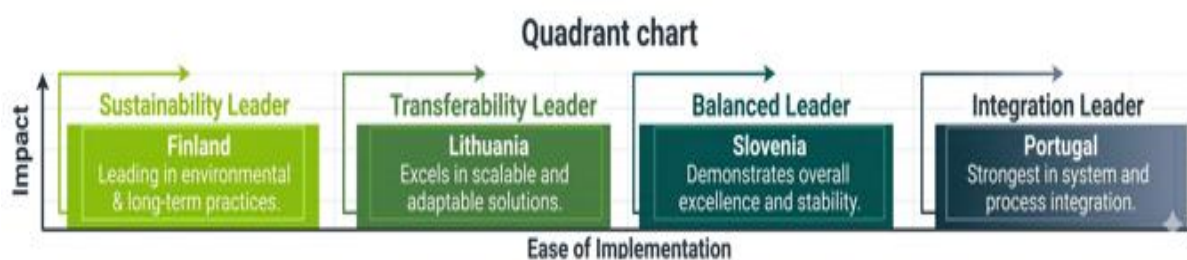


Figure 11 : ADMIRAL Pilots Quadrant Chart per Implementation

A direct comparison of pilots must recognise that each demonstrator operated under different conditions and pursued partly different operational objectives.

The Finland pilot focused strongly on emissions reduction and terminal efficiency, particularly through renewable fuel use and AI-supported cargo planning. This naturally favoured measurable sustainability outcomes.

The Portugal–Spain pilot operated in a corridor and multimodal integration environment, where the strategic challenge was coordination between actors, service visibility, and digital marketplace functionality. As a result, transferability and integration-related outcomes were particularly strong.

The Lithuania pilot emphasised digital interoperability, transport management integration, eCMR functionality, ETA services, and modular digital tools. This explains its strong transferability profile.

The Slovenia–Croatia pilot demonstrated practical deployment-oriented solutions in a real operational context, combining strong readiness, operational use, and measurable sustainability gains.

These contextual differences are essential for interpreting scores fairly. Lower performance in one dimension may reflect strategic focus rather than underperformance.

## 4.1 Cross-Pilot Success Factors

Despite their differences, several common success factors can be identified across the pilot portfolio. Pilots that embedded solutions directly into real logistics operations produced the most robust outcomes. Real-world deployment generated measurable impacts, stronger stakeholder engagement, and clearer evidence of maturity. Pilots with stronger operational datasets were better able to demonstrate quantified benefits. Access to route, fuel, utilisation, timing, and emissions data was particularly important for sustainability scoring. Where multiple actors actively cooperated, including carriers, shippers, terminal operators, and technology providers, implementation quality and transferability potential were stronger. Solutions that connected effectively to pre-existing operational systems performed better than stand-alone tools. API readiness, modularity, and interoperability were recurring drivers of success.

### Sustainability Patterns Across Pilots

The pilot comparison confirms that sustainability gains can be achieved through different mechanisms. In Finland, the strongest gains were linked to direct fuel substitution and planning optimisation. In Slovenia–Croatia, sustainability improvements were associated with operational efficiency and mature deployment. In Portugal–Spain and Lithuania, sustainability effects were more indirect, linked to digital coordination, reduced inefficiencies, and smarter decision-making. This demonstrates that decarbonisation in logistics is not limited to one pathway. ADMIRAL validated multiple routes to environmental improvement, including technological substitution, process optimisation, digital visibility, and interoperability.

### Maturity and Readiness Patterns

The maturity dimension revealed significant differences in deployment readiness. Slovenia–Croatia and Portugal–Spain reached the highest maturity scores, indicating strong implementation progress and successful real-world operation of demonstrated tools. Lithuania also performed strongly, reflecting advanced digital deployment. Finland’s lower maturity score does not indicate weak innovation quality, but rather that some components remained at an earlier stage of operational readiness at project close. The overall conclusion is positive: ADMIRAL delivered several solutions at late-stage readiness levels, which is a strong outcome for a Horizon Europe innovation project.

### Transferability Patterns

Transferability scores highlight the importance of interoperable digital architecture. Lithuania achieved the highest transferability score because of modular tools, eCMR functionality, API-enabled integration, and scalable digital services. Portugal–Spain also performed strongly due to its marketplace model (Service Catalogue) and corridor-oriented coordination logic. Slovenia–Croatia demonstrated good transferability through operationally proven tools. Finland’s lower score reflects greater dependence on site-specific terminal conditions. The results suggest that the most transferable innovations are typically digital, modular, standards-compatible, and not highly dependent on one local infrastructure setting.



## 4.2 Lessons Learned Across Pilots

Several practical lessons emerge from the comparative analysis. First, environmental sustainability gains are strongest when digital tools are directly connected to real operational decisions—such as route optimisation, load planning, modal shift, and fuel selection—rather than used only for monitoring purposes. This pattern is observed across multiple pilots: for example, Finland demonstrated strong gains through the combination of optimisation tools and alternative fuel use, while Slovenia–Croatia and Portugal–Spain showed how improved planning, coordination, and operational integration can also contribute to efficiency and emissions reduction.

Second, maturity depends not only on technical development, but also on organisational readiness, stakeholder engagement, and operational embedding. Third, transferability is maximised when solutions are modular, interoperable, and capable of integration with legacy systems. Fourth, pilot diversity should be regarded as a strategic asset.

Different logistics contexts require different innovation pathways, and ADMIRAL successfully demonstrated multiple models rather than a one-size-fits-all approach. Moreover, one of the strongest findings of the cross-analysis is that the pilots complement one another strategically (Table 7).

**Table 7 : Strategic role of each pilot**

Pilot	Main Strategic Contribution
<b>Slovenia–Croatia</b>	Balanced demonstrator with strong all-round performance
<b>Finland</b>	Environmental performance leader
<b>Portugal–Spain</b>	Cross-border platform and integration leader
<b>Lithuania</b>	Digital interoperability and transferability leader

Taken together, the pilots cover a broad spectrum of logistics transformation pathways. This portfolio diversity increases the relevance of ADMIRAL for different market segments and policy objectives.

Thus, pilot portfolio also demonstrated some implications for future deployment. The cross-pilot results indicate that future scale-up strategies should not replicate pilots as fixed packages. Instead, the most effective pathway is likely to involve transferring successful components according to local needs. For example:

- marketplace and integration solutions may be prioritised in fragmented cross-border corridors to leverage successful collaboration environments;
- planning and optimisation tools may be prioritised in terminal or fleet contexts;
- eCMR and interoperability tools may be prioritised where administrative efficiency is a barrier;
- emissions tools may be prioritised where reporting and decarbonisation targets are strongest.

This modular replication logic is one of the principal long-term benefits created by ADMIRAL.

Finally, the cross-analysis confirms that ADMIRAL’s strength lies not in a single pilot outperforming all others, but in the collective value generated by four differentiated demonstrators. Each pilot validated a distinct pathway towards greener, smarter, and more resilient freight transport. Slovenia–Croatia demonstrated balanced excellence, Finland demonstrated strong environmental impact, Portugal–Spain demonstrated corridor integration value, and Lithuania demonstrated high digital transferability.

Together, these pilots provide convincing evidence that sustainable freight transformation in Europe can be achieved through multiple complementary innovation models.

## 5 Solution by Solution

In addition to the pilot-level assessment presented in the previous chapters, ADMIRAL requires a solution-level evaluation to understand which individual tools, services, and digital components generated the strongest project value. While pilot analysis captures the performance of integrated demonstration environments, solution-level analysis isolates the contribution of specific innovations and provides a clearer view of exploitation potential, market readiness, and scalability.

This perspective is particularly relevant for Horizon Europe projects, where long-term impact often depends on the uptake of individual exploitable assets rather than on the continuation of pilot configurations as complete packages. ADMIRAL developed a diversified portfolio of solutions, including digital marketplace functions, planning and optimisation tools, integration services, transport management modules, emissions tools, digital documentation systems, and data exchange components. Each of these solutions contributes differently to sustainability, operational maturity, and transferability.

The objective of this chapter is therefore to compare the principal ADMIRAL solutions through the same common framework used for pilot assessment, namely the Logistics Sustainability Index (LSI), the Logistics Maturity Index (LMI), and the Logistics Transferability Index (LTI). This enables the identification of the solutions that generated the strongest direct impact, the solutions most ready for deployment, and the solutions with the greatest long-term replication potential.

### 5.1 Methodological Basis

The solution-level assessment applies the Overall Assessment Model described in Chapter 2. For each solution  $s$ , the final score was calculated. The same weighting structure was retained to ensure full comparability with pilot-level results. Sustainability therefore remains the largest contributor to final scores, while maturity and transferability capture deployment readiness and strategic scalability.

Solution-level scores were derived using evidence from pilot demonstrations, D6.2 KPI datasets, solution implementation reports, achieved TRL values, partner interviews, and documented integration or market-readiness evidence.

### 5.2 Solution Portfolio Assessed

The final assessment covered the principal ADMIRAL solution family delivered and/or deployed during the project. It is important to note that not all solutions were developed from scratch within ADMIRAL. Some, such as eCMR (Digital Bill of Lading), were pre-existing solutions that were further integrated, adapted, and validated within the project pilots to enhance interoperability, usability, and overall performance.

Table 8 presents the solution portfolio included in the final assessment, together with the pilots in which each solution was primarily developed and/or deployed.

**Table 8 : Solution portfolio included in the final assessment**

Code	Solution	Pilot(s)
S1	ADMIRAL Marketplace	Cross-pilot
S2	AI-Based Cargo Planning Tool	Finland
S3	Transport Service Order Management Tool	Slovenia–Croatia
S4	Transport Scheduling Tool	Slovenia–Croatia
S5	Digital Bill of Lading / eCMR	Lithuania
S6	Data Exchange Structures and Services	Lithuania, Portugal–Spain
S7	CO <sub>2</sub> Calculation Methodology / Tools	Lithuania, Finland
S8	Logistics Planning Tool (LOPTA)	Finland
S9	Crowdsourcing Tool	Portugal–Spain
S10	Integration Tool	Cross-pilot

This set reflects both directly user-facing solutions and enabling infrastructure components that support the broader ADMIRAL ecosystem.

### 5.3 Interpretation of Results

The results confirm that ADMIRAL delivered a balanced innovation portfolio composed of both high-impact operational tools and strategically important ecosystem enablers (Table 9).

**Table 9 : Final comparative scores of ADMIRAL solutions**

Rank	Solution	Description	LSI	LMI	LTI	Score
1	Logistics Planning Tool (LOPTA)	Optimisation tool for planning multimodal logistics operations and improving efficiency	74	100	82	<b>84.2</b>
2	CO <sub>2</sub> Calculation Tools	Tools for calculating emissions and supporting low-carbon decision-making in logistics chains	88	100	74	<b>84.0</b>
3	Crowdsourcing Tool	Platform for collecting and sharing real-time logistics data from distributed stakeholders	72	100	76	<b>82.7</b>
4	ADMIRAL Marketplace	Digital platform enabling coordination, service exchange, and integration across logistics actors	62	100	92	<b>78.4</b>
5	Digital Bill of Lading / eCMR	Electronic freight document solution supporting paperless and interoperable transport processes	58	100	95	<b>76.8</b>
6	Integration Tool	Middleware solution enabling system interoperability and data exchange between logistics platforms	52	100	96	<b>73.5</b>

<b>7</b>	Transport Service Order Management Tool	Tool for managing transport orders and coordinating logistics service execution	55	100	82	<b>73.3</b>
<b>8</b>	Data Exchange Structures and Services	Standardised data models and services enabling secure and scalable information exchange	46	100	94	<b>70.4</b>
<b>9</b>	Transport Scheduling Tool	Tool for planning and scheduling transport operations across logistics networks	50	75	78	<b>64.0</b>
<b>10</b>	AI-Based Cargo Planning Tool	AI-driven tool for optimising cargo allocation and improving transport efficiency	66	50	72	<b>63.7</b>

### Logistics Planning Tool (LOPTA)

The Logistics Planning Tool achieved the highest overall score. Its leading position reflects a combination of strong measurable operational sustainability gains, full maturity, and high transferability potential. Planning tools are directly linked to route efficiency, asset utilisation, and operational optimisation, which explains their strong sustainability performance. In strategic terms, LOPTA can be considered one of the flagship operational outcomes of ADMIRAL.

### CO<sub>2</sub> Calculation Tools

The CO<sub>2</sub> tools ranked second overall and achieved the highest sustainability score among the solution set. This reflects the increasing importance of emissions visibility, carbon accounting, and evidence-based decarbonisation management in logistics markets. Their strong maturity score indicates that these tools are already close to market relevance, while their transferability is high because they can be deployed across many sectors and geographies.

### Crowdsourcing Tool

The Crowdsourcing Tool ranked third overall. Its performance reflects strong operational efficiency potential, mature implementation status, and relevance for flexible urban or last-mile logistics environments. Its long-term scaling potential depends on labour-market regulation, user acceptance, and local demand density, but the solution demonstrates clear practical value.

### ADMIRAL Marketplace

The Marketplace ranked fourth overall and recorded one of the highest transferability scores. This confirms that platform-based coordination and service matching are among the most scalable outcomes of the project. Although its direct sustainability score is lower than that of optimisation tools, the Marketplace can generate indirect sustainability benefits by improving load matching, reducing empty trips, and increasing multimodal visibility.

### eCMR / Digital Bill of Lading

The Digital Bill of Lading solution performed strongly due to very high transferability and full maturity. Standardised digital documentation reduces administrative burden, improves transparency, and can be replicated widely across European freight corridors. This solution is particularly relevant for future policy alignment and regulatory modernisation.

### Integration Tool and Data Exchange Services

These solutions performed especially strongly in transferability. Their value lies in enabling other tools to connect, exchange data, and operate as part of a wider ecosystem. While such infrastructure solutions may generate less visible direct sustainability impact, they are essential for the long-term functioning and scale-up of the broader ADMIRAL architecture.

### Emerging Solutions

The Transport Scheduling Tool and AI-Based Cargo Planning Tool achieved lower overall scores than the leading solutions, primarily due to earlier maturity stages or narrower deployment evidence. However, these results should not be interpreted negatively. Both solutions remain strategically promising, particularly as data quality improves and market demand for predictive decision-support tools increases.

## 5.4 Cross-Solution Comparative Analysis

The solution-level results reveal two clearly complementary innovation families. The first family consists of **direct operational impact solutions**, such as planning tools, optimisation services, crowdsourcing models, and emissions tools. These solutions generate measurable short-term efficiency and sustainability benefits. The second family consists of **ecosystem transformation solutions**, such as the Marketplace, Integration Tool, eCMR services, and Data Exchange Structures. These solutions create the digital backbone required for future interoperability, scaling, and multi-actor coordination. This distinction is strategically important. Some solutions create immediate measurable gains, while others create the enabling conditions for long-term structural transformation.

The solution assessment indicates that several ADMIRAL outputs are already close to practical exploitation pathways. Short-term market-ready assets include CO<sub>2</sub> tools, Marketplace modules, eCMR functions, Planning tools, and Integration services. Medium-term assets include AI planning tools, advanced scheduling services, and broader ecosystem orchestration modules. This confirms that ADMIRAL generated not only research outputs, but commercially relevant innovation assets.

Several broader lessons emerge from the solution-level assessment. First, the highest-performing solutions tend to combine direct operational usefulness with simple integration pathways. Second, digital backbone solutions may produce lower immediate KPI gains but often carry the highest long-term strategic value. Third, maturity matters significantly. Solutions reaching high TRL levels consistently performed better overall. Fourth, sustainability gains and digitalisation are mutually reinforcing rather than competing objectives.

The solution-by-solution assessment confirms that ADMIRAL delivered a strong and diversified portfolio of exploitable innovations. No single solution type dominates all dimensions. Instead, operational tools lead in measurable impact, while ecosystem tools lead in scalability and long-term transformation potential. The highest-ranked solutions were the Logistics Planning Tool, CO<sub>2</sub> Calculation Tools, Crowdsourcing Tool, and ADMIRAL Marketplace. Together with the digital backbone solutions, these outputs form the principal exploitation legacy of the project. The results demonstrate that ADMIRAL successfully combined short-term operational improvements with long-term ecosystem innovation, thereby strengthening the project's overall European impact potential.

## 6 Overall Impact Assessment Outcomes

The overall impact assessment of ADMIRAL moves beyond the evaluation of individual pilots and solutions to examine the collective value generated at project portfolio level. While pilot-level analysis demonstrates the performance of specific demonstration environments, the portfolio perspective captures how these results combine to deliver systemic innovation in European freight transport.

ADMIRAL did not aim to validate a single technological solution or operational model. Instead, the project was designed as a multi-pilot, multi-solution innovation ecosystem, integrating digital tools, optimisation approaches, and collaborative platforms across different logistics contexts. As a result, the overall project impact emerges not from isolated outcomes, but from the complementarity and interaction between pilots and solutions.

At portfolio level, ADMIRAL achieved a balanced and robust performance across the three strategic dimensions defined in the assessment framework: sustainability, maturity, and transferability. The consolidated results indicate that the project successfully delivered:

- measurable environmental and operational improvements through optimisation, fuel substitution, and efficiency gains;
- advanced technological maturity, with several solutions reaching high TRL levels and being validated in real operational environments;
- strong transferability potential, particularly through interoperable digital tools, platform-based coordination mechanisms, and standardised data exchange structures.

The overall project impact score of 72.1/100 confirms that ADMIRAL delivered a strong and well-rounded performance, with particularly high results in maturity and transferability dimensions.

From a systemic perspective, the most important outcome of ADMIRAL is the demonstration that sustainability, digitalisation, and collaboration are mutually reinforcing. Environmental gains were strongest where digital tools were integrated into operational decision-making processes, while scalable impact depended on interoperability, stakeholder cooperation, and ecosystem integration.

Moreover, the project validated two complementary pathways to impact:

- Direct operational impact, achieved through planning, optimisation, and emissions-related tools that generate measurable short-term improvements;
- Ecosystem transformation, achieved through marketplace solutions, integration tools, eCMR services, and data exchange structures that enable long-term scalability and cross-organisational coordination.

These two pathways are not independent; rather, they form a combined transformation model, where digital backbone solutions enable the wider deployment and scaling of operational innovations.

A key finding of the overall assessment is that portfolio diversity is a major strength. The four ADMIRAL pilots addressed different logistics challenges, terminal operations, cross-border corridors, digital interoperability, and decarbonisation, resulting in a set of solutions that can be recombined and adapted to different contexts. This modular and flexible innovation structure significantly increases the project's relevance for wider European deployment.

In this respect, ADMIRAL contributes not only to individual technological advancements, but also to the development of a replicable innovation framework for multimodal logistics systems, aligned with the objectives of the digital and green transition. The project demonstrates that large-scale impact in freight transport can be achieved through integrated portfolios of interoperable, scalable, and stakeholder-driven solutions, rather than through isolated technological interventions.

Ultimately, the overall impact of ADMIRAL lies in its ability to deliver a coherent, mature, and transferable set of innovations that together form a practical foundation for future exploitation, replication, and policy support across Europe.

## 6.1 Pathway

The previous chapters assessed ADMIRAL at two complementary analytical levels. Chapter 3 examined the comparative performance of the four pilot demonstrations, while Chapter 5 evaluated the individual solutions developed and validated during the project. The purpose of the present chapter is to move beyond these separate perspectives and determine what ADMIRAL achieved at portfolio level.

This distinction is important. A multi-pilot Horizon Europe project should not be judged solely on the ranking of individual demonstrators, nor only on the performance of isolated technologies. Its real impact lies in the combined value created by the interaction of pilots, solutions, knowledge assets, operational evidence, and scalable innovation pathways. For this reason, the final ADMIRAL assessment adopts a portfolio perspective in which the project is treated as an integrated innovation ecosystem rather than a collection of disconnected outputs.

The objective of this chapter is therefore to quantify the overall outcomes generated by ADMIRAL across sustainability, maturity, and transferability dimensions, and to interpret the strategic significance of those results for European freight transport.

### 6.1.1 Methodological Basis

The portfolio-level assessment is grounded in the methodological framework established in Deliverables D6.1 and D6.2 and subsequently operationalised through the pilot and solution analyses presented in earlier chapters of this report. Project-wide outcomes were derived from the combined evidence base generated during the project lifecycle. This evidence included pilot-level index scores, solution-level index scores, quantified KPI results reported during pilot evaluations, Technology Readiness Level progression data, deployment maturity evidence, interoperability and transferability evidence, as well as stakeholder and user-performance findings gathered during implementation activities.

By combining these evidence streams, the final assessment captures both measurable short-term impacts and wider structural outcomes such as readiness for market uptake, ecosystem integration, and long-term replication potential.

The same weighted composite structure used throughout the deliverable was retained for the final portfolio calculation:

$$\text{Overall Impact} = (0.51) \cdot \text{LSI} + (0.24) \cdot \text{LMI} + (0.25) \cdot \text{LTI}$$

This weighting reflects the strategic prioritisation previously validated through the stakeholder process described in Deliverable D6.1. Sustainability remains the most influential dimension, representing 51% of the final score, while maturity and transferability account for 24% and 25% respectively.

The use of the same weighting structure at project level ensures methodological consistency between pilot, solution, and portfolio assessments.

### 6.1.2 Aggregation & Robustness of the Pathway

To avoid over-representing any single pilot, solution, or isolated KPI result, the final portfolio values were calculated through a balanced aggregation procedure. First, arithmetic mean values were derived from the pilot-level scores presented in Chapter 3. Second, arithmetic mean values were derived from the solution-level scores presented in Chapter 5. Third, these intermediate results were triangulated against the quantified KPI evidence reported in pilot evaluations and the wider implementation datasets generated during the project. Finally, consistency checks were performed across datasets to ensure that no extreme value or isolated case disproportionately influenced the final results. This procedure ensures that the project-wide indices represent balanced portfolio-level values rather than the performance of a single demonstrator or solution.

A portfolio-level perspective is particularly appropriate for ADMIRAL because the project intentionally pursued multiple pathways to innovation. Some pilots generated stronger direct sustainability outcomes, while others demonstrated higher maturity or stronger transferability. Likewise, some solutions produced immediate operational gains, while others created the digital backbone required for long-term scaling.

Assessing only one pilot or one solution would therefore understate the total value of the project. The portfolio model recognises complementarities between outputs and reflects how Horizon Europe innovation actions are expected to generate systemic impact through combinations of technologies, actors, and deployment contexts.

The chosen pathway for overall assessment is robust for three reasons. First, it combines quantitative and qualitative evidence rather than relying on a single data source. Second, it uses a weighting logic previously validated through stakeholder consultation. Third, it balances pilot-level and solution-level performance, thereby reducing the risk of distortion from context-specific results. For these reasons, the portfolio outcomes presented in the following sections should be interpreted as the most representative synthesis of ADMIRAL's final achievements.

The pathway adopted for the final overall impact assessment ensures that ADMIRAL is evaluated according to the total value created across its pilots, solutions, and innovation ecosystem. The next sections present the resulting portfolio-level scores and analyse what the project achieved in practical and strategic terms.

## 6.2 Overall Assessment Results

The objective of the overall impact assessment is to synthesise the combined results of the ADMIRAL pilot demonstrations and the project’s solution portfolio to determine the extent to which ADMIRAL achieved its strategic objectives in sustainable, digital, interoperable, and transferable logistics innovation. Whereas the previous chapters assessed performance at pilot level and solution level separately, the present section consolidates those findings into a project-wide perspective. The aim is to identify the net outcomes generated by ADMIRAL as an integrated innovation portfolio rather than as a collection of isolated pilots or technologies.

The assessment therefore applies the common three-index framework used throughout this deliverable to dimensions collectively describe how ADMIRAL performed in terms of measurable sustainability impact, readiness for deployment, and long-term European scalability.

### Portfolio Calculation Logic

This weighting structure reflects the stakeholder prioritisation process described in Deliverable D6.1, where sustainability received the highest importance, while maturity and transferability were also recognised as critical dimensions of project success.

To derive project-wide values, the arithmetic mean of pilot-level results was combined with the arithmetic mean of solution-level results. These values were then cross-checked against KPI evidence, maturity data, and implementation findings to ensure consistency.

#### 6.2.1 Consolidated Pilot-Level Results

The final pilot-level results established in Chapter 3 are summarised in Table 10.

**Table 10: Final pilot-level scores**

Pilot	LSI	LMI	LTI	Overall
Slovenia–Croatia	74.0	100.0	79.1	81.5
Finland	91.0	50.0	65.8	74.9
Portugal–Spain	32.5	100.0	84.1	61.6
Lithuania	26.8	90.0	91.3	58.1

The mean pilot-level values are:

$$LSI_{pilot} = 56.1$$

$$LMI_{pilot} = 85.0$$

$$LTI_{pilot} = 80.1$$

$$Overall_{pilot} = 69.0$$

These results confirm that the pilot portfolio delivered differentiated but consistently positive outcomes, with particularly strong maturity and transferability performance.

The final solution-level results established in Chapter 5 are summarised in Table 11.

Table 11: Final solution-level scores

Solution	LSI	LMI	LTI	Overall
Logistics Planning Tool	74	100	82	84.2
CO <sub>2</sub> Tools	88	100	74	84.0
Crowdsourcing Tool	72	100	76	82.7
Marketplace	62	100	92	78.4
eCMR / Digital Bill	58	100	95	76.8
Integration Tool	52	100	96	73.5
Order Management Tool	55	100	82	73.3
Data Exchange Solutions	46	100	94	70.4
Scheduling Tool	50	75	78	64.0
AI Cargo Planning Tool	66	50	72	63.7

The mean solution-level values are:

$$LSI_{solution} = 62.3$$

$$LMI_{solution} = 92.5$$

$$LTI_{solution} = 84.1$$

$$Overall_{solution} = 75.1$$

These values indicate that ADMIRAL solutions performed particularly strongly in maturity and transferability, confirming the presence of several market-relevant and scalable assets.

Project-wide values were derived by combining pilot-level and solution-level means.

$$LSI = 56.1 + 62.32 = 59.2$$

$$LMI = 85.0 + 92.52 = 88.8$$

$$LTI = 80.1 + 84.12 = 82.1$$

Substituting these values into the overall model gives:

$$OA = 0.51(59.2) + 0.24(88.8) + 0.25(82.1) = 72.1$$

## Final ADMIRAL Project Scores

Table 12: Final overall project results

Project Index	Score
Logistics Sustainability Index (LSI)	59.2
Logistics Maturity Index (LMI)	88.8
Logistics Transferability Index (LTI)	82.1
Overall ADMIRAL Impact Score	72.1

These results indicate that ADMIRAL achieved a strong final project outcome, with particularly high performance in maturity and transferability (Table 12).

### Interpretation by Strategic Dimension

To ensure consistency and transparency in the interpretation of results, the overall index scores (expressed on a standardised 0–100 scale) are classified according to a qualitative impact scale. This classification follows common practices in multi-criteria decision analysis (MCDA) and performance benchmarking, where normalised scores are grouped into qualitative performance levels to support interpretation and decision-making (e.g. OECD performance frameworks, EC impact assessment practices, and MCDA literature such as Keeney & Raiffa, 1993).

Accordingly, the following scale is applied:

- **0–40:** Limited impact
- **40–60:** Moderate impact
- **60–75:** Strong impact
- **75–90:** Very strong impact
- **90–100:** Excellent impact

This scale provides an interpretable mapping between quantitative results and qualitative performance levels, while preserving the relative differences derived from the underlying KPI-based calculations.

### Sustainability Performance (59.2)

ADMIRAL achieved a positive sustainability result across the project portfolio. Quantified pilot evidence demonstrated greenhouse gas reductions, route optimisation gains, fuel substitution benefits, improved cargo utilisation, and reductions in operational inefficiencies. The portfolio average is moderated by the fact that some pilots focused more strongly on interoperability and ecosystem development than on direct emissions reductions. Overall, the sustainability dimension can be classified as **strong positive impact**.

### Maturity Performance (88.8)

Maturity represents ADMIRAL's strongest dimension. Multiple solutions reached TRL 7–8, several tools were validated in real operational settings, and numerous components demonstrated readiness for deployment. This is a particularly strong outcome for a Horizon Europe innovation project, where moving solutions from concept stage to operational readiness is a key objective. The maturity dimension can therefore be classified as **excellent impact**.

### Transferability Performance (82.1)

ADMIRAL also achieved very strong transferability performance. This reflects the modular and interoperable nature of many project outputs, including marketplace architecture, integration services, eCMR functionality, data exchange tools, and reusable CO<sub>2</sub> methodologies. These results indicate that several ADMIRAL innovations can be replicated beyond the original pilot environments. The transferability dimension can be classified as **very strong impact**.

### Comparative Interpretation

The relative strength of the three dimensions is summarised in Table 13.

**Table 13: Relative project performance**

Dimension	Score	Relative Position
Sustainability	59.2	Good
Maturity	88.8	Highest
Transferability	82.1	Very High

The results show that ADMIRAL’s strongest project-wide legacy lies in the creation of mature and scalable digital logistics assets, while sustainability gains are strong but more heterogeneous across pilots.

### Portfolio Complementarity

A major finding of the assessment is that ADMIRAL should be understood as a portfolio innovation project.

At pilot level, different demonstrators generated different forms of value. Slovenia–Croatia was the strongest balanced performer, Finland was the sustainability leader, Portugal–Spain demonstrated strong integration capability, and Lithuania led in transferability.

At solution level, planning tools and emissions tools generated direct operational benefits, while marketplace, eCMR, and integration services created the enabling ecosystem for future scaling.

This complementarity significantly increased the total value created by the project.

### Final Overall Outcome Statement

ADMIRAL can be classified as a high-performing European innovation project with a final overall impact score of:

*72.1/100*

This classification is based on the standardised 0–100 scoring framework applied in this deliverable and its interpretation through a qualitative impact scale grounded in multi-criteria decision analysis (MCDA) and performance benchmarking practices (e.g. Keeney & Raiffa; OECD evaluation frameworks; European Commission impact assessment guidelines). Within this context, a score above 70 indicates a strong overall impact, reflecting consistent performance across multiple evaluation dimensions.

The project’s strongest legacy lies in the delivery of mature, interoperable, and transferable logistics solutions, supported by meaningful sustainability improvements across multiple operational contexts. As demonstrated throughout the assessment, ADMIRAL successfully combines measurable operational benefits with high levels of deployment readiness and replication potential, confirming its contribution to the digital and green transition of European freight transport systems.

## Final Classification

Table 14: Final ADMIRAL Classification Table

Dimension	Score	Classification
Sustainability	59.2	Moderate to strong
<b>Maturity</b>	88.8	Very strong to excellent
<b>Transferability</b>	82.1	Very strong
<b>Overall Impact</b>	72.1	Moderate to strong (high-performing)

As shown in Table 14, the sustainability dimension (59.2) falls at the upper end of the moderate range, approaching strong performance, which reflects meaningful but uneven gains across pilots due to differing strategic focuses. In contrast, maturity (88.8) reaches the boundary between very strong and excellent impact, confirming that several solutions achieved advanced deployment readiness. Transferability (82.1) is firmly within the very strong range, demonstrating high scalability potential supported by interoperable and modular solution design.

The overall score (72.1) positions ADMIRAL within the moderate-to-strong impact range, justifying its classification as a high-performing project, particularly when considering the balanced contribution across all three dimensions and the diversity of pilot contexts.

The final portfolio-level assessment demonstrates that ADMIRAL successfully combined measurable sustainability gains with advanced deployment maturity and high replication potential. The project therefore provides convincing evidence that digital innovation, multimodal coordination, and interoperable logistics tools can jointly accelerate the transition towards more efficient and low-emission freight transport systems across Europe.

## 7 Transferability of Results

The objective of this chapter is to assess the extent to which the ADMIRAL results can be replicated, adapted, and scaled beyond the original pilot environments. While the previous chapters examined performance within the pilots and across the solution portfolio, the present chapter focuses on the longer-term strategic question of diffusion: whether the benefits demonstrated during the project can be transferred to other logistics environments across Europe.

Transferability is a critical dimension of success for innovation actions in freight transport. Demonstration projects often prove that a solution can function under specific local conditions; however, their broader value depends on whether similar results can be reproduced in other terminals, ports, urban freight systems, cross-border corridors, and multimodal supply chains. In this sense, transferability converts project outcomes into European added value.

Within the ADMIRAL framework, transferability is defined as the capacity of a solution to be technically deployable in another environment, operationally usable by other actors, economically feasible to replicate, interoperable with existing systems, regulatorily compatible across jurisdictions, and scalable over time. The chapter therefore addresses four analytical questions. First, which ADMIRAL solutions demonstrate the strongest replication potential? Second, under which enabling conditions

can transfer succeed? Third, which barriers still constrain wider deployment? Fourth, what practical scale-up pathways emerge from the evidence?

## 7.1 Methodological Basis

Transferability was assessed through the Logistics Transferability Index (LTI), introduced in Deliverable D6.1 and applied in the final assessment model. Because transferability is inherently multidimensional, the index combines several criteria reflecting technical, organisational, and market readiness factors.

The weighting structure applied in this section is derived directly from the KPI prioritisation and stakeholder validation process described in Deliverable D6.1, including the consortium workshops conducted during the General Assembly (May 2024). These weights reflect the relative importance assigned by project partners and domain experts to different aspects of transferability, ensuring consistency with the overall ADMIRAL impact assessment framework.

As seen in Table 15, five criteria were retained for the final evaluation:

**Table 15: Methodology Criteria and Weights**

Criterion	Weight
API / System Integration Capability	25%
Standards and Interoperability Readiness	20%
Replicability Across Sites	20%
Deployment Readiness	20%
Ecosystem Fit / Stakeholder Usability	15%

The resulting index is expressed as:

$$LTI = (0.25).A + (0.20).B + (0.20).C + (0.20).D + (0.15).E$$

where *A* to *E* correspond to the five criteria above. Scores are reported on a 0–100 scale.

The weighting logic gives greatest importance to integration capability because fragmented digital environments remain one of the main barriers to innovation uptake in logistics. Standards readiness, replicability, and deployment maturity receive equal secondary importance, while ecosystem fit captures the practical usability of solutions by end users and stakeholders.

The scoring process relied on documented project evidence rather than speculative judgment. Sources included achieved pilot integrations, TRL maturity progression, API connectivity evidence, modularity of solution architectures, compatibility with digital standards, stakeholder usability findings, and observed applicability across more than one pilot context.

To ensure transparency and traceability, the detailed scoring of each criterion and the corresponding indicator-level assessments used in the LTI calculation are provided in Annex 1, where individual scores, normalisation results, and aggregation steps are documented. This allows full verification of how the final transferability scores were derived.

This mixed evidence base is methodologically appropriate because transferability cannot be captured through operational KPIs alone. Many scalable innovations create value through architecture, standardisation, and network effects rather than through a single numerical metric.

## 7.2 Solution-Level Transferability Ranking

The final solution-level ranking reveals a clear pattern: the most transferable ADMIRAL outcomes are primarily digital backbone solutions that enable interoperability, coordination, and administrative simplification.

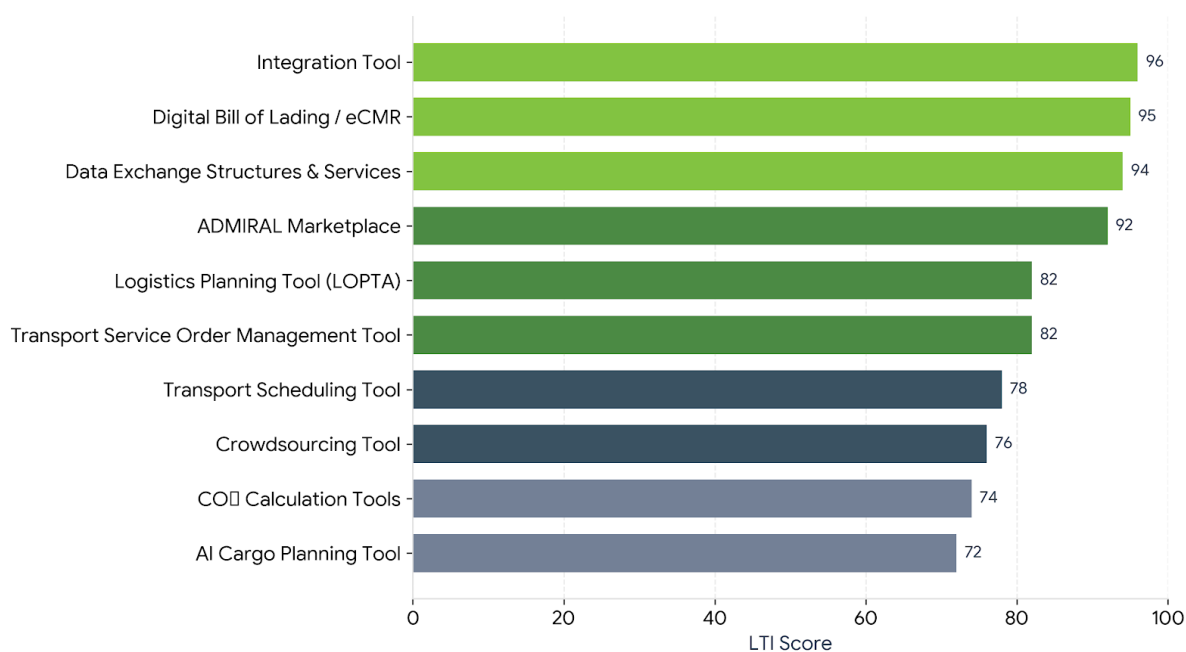


Figure 12 : Solutions Transferability Analysis

Figure 12, Horizontal bar chart presenting the Logistics Transferability Index (LTI) scores of the principal ADMIRAL solutions. Scores are expressed on a 0–100 scale and derived from the weighted transferability model combining system integration capability, standards/interoperability readiness, replicability across sites, deployment readiness, and ecosystem usability.

The ranking demonstrates that the highest transferability is associated with modular tools that can plug into many logistics ecosystems with relatively limited local adaptation. By contrast, tools dependent on site-specific workflows, advanced data maturity, or local operating logic tend to score lower despite potentially high direct value.

This distinction is strategically important: the solutions most likely to scale across Europe are not always those generating the strongest short-term pilot KPIs, but those that remove structural frictions across fragmented logistics networks.

The distribution of LTI scores reveals a strong and statistically coherent transferability profile across the ADMIRAL solution portfolio. All assessed solutions score above 70/100, indicating that no solution can be considered low-potential from a replication perspective. This is an important result because it suggests that ADMIRAL did not generate isolated pilot prototypes only, but rather a portfolio of outputs with broad post-project applicability.

Scores above 90 demonstrate exceptionally strong transferability. In particular, the top-performing solutions—Integration Tool (96), Digital Bill of Lading / eCMR (95), and Data Exchange Structures and Services (94)—form a leading cluster of highly scalable innovations. Scientifically, this indicates that solutions creating network connectivity, interoperability, standardisation, and coordination mechanisms are more scalable than tools optimising only one local process. This finding is consistent with diffusion theory in logistics systems: infrastructure-enabling innovations tend to scale faster than site-specific operational innovations because they address common structural bottlenecks across multiple organisations simultaneously.

The score range extends from 72 to 96, producing a total spread of 24 points. This indicates meaningful differentiation among solutions while preserving consistently positive performance across the portfolio. In innovation assessment terms, such a range is desirable: it is wide enough to identify priorities for exploitation, yet narrow enough to show overall quality consistency.

The strongest replication potential lies in technologies that combine interoperability, standardisation, immediate business usefulness, and low dependence on local physical infrastructure. This indicates that ADMIRAL’s long-term European impact is likely to exceed the boundaries of the original pilots through broader market diffusion of its enabling digital assets.

## 7.3 Interpretation of the Transferable Solutions

### 7.3.1 Tier I – Highest Transferability

The Integration Tool achieved the highest score because it directly addresses one of the largest barriers to logistics innovation: the coexistence of multiple legacy systems with limited interoperability. Its connector role between existing software environments and new digital services gives it strong relevance across a wide variety of operational contexts. Since many logistics actors need integration before adopting more advanced tools, this solution has particularly strong market potential.

The Digital Bill of Lading / eCMR ranked second. Its high score reflects the universal relevance of paperless documentation, administrative efficiency, transparency, and alignment with ongoing European digitalisation efforts. Unlike many specialised operational tools, digital documentation solutions are useful to carriers, shippers, terminals, freight forwarders, and public authorities simultaneously. Their value therefore increases as adoption spreads.

Data Exchange Structures ranked third because they support harmonised data flows across otherwise fragmented actors. These solutions are platform-neutral, scalable, and future-oriented. Their strategic significance is high because many later-stage optimisation and sustainability tools depend on reliable shared data foundations.

The ADMIRAL Marketplace ranked fourth. Its transferability derives from a modular platform model, reusable service catalogue logic, and relevance for fragmented freight markets where capacity matching, visibility, and multimodal coordination remain weak. Marketplace logic is especially promising in corridor environments and regions with dispersed logistics demand.

### 7.3.2 Tier II – Strong Transferability

The Logistics Planning Tool and Order Management Tool both achieved strong transferability scores. Their practical value is clear, but replication depends more heavily on process discipline, internal management commitment, and the existence of sufficient operational data.

The Scheduling Tool also performed positively, particularly for ETA-sensitive chains, congestion-prone corridors, and dynamic dispatch environments. However, implementation typically requires integration with real-time operational systems and stable planning processes.

### 7.3.3 Tier III – Conditional Transferability

The Crowdsourcing Tool remains promising but more context-dependent. Its replication depends on labour market conditions, local regulation, density of demand, and consumer acceptance of crowd-logistics models.

CO<sub>2</sub> Calculation Tools are broadly relevant across Europe, yet their effective use depends on data quality, methodology alignment, and integration with enterprise systems. Their lower relative score does not indicate weak strategic value; rather, it reflects dependence on wider organisational data maturity.

AI Cargo Planning demonstrates long-term promise but currently faces higher barriers linked to training data requirements, integration complexity, terminal-specific workflows, and organisational trust in algorithmic decision support.

## 7.4 Transferability Conditions

### 7.4.1 By Solution Type

The evidence suggests that transferability depends strongly on solution category.

Digital platform solutions such as the Marketplace, Integration Tool, and Data Exchange Services require API access, governance clarity, trusted data-sharing arrangements, cybersecurity readiness, and sufficient user participation. Their technical scalability is high, but ecosystem governance is decisive.

Operational optimisation solutions such as Planning, Scheduling, and AI Cargo Planning depend more strongly on data quality, management sponsorship, workflow discipline, staff capability, and willingness to redesign existing processes.

Standardisation-oriented solutions such as eCMR, CO<sub>2</sub> methodologies, and Order Management tools depend on legal recognition, harmonised procedures, partner alignment, and integration with documentation or ERP systems.

This means that successful replication strategies should be tailored to the type of innovation rather than treating all solutions identically.

### 7.4.2 Pilot-Level Insights

To support interpretation, transferability scores (LTI) are classified into qualitative tiers based on the standardised 0–100 scale used throughout this deliverable. The following ranges are applied:

- **Tier I (90–100): Very high transferability** – solutions or pilots with strong scalability, interoperability, and minimal contextual constraints,
- **Tier II (75–90): High transferability** – solutions or pilots with strong replication potential, subject to moderate adaptation,
- **Tier III (60–75): Moderate transferability** – solutions or pilots with replication potential dependent on specific conditions or contexts, and
- **Below 60: Limited transferability** – solutions requiring significant adaptation or facing structural constraints.

Pilot-level results also provide important evidence on different replication models (Table 16).

**Table 16: Pilot Site and Transferability Characters**

Pilot	LTI	Transferability Character	Tier
Lithuania	91.3	Strongest digital replication model	Tier I
Portugal–Spain	84.1	Strongest corridor/platform integration model	Tier II
Slovenia–Croatia	79.1	Strongest operational deployment model	Tier II
Finland	65.8	Strongest specialised terminal-use model	Tier III

Lithuania’s leading score reflects the strong modularity and interoperability of its digital solution set. Portugal–Spain demonstrates the transferability of cross-border platform and service-catalogue logic. Slovenia–Croatia shows the value of practically proven deployable tools. Finland’s more specialised profile reflects stronger dependence on terminal conditions and fuel-transition context.

These results confirm that transferability can emerge through different pathways: digital modularity, corridor coordination, operational readiness, or specialised niche excellence.

## 7.5 Wider Deployment & Strategy

Despite the strong transferability profile of ADMIRAL, several barriers remain typical of the European logistics market. Technical barriers include legacy systems lacking APIs, fragmented data formats, cybersecurity concerns, weak master data quality, and limited digital capacity among SMEs. Organisational barriers include resistance to process change, insufficient digital skills, unclear ownership models, and absence of internal champions capable of leading transformation. Economic barriers include upfront integration costs, uncertain perceptions of return on investment, fragmented buyer markets, and limited investment capacity among smaller operators. Regulatory barriers include uneven recognition of digital documents, cross-border procedural differences, uncertainty around data governance, and labour regulation constraints relevant to crowd-logistics models. These barriers are not specific weaknesses of ADMIRAL. Rather, they define the practical conditions under which future exploitation must occur.

The evidence supports a phased scale-up pathway. In the short term (0–2 years), the strongest immediate candidates are eCMR solutions, Integration Tools, CO<sub>2</sub> reporting tools, and Marketplace modules.

These combine relatively high maturity with broad market relevance. In the medium term (2–5 years), Logistics Planning Tools, Scheduling Tools, Order Management solutions, and wider Data Exchange networks are likely to grow as organisational digital readiness improves. In the longer term (5+ years), AI Cargo Planning, large-scale crowdsourcing ecosystems, and increasingly autonomous decision-support systems may become more viable as richer data environments and organisational trust mature. This phased sequence is consistent with technology diffusion logic: foundational interoperability tools scale first, optimisation layers follow, and advanced intelligence systems emerge later.

### Table Final Classification

To ensure consistency in the qualitative interpretation of transferability outcomes, the following classification scale—based on the standardised 0–100 LTI scores—is applied to solution categories:

- **90–100:** Excellent transferability
- **75–90:** Very strong transferability
- **60–75:** Strong transferability
- **50–60:** Medium–high transferability
- **Below 50:** Moderate to limited transferability

This scale allows grouping individual solution scores into broader categories reflecting their overall replication potential (Table 17).

**Table 17: Final Classification**

Category	Outcome
<b>Digital Backbone Solutions</b>	Excellent Transferability
<b>Operational Tools</b>	Strong Transferability
<b>AI / Specialised Tools</b>	Medium–High Transferability
<b>Overall Project Transferability</b>	Very Strong

The transferability analysis demonstrates that ADMIRAL’s strongest European legacy lies in its digital backbone solutions rather than only in isolated pilot tools. The most scalable value resides in integration capabilities, standardised digital documentation, interoperable data exchange, marketplace coordination logic, and reusable emissions methodologies. Operational tools also show significant promise, but generally require stronger local adaptation and organisational readiness. This reinforces an important policy lesson: the most scalable logistics innovations combine standardisation, interoperability, modular deployment, and clear business value.

The ADMIRAL solutions with the highest transferability potential are the Integration Tool, eCMR / Digital Bill of Lading, Data Exchange Structures, and the Marketplace. Optimisation and AI-based tools remain highly promising, but their successful replication depends more strongly on local operational readiness, data quality, and organisational change capability. Overall, ADMIRAL leaves a strong European replication legacy built on interoperable, modular, and scalable logistics innovation.

## 8 Recommendations

The final assessment of ADMIRAL shows that the project generated a portfolio of mature, interoperable, and transferable logistics innovations with demonstrated relevance for more sustainable and digitally connected freight transport. At the same time, the evidence collected across pilots, stakeholder interviews, questionnaires, and implementation datasets also confirms that successful project results do not automatically translate into market uptake. Replication beyond pilot environments depends on deployment readiness, business incentives, integration capacity, regulatory alignment, and the willingness of organisations to redesign operational processes.

For this reason, the present chapter translates the analytical findings of the previous chapters into practical recommendations. The objective is not only to identify what ADMIRAL achieved, but also to indicate how the most valuable results can be exploited after project closure. Recommendations are therefore structured around five complementary dimensions: operational deployment, replication and scale-up, business uptake, interoperability and data governance, and policy support. In addition, specific attention is given to the exploitable results that demonstrate the highest post-project commercial or strategic value.

The recommendations below are grounded in the evidence base of D6.2, the pilot demonstrations, the solution-level assessment, the transferability analysis, and stakeholder feedback collected throughout WP6.

### 8.1 Recommendations for Operational Deployment

A first priority after project completion should be the structured deployment of those solutions that already demonstrated high maturity and operational usefulness during the pilots. Several ADMIRAL outputs reached late-stage readiness levels and therefore require commercialisation pathways rather than further conceptual development.

In practical terms, the Integration Tool, eCMR / Digital Bill of Lading functions, Marketplace modules, CO<sub>2</sub> calculation tools, and selected planning tools should move rapidly toward real customer deployment. These solutions already demonstrated either direct operational value or strong enabling value for digital logistics ecosystems.

Deployment should follow a staged approach. Initial commercial roll-out is likely to be most successful with organisations that already possess moderate digital readiness and clear pain points such as fragmented data exchange, manual documentation processes, empty mileage, or reporting obligations related to emissions. Early adopters can then provide references, additional case evidence, and business credibility for wider expansion.

At the same time, deployment strategies should avoid the common mistake of presenting tools as stand-alone technologies. The evidence from ADMIRAL shows that solutions generate stronger value when embedded into workflows, connected to existing systems, and supported by change management. Therefore, implementation packages should combine software deployment with onboarding, training, process redesign, and performance monitoring.

## 8.2 Recommendations for Replication and Scale-Up

The project results indicate that ADMIRAL should not be replicated as one fixed pilot package. Instead, the most effective pathway is modular replication, where individual solutions or bundles of solutions are transferred according to local needs.

For example, cross-border corridor environments may benefit most from Marketplace services, Integration Tools, and Order Management solutions. Port or terminal environments may prioritise planning tools, scheduling tools, ETA functions, and emissions modules. Administrative bottlenecks may be addressed through eCMR and digital documentation packages. Urban logistics ecosystems may find stronger value in crowdsourcing and dynamic optimisation tools.

Replication should therefore begin with diagnostic assessments of local maturity, data availability, organisational capability, and ecosystem structure. Solutions should then be selected accordingly rather than copied mechanically from original pilots.

The evidence also suggests that digital backbone solutions scale faster than highly customised operational tools. For this reason, post-project exploitation should prioritise reusable components such as integration layers, API connectors, data exchange structures, and documentation standards before more advanced AI or bespoke optimisation tools.

A phased replication strategy is recommended:

- **Short term (0–2 years):** Integration Tool, eCMR, CO<sub>2</sub> reporting tools, Marketplace modules
- **Medium term (2–5 years):** Planning tools, scheduling tools, Order Management, data exchange networks
- **Long term (5+ years):** AI cargo planning, advanced autonomous decision-support tools, scaled crowdsourcing ecosystems

## 8.3 Recommendations for Business Uptake and Exploitable Results

ADMIRAL generated several exploitable results with clear post-project market potential. These results should now be managed through targeted business development rather than remaining framed only as research outputs.

The **Integration Tool** is among the strongest commercial assets because system interoperability remains a structural challenge in freight transport. A connector solution capable of linking legacy TMS, ERP, port community systems, and new digital services address a widespread market need.

The **Digital Bill of Lading / eCMR solution** also represents a high-value exploitable result. As regulatory and market pressure for paperless logistics increases, documentation digitalisation offers immediate cost savings, transparency gains, and faster transactions.

The **ADMIRAL Marketplace** has exploitation potential where transport markets remain fragmented and underutilised capacity exists. The commercial model should focus on sectors where coordination inefficiencies are costly and where network effects can be built gradually.

The **CO<sub>2</sub> Calculation Tools** are strategically timely because many operators now face ESG disclosure requirements, Scope 3 reporting expectations, and customer pressure for emissions transparency. This makes emissions intelligence tools commercially relevant beyond the ADMIRAL pilots.

The **Planning and Scheduling Tools** also have exploitable value, particularly where routing complexity, congestion exposure, or multimodal coordination needs are significant.

To maximise business uptake, partners should convert technical assets into clear market propositions. Buyers typically purchase solutions to reduce cost, improve service levels, meet compliance requirements, or solve coordination problems—not to acquire innovation for its own sake. Commercial messaging should therefore focus on measurable value propositions rather than technical functionality alone.

Where appropriate, consortium partners should also consider licensing models, Software-as-a-Service approaches, strategic partnerships, white-label deployment, or integration into existing commercial product portfolios.

## 8.4 Recommendations for Interoperability and Data Governance

One of the strongest lessons from ADMIRAL is that interoperability is not an optional feature; it is a prerequisite for scalable logistics innovation. Many otherwise promising tools fail commercially because they cannot connect efficiently with incumbent systems or because data governance arrangements remain unclear.

Future deployment should therefore prioritise open APIs, modular architectures, reusable data connectors, and standardised data dictionaries wherever possible. Solutions that remain closed or highly proprietary may secure short-term contracts but are less likely to scale widely across fragmented European logistics networks.

Governance is equally important. Successful digital ecosystems require clear agreements regarding data ownership, access rights, cybersecurity responsibilities, liability allocation, and performance accountability. These issues should be addressed contractually during deployment rather than postponed until after technical roll-out.

The evidence also suggests that SMEs require simplified integration pathways. Many smaller operators lack internal IT teams capable of managing complex onboarding processes. Lightweight connectors, managed services, and standardised onboarding kits would significantly improve adoption potential.

## 8.5 Recommendations for Policy and Public Support

Several ADMIRAL results align strongly with broader European policy objectives, particularly decarbonisation, digitalisation, modal integration, and supply-chain resilience. Public support can therefore play an important role in accelerating post-project uptake.

First, policymakers should continue promoting recognition and harmonisation of digital freight documentation such as eCMR. Regulatory consistency across Member States would materially reduce barriers to adoption.

Second, public programmes supporting SME digitalisation should explicitly include logistics integration, emissions reporting, and interoperability tools. Smaller operators often face the greatest adoption barriers despite potentially large efficiency gains.

Third, procurement and funding schemes should reward interoperable and standards-based solutions rather than isolated proprietary systems. This would strengthen ecosystem-wide innovation rather than fragmenting the market further.

Fourth, public authorities managing ports, terminals, and corridors can act as anchor adopters by incorporating ADMIRAL-type tools into logistics nodes where coordination failures are concentrated.

Finally, future research and innovation calls should continue supporting real-life pilot environments that combine digital innovation with measurable operational KPIs. ADMIRAL demonstrated the value of this model.

## 8.6 Final Strategic Recommendation

The end of the project should be treated as the beginning of exploitation rather than the end of activity. Consortium partners are encouraged to map ownership, maturity, commercial readiness, and strategic fit for each exploitable result. Where a solution already has a clear owner and market route, the next step should be sales pipeline development.

Where ownership is shared or unclear, exploitation governance should be resolved rapidly.

Where solutions are valuable but incomplete, targeted post-project refinement should focus only on the remaining barriers to commercial readiness.

Partners should also preserve the consortium network as a business ecosystem. Several ADMIRAL assets become more valuable when combined. This is the case, for example of the following set: Marketplace + Integration + CO<sub>2</sub> Tools, or Planning + Scheduling + Data Exchange. Joint exploitation packages may therefore outperform isolated offers.

The evidence also highlights several risks that require active management. Technically strong solutions may remain underutilised if not translated into market-ready products, while fragmented ownership can slow exploitation. In addition, excessive customisation may reduce interoperability, and complex or costly onboarding processes may limit SME participation. These risks can be mitigated through clear commercial packaging, defined governance structures, adherence to standardisation, and simplified deployment pathways.

ADMIRAL should be positioned externally not as a closed project result, but as a scalable portfolio of European logistics solutions aligned with the digital and green transition. The strongest long-term value lies in combining mature operational tools with digital backbone assets that enable ecosystem-wide coordination.

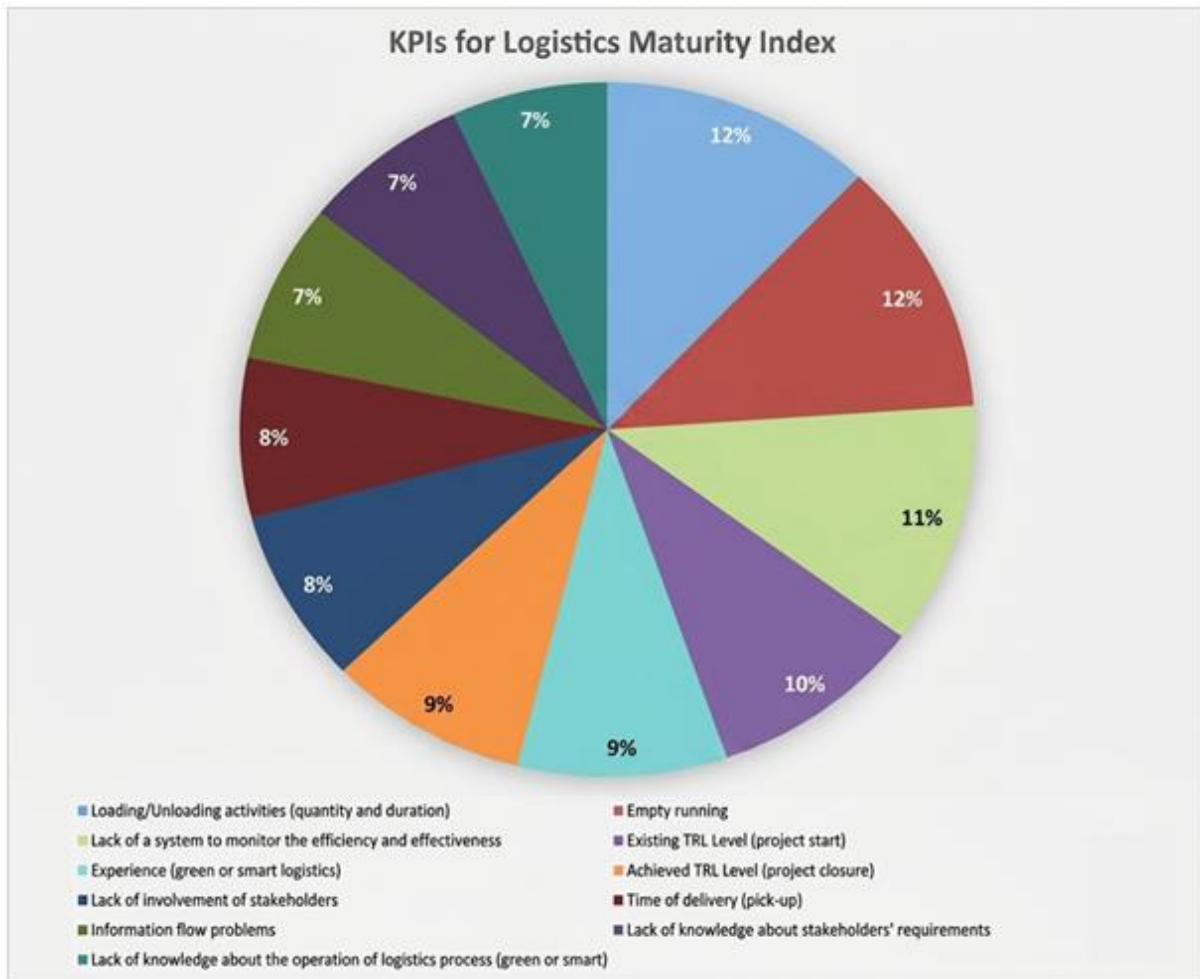
The project demonstrated that sustainable freight innovation becomes commercially viable when four elements are combined: measurable business value, interoperability, deployability, stakeholder trust, and collaboration across the supply chains. Post-project exploitation strategies should therefore be built around these four principles.

The recommendations of this chapter show that ADMIRAL has clearly progressed beyond proof-of-concept status (TRL 3–4) towards advanced validation and deployment stages (TRL 7–8). Several outputs have reached a level of maturity suitable for real operational use, while many others demonstrate high transferability potential across different logistics contexts. The broader portfolio aligns strongly with European transport priorities.

If supported by targeted exploitation, partnership continuity, and policy alignment, ADMIRAL can continue generating value well beyond the formal end of the project through wider market uptake, replication across logistics ecosystems, and contribution to a more sustainable and digitally integrated European freight system.



**KPI Prioritization List for Logistics Maturity Index**



**KPI List for Logistics Maturity Index**

- 
- Stakeholder awareness and acceptance level (survey score)

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  - Willingness to adopt and use ADMIRAL solutions (before/after)**

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  - Change in user perception of service efficiency and sustainability**

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  - Resilience of solutions based on stakeholder feedback**

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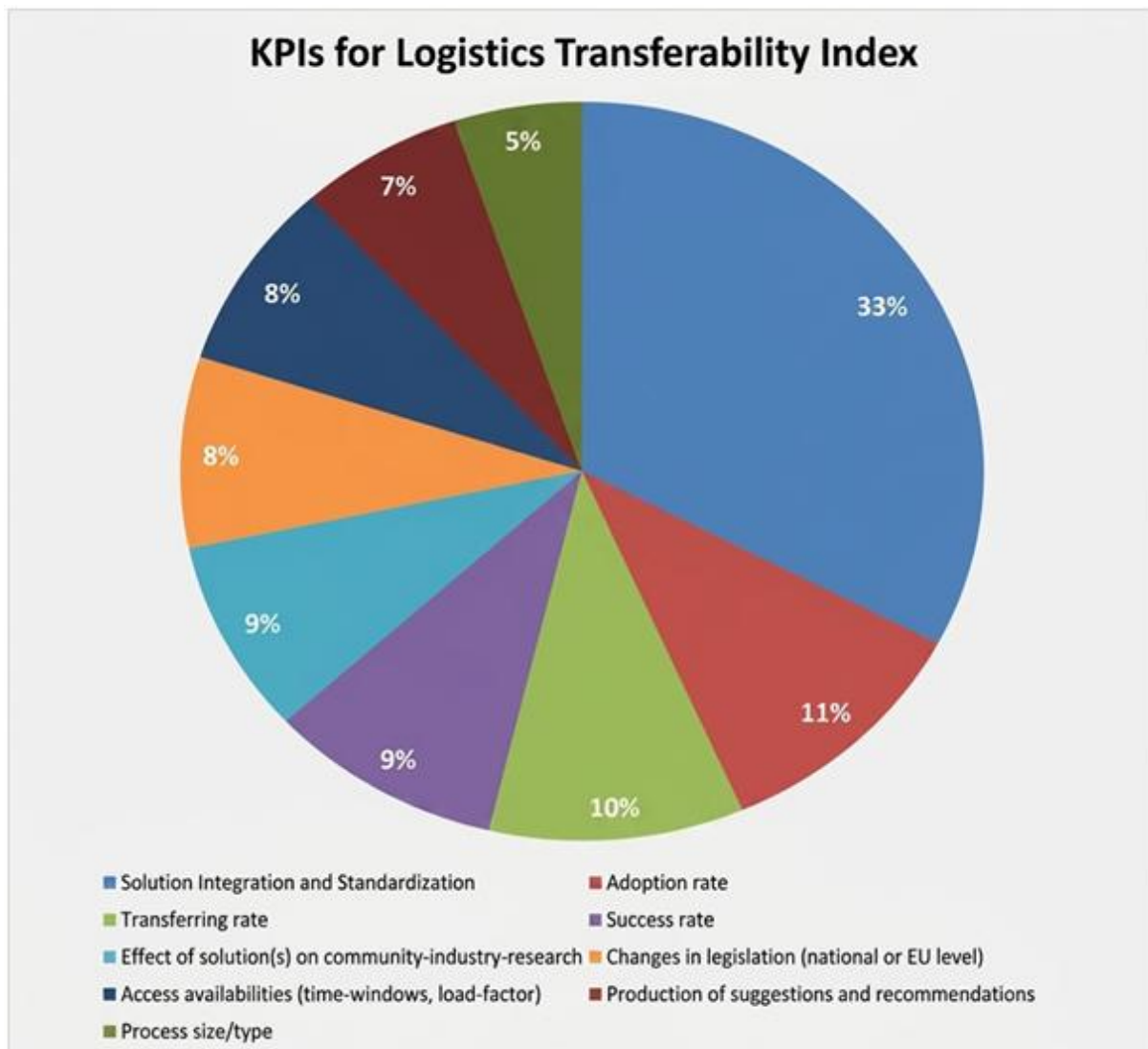
  - Level of usability and availability scored by stakeholders (1–5 scale)**

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  - Monthly trend analysis of stakeholder sentiment during pilots**

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**KPI Prioritization List for Logistics Transferability Index**



**KPI List for Logistics Transferability Index**

- New business models identified based on pilot results
- **Jobs or roles impacted by ADMIRAL solutions (quantitative)**
- Equity issues and digital barrier assessments conducted
- Number of new skill/training needs identified
- Impacts on land use, urban space, and operational costs
- Economic fairness assessed across stakeholders