D3.6 Optimal design selected for 6 S2Z novel concepts

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Deliverable information sheet

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Executive summary

Project summary

Shift2Zero, Shifting to zero-emission logistics through right-sized, mission-focused, N1 e-LCVs

Current market dynamics in the EU reveal a gap between supply - existing N1 vehicles, and demand - evolving needs of urban logistics and climate targets. In 2023, 1.2M new Light Commercial Vehicle (LCV) registrations were diesel-powered, and only 108,200 battery electric. Last-mile logistics, the least efficient and most complex part of the supply chain, presents significant opportunities for improvements at vehicle and operations levels. Dynamic requirements and increasing environmental impact require innovative solutions from the automotive industry, both from high volume Original Equipment Manufacturer (OEM)s and new entrants. Shif2Zero (S2Z) aims to capitalize on the benefits of both vehicle platforms in the N1 segment - represented by IVE's eDaily multipurpose platform, and ALK's ATX design-for-purpose platform - ultimately contributing to "Shifting to zero-emission logistics through right-sized, mission-focused, N1 e-LCVs".

To achieve this vision, S2Z proposes a 4-step user- and mission-centric design approach placing end-users and their needs at the core of all project activities. To this end, S2Z involves 5 Logistic Service Provider (LSP)s & mobility operators as partners: GRU, DHL, DIA, CLE, DPD. As a result, S2Z will co-develop and shape at least 6 novel N1 concepts with enhanced and safe functionalities leading to tighter market fit, particularly in the segments of e-commerce, returns and cold deliveries.

Innovative concepts, from modular cargo bodies to vehicle control strategies with optimized tyres & brakes, as well as dual transport of people & freight, will be physically prototyped and tested in real-life operations in 6 pilot sites (Belgium, Greece, Italy, 2 in Norway, Poland).

S2Z brings a multidisciplinary consortium of 30 partners from 10 countries to cover the complete automotive and logistics value chains, complemented by policymakers to effectively ensure route to market: overcoming barriers for the adoption of S2Z eLCVs, reducing operational costs and environmental impact in scalable urban & suburban operations.

D3.6 Executive summary

S2Z develops user- and mission-centred N1 (e)LCV concepts intended to respond to evolving urban and suburban logistics needs. Within the project methodology, WP2 identifies and translates end-user needs into technical requirements, while WP3 operationalises these requirements into vehicle designs, configurations, functionalities and control strategies to be subsequently prototyped, integrated and validated in WP4.

Deliverable D3.6 consolidates the work performed in WP3 and presents the optimal designs selected for the six S2Z novel concepts. It brings together the design-assessment framework developed in task T3.1 and the technical developments carried out in tasks T3.2, T3.3, T3.4 and T3.5, covering energy management and component optimisation, vehicle safety and ergonomics, modular and multipurpose cargo-body solutions, and vehicle-control strategies for improved energy efficiency and reduced tyre and brake emissions.

The deliverable focuses on the design decisions defining the configurations transferred to WP4. For each concept, it describes the user need addressed, the innovations developed within WP3, the main design alternatives or iterations considered, the outcome of the corresponding design assessments, the selected solution and its rationale, and the expected integration into the relevant vehicle prototype. Detailed or commercially sensitive technical information remains in the corresponding technical deliverables and controlled assessment reports.

Main results

The main result of WP3 is the definition of the selected design baseline for the six S2Z concepts and its translation into a coherent package for prototyping and integration in WP4. The work performed during WP3 has:

- *Applied the common T3.1 assessment framework to support structured and traceable design decisions*
- *Consolidated the main technical developments and innovations produced across T3.2 to T3.5 tasks*
- *Compared relevant design alternatives using the D3.1 assessment criteria, supported by technical, operational, safety and integration evidence*
- *Identified the selected configurations and the evidence supporting their selection*
- *Defined the interfaces and dependencies between the selected innovations and the target IVE and ALK vehicle platforms*
- *Distinguished the work completed and assessed in WP3 from the physical integration and vehicle-level validation to be carried out in WP4*
- *Established traceability between the design assessments, the alternatives or design versions evaluated, the WP3 innovations and the corresponding project Key Performance Indicators (KPI)s*

Two design assessments relating to the materials selected for the multipurpose cargo-body partitions and for the swap box were completed within T3.4 and documented in the technical annexes to D3.4. The remaining assessments address the cabin configuration with and without insulation, the position of e-bike batteries within the vehicle, the materials and manufacturing methodologies for the new door trim, the retractable second-row seat options, and the Human-Machine Interface (HMI) options based on the holistic energy-management models developed in T3.5. Their approved public outcomes are incorporated into D3.6, while the complete assessment matrices and sensitive technical evidence remain in the corresponding controlled documents.

Relevant differences from the Grant Agreement

During WP3, two relevant design evolutions were introduced with respect to the baseline described in the Grant Agreement (GA). These changes respond to updated technical and operational evidence and do not alter the overall objectives of WP3 or the intended functionality of the corresponding S2Z concepts.

First, the dual-transport concept was adapted from the 6-seater configuration described in the original proposal to a 4-seater configuration with a retractable second row. This change followed input from ALK, which identified the 4-seater layout as more representative of commonly used vehicle configurations and better aligned with existing vehicle architectures and potential applications. The revised design preserves the original objective of dynamically adapting passenger and cargo capacity to different operational requirements.

Second, the bidirectional-charging use case was changed following the replacement of InPost by DPD as logistics partner. The original proposal envisaged supplying energy from the vehicle to off-grid Automated Parcel Machines (APM). The revised use case focuses on supplying electric cargo-bike batteries and therefore includes the assessment of alternative battery positions within the vehicle, considering available space, accessibility, integration and safety. This adaptation maintains the original objective of using the electric commercial vehicle as a mobile energy source for urban logistics operations.

Both changes are therefore considered implementation-level adaptations resulting from the iterative and user-centred design process established in WP3. Their implications for technical requirements, interfaces, prototype configuration and WP4 validation are explicitly documented in this deliverable.

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Terminology and Acronyms

(e)HDV	*(electric) Heavy Duty Vehicle*
(e)LCV	*(electric) Light Commercial Vehicle*
ABS	*Anti-lock Braking System*
AIT	*Austrian Institute of Technology*
API	*Application Programming Interface*
APM	*Automated Parcel Machine*
ALK	*Alkè Electric Vehicles*
BRE	*Brembo*
CAD	*Computer-Aided Design*
CER	*Centre for Research and Technology Hellas*
CFD	*Computational Fluid Dynamics*
COL	*Cold Car*
DHL	*DHL Express*
DIA	*DIAKINISIS Logistics Services*
DoE	*Design of Experiments*
EBD	*Electronic Brakeforce Distribution*
EC	*European Commission*
ePTO	*electric Power Take-Off*
EU	*European Union*
EUT	*Eurecat*
FEA	*Finite Element Analysis*
FEM	*Finite Element Modeling*
GA	*Grant Agreement*
GDPR	*General Data Protection Regulation*
GRU	*Gruber Logistics*
HBM	*Human Body Models*
HMI	*Human–Machine Interface*
HV	*High Voltage*
HVAC	*Heating Ventilation and Air Conditioning*
KPI	*Key Performance Indicator*
IDI	*Applus IDIADA*
IR	*Infrared*
IoT	*Internet of Things*
IRP	*Infrared Heating Panel*
IVE	*Iveco*
LCA	*Life Cycle Analysis*
LCC	*Life Cycle Costing*
LEZ	*Low Emission Zone*
LPIMOT	*Łukasiewicz Automotive Industry Institute*
LSP	*Logistic Service Provider*
LV	*Low Voltage*
MDS	*Mobility Data Specification*
MIC	*Michelin*

OEM	*Original Equipment Manufacturer*
OMF	*Open Mobility Foundation*
PAX	*Paxster*
PCM	*Phase Change Material*
PU	*Public*
PTC	*Positive Temperature Coefficient (of resistance)*
RWTH (IKA)	*Institute for Automotive Engineering – RWTH Aachen University*
S-LCA	*Social Life Cycle Assessment*
S2Z	*Shift2Zero*
SEN	*Sensitive*
SOTA	*State of the Art*
TCO	*Total Cost of Ownership*
TØI	*Institute of Transport Economics*
UVAR	*Urban Vehicle Access Regulations*
V2L	*Vehicle-to-Load*
VCU	*Vehicle Control Unit*
VIP	*Vacuum Insulation Panel*
VUB	*Vrije Universiteit Brussel*
WP	*Work Package*
ZEZ	*Zero Emission Zone*

1. Introduction

S2Z develops a new generation of user- and mission-centred N1 (e)LCV concepts designed to respond to evolving urban and suburban logistics needs. The project addresses the increasing demand for more flexible, energy-efficient, safe and sustainable vehicles capable of adapting to different operational scenarios, cargo requirements and urban mobility constraints. The proposed concepts combine developments at vehicle, component and system level, including energy management, thermal comfort, charging functionalities, safety and ergonomics, modular cargo-body solutions and vehicle-control strategies.

Within the overall S2Z methodology, WP2 identifies the relevant end-user and mission requirements and translates them into technical specifications and performance targets. WP3 then operationalises these requirements by developing and assessing alternative vehicle designs, configurations, components and functionalities. This work combines conceptual design, modelling, simulation, comparative studies, safety analysis, component optimisation and vehicle-integration considerations. The resulting solutions provide the technical basis for physical prototyping and vehicle integration in WP4, digital integration and simulation in WP5, and operational validation in WP6.

Deliverable D3.6 represents the final consolidation point of the WP3 design phase. It brings together the methodological framework developed in task T3.1 and the technical developments carried out in tasks T3.2, T3.3, T3.4 and T3.5 to present the selected design baseline for the six S2Z novel concepts. Rather than reproducing the detailed technical content of the preceding WP3 deliverables, D3.6 provides a cross-cutting view of how the different task results contribute to the final concepts and how the main design decisions were reached.

1.1 Objectives of the deliverable

The main objective of the deliverable D3.6 is to present the optimal designs selected for the six S2Z novel concepts and to demonstrate the traceability of the corresponding design-selection process. The deliverable connects the initial user and mission requirements with the technical developments undertaken in WP3, the design alternatives or iterations evaluated, the evidence used in their assessment and the final configurations selected for transfer to WP4.

More specifically, D3.6 aims to consolidate the main developments and innovations produced across tasks T3.1 to T3.5, describe the design space explored for each concept and identify the principal alternatives and design versions considered. It summarises how the alternatives were assessed against the relevant D3.1 criteria (sustainability, modularity, circularity and user acceptance) using the available technical, operational, safety and integration evidence. The deliverable also records the public outcome of the relevant design assessments, identifies the option selected for each application and explains the rationale supporting the final decision.

A further objective is to provide a coherent view of how the individual WP3 innovations are combined within the six S2Z concepts and integrated into the target IVE and ALK vehicles. This includes identifying the relevant interfaces and dependencies between

components, vehicle systems, control strategies and operational use cases. D3.6 therefore acts as the main bridge between the design work completed in WP3 and the prototyping, integration and validation activities planned in WP4.

The deliverable also contributes to monitoring the project's technical progress by establishing traceability between the assessments carried out, the alternatives or design versions evaluated, the six project concepts and the applicable project KPIs. It distinguishes between evidence already obtained through design studies, modelling, simulation, comparative assessment or small-scale testing and the vehicle-level validation that remains to be completed in WP4.

As D3.6 is a public deliverable, it presents the information needed to understand the innovations, the comparative assessment process and the rationale for the selected configurations without disclosing commercially sensitive or proprietary information. Detailed assessment matrices, raw technical data, weighting factors, detailed geometries, manufacturing know-how, control parameters and other restricted information remain in the corresponding sensitive technical deliverables or controlled assessment reports.

1.2 Structure of the deliverable

Following this introductory section, Section 2 describes the WP3 design and selection methodology. It explains how the user and mission requirements generated in WP2 were translated into technical design decisions and how the common assessment framework developed in T3.1 was applied throughout WP3. This is not intended to provide an exhaustive description of the design methodology, which is already documented in Deliverable D3.1.

Section 3 summarises the technical developments undertaken in the tasks T3.2, T3.3, T3.4 and T3.5. It presents the main work performed in energy management and component optimisation, vehicle safety and ergonomics, swap box definition, multipurpose cargo-body design, cargo-hitching solution and vehicle-control strategies. The purpose of this section is to provide the technical context required to understand the final design decisions without duplicating the detailed content of deliverables D3.2, D3.3, D3.4 and D3.5.

Section 4 provides a consolidated overview of the WP3 innovation portfolio and its contribution to the six S2Z concepts. It also contains the registry of design assessments used to support the selection process, identifying their status, the number of alternatives or design versions evaluated and the location of the supporting technical evidence. This section highlights cross-task dependencies and shows how developments originating in different WP3 tasks are combined within the final concepts.

Section 5 constitutes the core of the deliverable. It presents the optimal design selected for each of the six S2Z novel concepts using a common structure. For every concept, it describes the relevant user need or target mission, the contributing WP3 innovations, the main design alternatives or iterations considered, the related design assessments, the public comparative outcome, the selected configuration, the rationale for selection, the supporting evidence and the expected transfer to WP4.

Section 6 consolidates the selected innovations at vehicle and prototype level. It maps the final WP3 solutions to the relevant IVE and ALK configurations, identifies their integration status at M22 and describes the critical interfaces, dependencies and remaining

validation activities. This section defines the design baseline and technical package transferred from WP3 to WP4.

Section 7 documents the relevant evolution of the selected designs with respect to the baseline described in the GA. It explains the main changes introduced during project implementation, the technical or operational reasons supporting them and their implications for vehicle integration, use-case implementation and WP4 validation.

Finally, Section 8 summarises the main conclusions of the WP3 design and selection phase, the readiness of the selected solutions for transfer to WP4 and the aspects that remain to be physically integrated or validated.

1.3 Relationship with previous and subsequent deliverables

The following table shows the relationship between the current deliverable and the previous and subsequent ones.

Table 1. Relationship with previous and subsequent deliverables

Deliverable	Title	Dissemination	Relation to D3.6
D2.5	Technical requirements and targets integrated for pilots	**PU**	Baseline requirements for WP3 design activities
D3.1	Design guidelines & framework for structured assessment	**PU**	Provides the assessment framework and design-selection logic
D3.2	Energy management & component optimisations	**SEN**	Detailed technical basis for energy, thermal, brake/tyre and charging innovations
D3.3	Safe and ergonomic system designs in cabin	**SEN**	Detailed technical basis for safety and ergonomic design decisions
D3.4	Modular and multipurpose cargo body designs	**SEN**	Detailed technical basis for multipurpose cargo-body, swap box and dual-transport solutions
D3.5	Vehicle control strategies integrating tyres & brakes	**SEN**	Detailed technical basis for control strategies and Digital Twin activities
D3.6	Optimal design selected for 6 S2Z novel concepts	**PU**	Consolidated public design baseline at the end of WP3
D4.x	WP4 prototyping, integration and testing deliverables	**PU/SEN**	Physical implementation and validation of the WP3 selected designs

2. WP3 design and selection approach

The design activities in WP3 are based on two complementary methodological foundations established in preceding project tasks. Deliverable D2.5 consolidated the user and technical requirements elicited in WP2 and thus defines what the S2Z innovations are expected to achieve. Deliverable D3.1 defined a common framework for the guidance and structured assessment of the S2Z innovations and thus provides orientation on how the quality and expected impact of different solutions can be evaluated. Both foundations are closely interrelated. Through their combined application, it is possible to support that the developed solutions are technically feasible and, at the same time, aligned with user needs and the overarching objectives of the project.

This section outlines how these inputs were operationalised within WP3 to translate user and mission needs into the technical configurations presented in the subsequent chapters. The underlying methodologies and detailed results are reported in D2.5 and D3.1 and are therefore not fully reproduced here.

2.1 Requirements baseline from WP2

D2.5 synthesised the empirical evidence gathered in WP2 by means of stakeholder interviews, two-stage workshops, discrete choice experiments, agent-based simulations, co-creation workshops, and structured consultations with the project partners. By combining these complementary methods, both the stakeholder perspectives, user preferences, and the operational requirements and implications of the logistics missions could be captured. This process yielded a consolidated set of 181 validated requirements spread across the six S2Z innovations. These requirements span the system, fleet and vehicle levels and address the social, political, economic and technical dimensions of the S2Z developments.

The requirements span the system, fleet and vehicle levels and address the social, political, economic and technical dimensions of the S2Z developments. All four dimensions were considered within WP3, although their relative relevance depended on the innovation and design decision concerned. The requirements were prioritised in discussions with innovation developers and OEMs using the Kano model. The resulting categories included must-be, one-dimensional and attractive requirements, reflecting their potential contribution to user satisfaction. Particular attention was given to the must-be requirements, as they represent essential user and operational needs, as well as to requirements that could be feasibly addressed within the scope and timeframe of WP3. This prioritisation informed the application of the requirements in the WP3 technical tasks, as described in Section 2.3.

In this context, the requirements formed the user- and mission-oriented baseline for WP3. They describe the expected functionalities, operational needs and constraints of the innovations and link them to the logistics missions and pilot applications considered in the project. This is essential because innovations that are not aligned with real operational conditions are unlikely to achieve acceptance in practice, regardless of their technical maturity. Within WP3, the requirements relevant to each development were translated into technical design objectives. These objectives were refined iteratively as engineering and integration evidence became available.

D3.6 does not reproduce the full requirements list. Instead, the relevant requirements and user needs are reflected in the design rationale and traceability information provided for each of the six concepts in Section 5.

2.2 Design guidelines and assessment framework

D3.1 complements the requirements baseline with a common framework for the structured development and assessment of vehicle concepts and innovations. The framework is built around four main criteria: sustainability, modularity, circularity and user acceptance. These are organised hierarchically into sub-criteria and a total of 52 individual criteria. Sustainability is divided into economic, environmental and social sustainability. Circularity is structured along the circular-economy strategies of narrowing, slowing and closing the loop. User acceptance covers fundamental and functional factors, social influence, ease of use, enjoyment and safety, and reflects the perspectives of both fleet managers and drivers.

The individual criteria were derived from three sources: a targeted literature review, user statements from the WP2 interviews and workshops, and expert input from consortium partners representing OEMs, logistics service providers, consultancies and research institutions. Each criterion is described in terms of its relevance and its contribution to the respective main criterion. This allows the criteria to be used directly as design guidelines during development.

For assessment, the framework provides a structured qualitative comparison of two alternatives. It is intended for two use cases: comparing alternative concepts or design variants that emerge during development and benchmarking an innovation against an existing state-of-the-art (SOTA) solution. A qualitative approach was chosen deliberately. At early development stages, full life-cycle assessments (LCA)s, life-cycle costing (LCC) or social life-cycle assessments (S-LCA) are rarely feasible and would have to rely largely on assumptions. Using the assessment table provided in D3.1, each alternative is described for every individual criterion, including strengths, limitations and possible improvements. The alternatives are then compared, and a recommended action is derived. The findings are consolidated at main-criterion level and finally summarised in an overall recommendation.

The framework therefore serves two purposes. It provides design guidelines, and it acts as a decision-support instrument. Beyond selecting a preferred alternative, it helps to identify weaknesses and improvement potential early and so supports the iterative refinement of designs before a configuration is selected for further development.

2.3 Application within WP3

The requirements defined in D2.5 and the assessment approach specified in D3.1 were applied throughout the development of the S2Z innovations. Candidate solutions were progressively designed, analysed and refined using comparative design studies, modelling and simulation results, safety analyses, packaging constraints, manufacturability assessments and OEM integration reviews. The four main criteria of D3.1 provided a common reference structure for assessing the broader value of the alternatives, while the available technical evidence was used to substantiate the qualitative assessments and verify their feasibility.

The selection process did not apply a single numerical weighting or ranking method across all six concepts, since the relevance of individual requirements and assessment criteria varied according to the innovation and application concerned. The must-be requirements identified in WP2, together with technical feasibility, safety and vehicle-integration constraints, were treated as essential conditions. Alternatives that did not adequately satisfy these conditions were therefore not considered suitable for selection. Within the limited scope and timeframe of WP3, priority was also given to requirements that could be feasibly addressed through the planned design and development activities.

Among the feasible alternatives, the D3.1 criteria were used to structure a qualitative comparison of their broader benefits, limitations and potential for improvement. Where competing objectives arose, the supporting technical evidence was used to assess the consequences of the trade-offs and determine which solution provided the most appropriate balance between user needs, technical performance, safety, integration feasibility and the wider project criteria. This combined approach enabled the systematic consideration of trade-offs such as thermal autonomy versus payload, modularity versus usable cargo volume, and functional benefit versus integration complexity.

Accordingly, the term “optimal design” in this deliverable does not refer to a single mathematically optimised solution based on a common weighting formula. It refers to the most appropriate and justifiable configuration selected for each concept, considering the relevant requirements, the qualitative D3.1 assessment, the available technical evidence and the scope and maturity reached within WP3.

In retrospect, the framework proved to be an effective instrument for guiding innovation development. Because the criteria were available as design guidelines from the outset, aspects such as circularity and user acceptance could be addressed at the early concept stage rather than evaluated retrospectively. The user-acceptance criteria were partly derived from WP2, which ensured continuity between user requirements and technical design. In addition, the framework provided a shared terminology for an interdisciplinary consortium and facilitated structured discussion of the design alternatives. Its requirement to formulate a recommended action for each criterion proved particularly valuable, since it turned the assessment into direct input for the next design iteration.

The framework could also be applied consistently across highly heterogeneous innovations. Some limitations nonetheless became apparent. Not all criteria were equally relevant to every development, and the qualitative assessments depended on the maturity of the available evidence. As prototypes and operational data become available, the assessments can increasingly be complemented by quantitative indicators. Overall, the experience in WP3 confirms that the framework fulfilled its dual function as a design guideline and decision-support instrument and contributed substantially to a structured, transparent and user-oriented development process.

The following sections document the results of this process. Sections 3 and 4 present the technical developments and the underlying design assessments. Section 5 consolidates the results at concept level, and Section 6 describes the resulting vehicle configurations and their transfer to prototyping, integration and validation.

3. WP3 technical developments

This section summarises the work carried out in the tasks T3.2, T3.3, T3.4 and T3.5. The objective is not to reproduce the detailed technical content of deliverables D3.2, D3.3, D3.4 and D3.5, but to provide the public technical context needed to understand how each task contributes to the final six concepts and to the design decisions documented in Section 5.

3.1 Energy management and component optimisations for enhanced efficiency and charging integration

Task T3.2 addresses new energy-efficient functionalities for N1 vehicles through a holistic approach combining cabin thermal management (ST3.2.1), brake and tyre optimisation (ST3.2.2), and vehicle charging strategies (ST3.2.3). These developments provide both hardware- and system-level inputs that are subsequently integrated with vehicle control activities in T3.5 and with the final S2Z concepts.

3.1.1 Novel cabin thermal management system

The thermal-management activity explores improvements to cabin heating with the aim of reducing the energy demand associated with driver and passenger comfort. The concept proposed in S2Z is based on an innovative radiant heating solution using flexible infrared (IR) Heating Panels, integrated with the existing vehicle Heating Ventilation and Air Conditioning (HVAC) architecture. Virtual models and simulations are used to analyse the relevant components and support the design and integration process.

The S2Z cabin thermal-management concept that has been considered, combines the existing vehicle HVAC system with localised radiant heating provided by flexible Infrared Heating Panels (IRPs). The objective is to improve occupant comfort in cold-weather operation while reducing the electrical energy required to heat the complete cabin air volume. The development was performed within T3.2 through coupled cabin, HVAC and human-comfort modelling and was iterated in close collaboration with the vehicle OEM partners. User and mission requirements collected in WP2 were treated as design inputs throughout the activity, in particular the need for rapid heat availability at route start, safe operation, low driver workload and a solution that can be integrated into existing demonstrator vehicle architectures.

The cabin thermal-management system is assessed through representative numerical analyses of the demonstrator vehicle cabins, in order to stay independent from the platform-specific descriptions. A Modelica/Dymola simulation framework was established to represent cabin thermal behaviour together with the conventional Positive Temperature Coefficient (PTC)-based heating system. The models were complemented by improved cabin insulation and by IRP zones positioned close to the occupant head, torso and leg regions (Figure 1). This arrangement exploits the principal advantage of radiant heating: thermal comfort can be influenced directly at the occupant without relying exclusively on increasing the bulk cabin-air temperature. The virtual assessments considered cold ambient operation and compared baseline configurations with cases using insulation, IRPs, or both measures together.

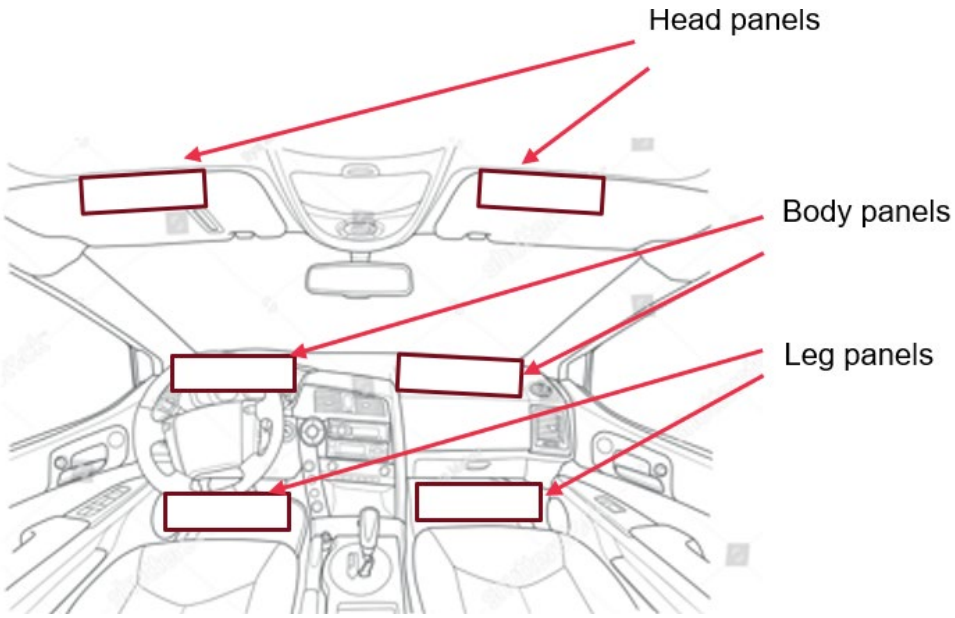


Figure 1. Representative positioning of infrared heating panels in the demonstrator cabin model

In one detailed cabin-model analysis, the comparative simulations showed a consistent reduction in heating demand when either insulation or IR heating was introduced, with the strongest effect obtained when both measures were combined. Relative to the uninsulated reference case, insulation alone reduced thermal and electrical power demand by approximately 4.2%, while the IRP-only configuration achieved a reduction of about 4.7%. Combining insulation and IRPs increased the simulated reduction to approximately 8.8% after the analysed warm-up period. These values are model-based results and therefore constitute design evidence rather than final vehicle-level validation; physical integration and validation are transferred to WP4.

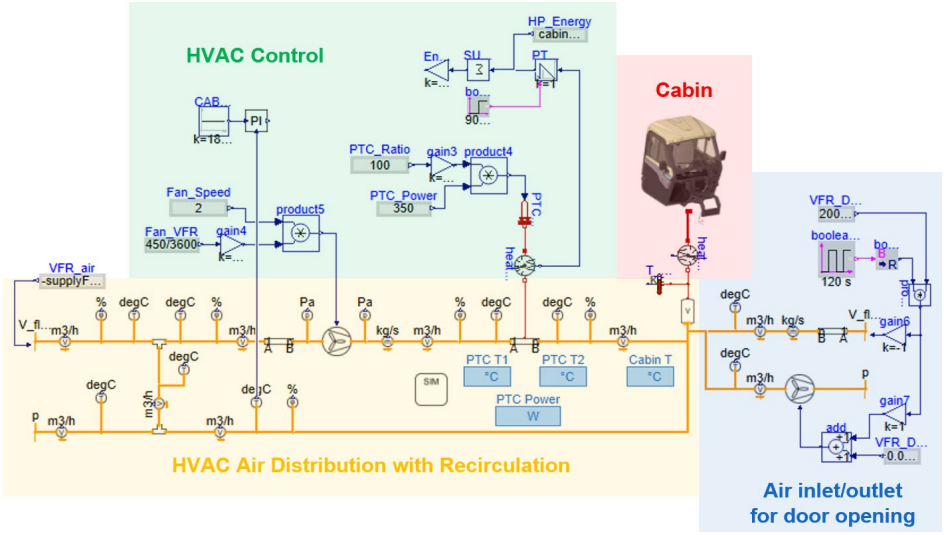
Thermal comfort was evaluated using local comfort indicators for the occupant body regions. The simulations indicate that, once the transient warm-up phase has passed, the relevant local comfort values remain predominantly within the neutral or near-neutral range. This is important because the energy benefit is not obtained simply by lowering the cabin temperature: the concept shifts part of the heating function from uniform air heating to targeted radiant heat at comfort-sensitive body areas. The resulting design direction therefore combines cabin-loss reduction, local radiant heating and the existing HVAC system rather than replacing the HVAC system altogether.

The analyses also highlighted practical integration constraints that are carried forward into prototyping. IR heating effectiveness depends on panel position, occupant proximity and line-of-sight, while panel surface temperature must remain within safe limits.

Additional insulation can reduce heat losses but introduces demonstrator-specific implications for packaging, mass and manufacturability. These trade-offs were reviewed together with the OEM partners and were used to define the design package transferred to WP4, where final panel positioning, electrical interfaces, insulation configuration and vehicle-level comfort and energy performance will be confirmed.

Table 2. Representative simulation results for cabin-heating energy demand

Comparison with uninsulated reference	Thermal power reduction	Electrical power reduction
Insulated cabin	4.152%	4.220%
Uninsulated cabin with IRPs	4.680%	4.746%
Insulated cabin with IRPs	8.767%	8.833%



A representative model layout

Looking at a single demonstrator use case (as analysed with a compact one-dimensional cabin thermal model that includes the main cabin walls, HVAC air recirculation and additional air exchange during repeated door-opening events) showed that adding cabin insulation reduced the simulated heating-energy demand by approximately 21% while maintaining the same target average equivalent temperature. Combining insulation with localised IR heating reduced the simulated energy demand by approximately 41% relative to the baseline in that modelling setup, while achieving the comfort target at a substantially lower cabin-air temperature.

In the numerical analysis of variable operating conditions, the IR-assisted case improved the minimum equivalent temperatures during the disturbance by approximately 29% on average and reduced transient heating-energy demand by approximately 22% compared with the insulated-only case. Given that these obtained results are not complementary on the physical modelling level, they are treated as complementary design evidence (rather than directly comparable performance figures).

3.1.2 Hardware optimisation at brake and tyre level

At brake level, WP3 investigates increased use of regenerative braking together with an advanced braking architecture, targeting improved energy recuperation, reduced friction-brake use and lower particulate emissions.

BRE's contribution is based on a localised brake-by-wire architecture that precisely controls friction braking while executing the braking requests coordinated with the vehicle's regenerative-braking strategy. By increasing the usable share of regenerative braking

and reducing unnecessary friction-brake activation, the solution is intended to improve braking precision, energy efficiency and component lifetime while reducing brake-pad and disc wear and associated particulate emissions.

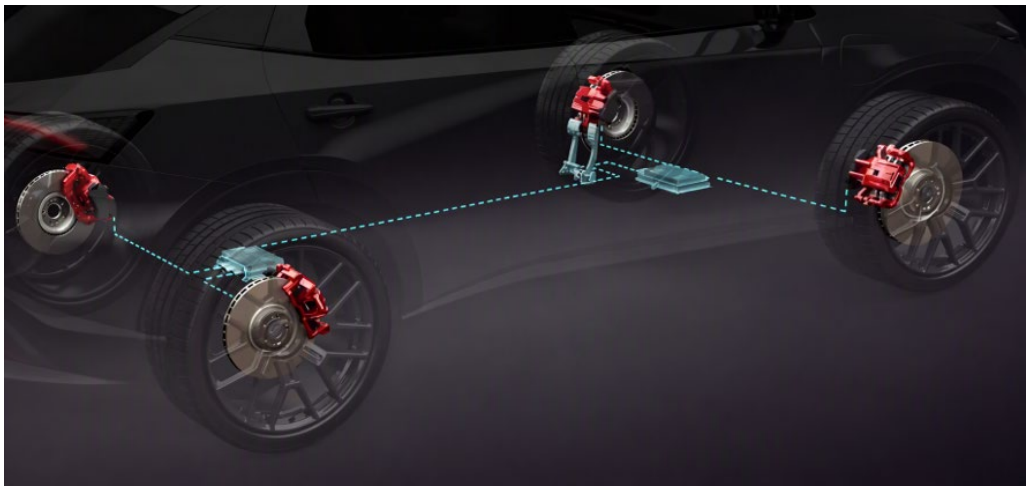


Figure 2. Sensify system developed by BRE

At tyre level, MIC applied a mission-based multi-criteria selection process to identify suitable tyre solutions for the IVE and ALK vehicle configurations. Candidate tyres were first screened according to vehicle fitment and load-capacity requirements and were then compared considering rolling resistance and energy efficiency, wear and tyre-particle emissions, grip and seasonal suitability. Environmental and economic indicators, including LCAs and total cost of ownership (TCO), were also used to complement the performance analysis. The resulting tyre selection therefore aims at achieving the best compromise between energy efficiency, durability, safety and tyre and road wear particle emissions for each vehicle and operating scenario.

3.1.3 Vehicle charging strategies

The charging activity focuses on bidirectional charging strategies and relevant standards and protocols, enabling the vehicle to act not only as an energy consumer but also as an energy source for external loads.

The external-charging concept enables the electric light commercial vehicle to act as a mobile energy source for cargo-bike batteries. The development considers alternative power-supply architectures using either the vehicle's Low-Voltage (LV) auxiliary electrical system or a dedicated interface to the High-Voltage (HV) traction system. The objective is to provide a practical charging functionality while minimising energy-conversion losses and preserving the energy available for the vehicle's own logistics mission.

Supplying the charging equipment from the low-voltage installation offers the advantage of using an existing vehicle interface and limiting the need for direct integration with the high-voltage system. However, delivering charging power at low voltage requires comparatively high currents. This increases resistive losses in cables and connectors, voltage drops and thermal loading and may require larger conductor cross-sections. The available charging power is also constrained by the capacity of the vehicle's auxiliary DC/DC converter and the simultaneous demand from other low-voltage consumers.

Where energy is supplied from the traction battery through the auxiliary DC/DC converter and subsequently converted again by the charging equipment, the losses of both conversion stages contribute to the overall energy demand.

A dedicated HV supply offers the potential to improve the efficiency of the complete energy-transfer path. For the same transferred power, the higher supply voltage reduces current in the vehicle-side wiring and therefore limits conduction losses and voltage drops. An appropriately designed HV-fed charging architecture may also avoid routing charging power through the vehicle's low-voltage auxiliary network and reduce intermediate conversion losses. However, the efficiency benefit depends on the actual converter topology, operating voltage range and charging load; it cannot be inferred from the supply voltage alone. HV integration additionally requires suitable electrical isolation, protection, controlled activation and coordination with the vehicle's safety architecture, Figure 3.

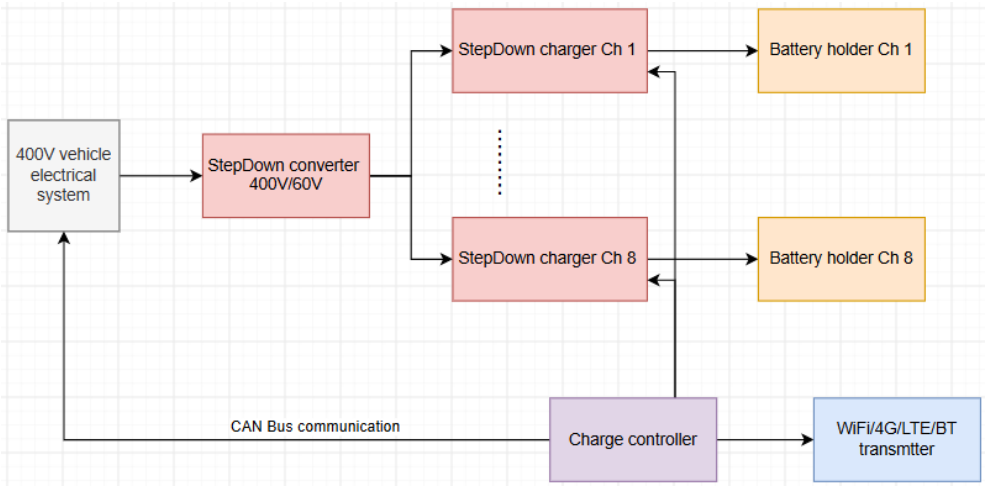


Figure 3. HV supply: Traction battery → Dedicated HV power interface → Charging equipment → Cargo-bike batteries

The comparison therefore focuses on end-to-end efficiency, from the vehicle traction battery to the electrical energy delivered to the cargo-bike batteries, rather than on the efficiency of an individual converter. Relevant considerations include conversion and wiring losses, standby consumption, operation at partial load and the number of batteries charged simultaneously. These factors are assessed together with installation space, accessibility, additional mass and safe battery storage. The resulting architecture is intended for integration into the IVE S2Z v1 vehicle, with physical integration and validation of charging functionality, safety and energy performance to be completed in WP4.

3.2 Safe and ergonomic systems design on vehicle cabin

Task T3.3 develops advanced vehicle-body and cabin solutions to enhance pedestrian and occupant safety while optimizing weight efficiency through innovative materials and manufacturing approaches. Based on WP2 requirements, this task delivers comprehensive design studies for critical safety components including frontal bonnet, bumper systems, and interior door trim assemblies.

This work has successfully implemented a comprehensive multi-disciplinary approach combining advanced simulation methodologies with innovative material and structural

concepts. The methodological framework integrates Design of Experiments (DoE) for systematic parametric studies, Multi-Body Simulation for dynamic impact analysis, Finite Element Method (FEM) for detailed structural assessment, and comparative studies using both classical impactors and state-of-the-art Human Body Models (HBM).

The DoE methodology represents a cost-effective approach that significantly reduces development expenses by enabling virtual exploration of the design space before committing to physical prototyping. Through DoE, multiple design alternatives can be evaluated efficiently, allowing selection of the best solution while minimizing resource consumption and accelerating time-to-market.

The primary focus has been passive safety enhancement for occupant protection, particularly through advanced interior door trim solutions incorporating optimized padding and structural reinforcements. Extensive simulation campaigns using HBM have validated measurable improvements in injury risk metrics compared to baseline configurations.

A distinctive innovation is the integration of circular economy principles into safety component design. Solutions incorporate modular architectures facilitating disassembly and material recovery, multi-material constructions designed for separability, and biodegradable materials in non-structural padding elements. This demonstrates that circular design achieves environmental benefits without compromising safety performance.

The task has explored next-generation lightweight materials and structures including advanced composites, lattice structures for optimized energy absorption, and hybrid constructions, demonstrating significant weight reduction potential while maintaining superior crashworthiness characteristics. Lattice geometries have been particularly effective in creating tunable stiffness gradients within door trim assemblies, enabling precise control of deformation behavior during impact.

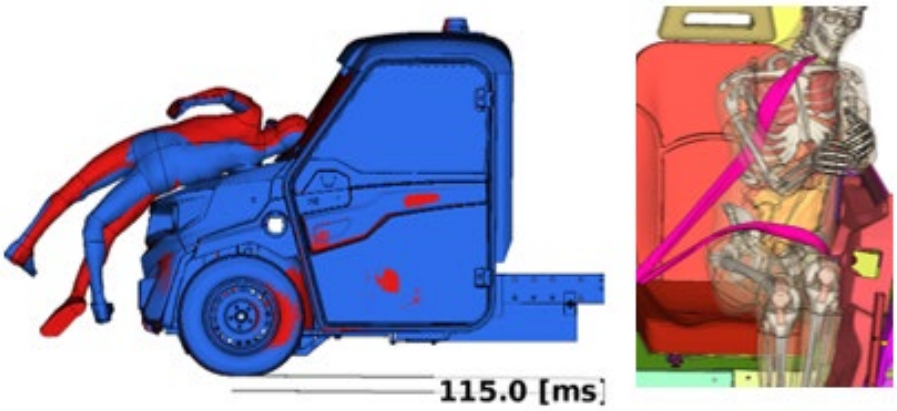


Figure 4. Pedestrian (left) & occupant (right) safety activities

Virtual assessment of frontal bonnet and bumper systems for pedestrian safety confirmed that the existing baseline design demonstrates adequate performance. Minor refinements were identified, but no major design changes were necessary.

The interior door trim assemblies represent the most significant development outcome. These ergonomic solutions balance safety, comfort, and aesthetics while integrating circular design principles. Innovations include adaptive padding systems utilizing biode-

gradable foams optimized for both performance and recyclability, lattice-reinforced structures with impact energy management, and modular construction enabling component replacement throughout vehicle service life.

The optimized designs demonstrate compliance with current and anticipated future safety regulations. The DoE methodology has proven its value for cost reduction by enabling virtual design space exploration, reducing development time, minimizing material waste, and improving resource allocation efficiency.

The integration of circular design principles with advanced manufacturing techniques such as lattice structures establishes that environmental responsibility and safety performance are complementary objectives. These validated concepts have been transferred to WP4 for physical prototyping and integration into demonstration vehicles. The comprehensive simulation database and methodologies developed provide a robust foundation for future development programs with quantifiable benefits in cost efficiency, environmental impact, and safety performance.

3.3 Modular and multipurpose cargo-body designs including concepts for dual transport

Task T3.4 develops user-centric cargo-body solutions that enable new vehicle shapes and functionalities while responding to the requirements generated in WP2 and the assessment logic of T3.1. The task covers three complementary design streams: a multi-temperature modular cargo body (ST3.4.1), a modular swap box concept (ST3.4.2), and a dual-transport configuration for goods and people (ST3.4.3).

3.3.1 Multipurpose cargo body with modular temperature-controlled areas

The multi-temperature cargo-body concept combines dynamically adjustable cargo volumes with temperature-controlled compartments. The design approach integrates movable panels, thermal insulation, eutectic thermal storage and a ventilation strategy intended to maintain different temperature ranges within the same cargo body. Computational Fluid Dynamics (CFD)/thermal simulations support design optimisation and evaluation of eutectic evaporator operation, compartment configuration, airflow, and access.

The concept also includes smart sensing and Internet of Things (IoT)-enabled monitoring, with the overall objective of allowing different types of goods to be transported in one vehicle while adapting the refrigerated volume to the actual mission and demand.

Unlike conventional refrigerated bodies with fixed compartments, the cargo space can be rapidly reconfigured into one, two, or three independent zones. This allows operators to transport frozen, chilled, and ambient products in the same vehicle while optimizing available cargo volume and reducing unnecessary refrigeration demand.

A key innovation is the use of a eutectic refrigeration system that stores cooling energy during charging periods and releases it passively during distribution operations. This enables autonomous temperature maintenance without continuous energy consumption from the vehicle, reducing operating costs and improving overall energy efficiency.

The eutectic refrigeration system is recharged during overnight parking using grid electricity, preferably from renewable energy sources and during off-peak tariff periods. The thermal energy stored in the eutectic plates/beams provides autonomous cooling

throughout the delivery mission, reducing operating costs and energy consumption. For battery-electric vehicles, this approach minimizes the energy required for refrigeration during operation, preserving traction battery capacity and extending vehicle driving range.

A key innovation of the cargo-body concept is the introduction of movable and foldable insulated partitions designed to allow rapid reconfiguration of the refrigerated compartments according to the daily transport mission. The partitions incorporate a high-performance thermal insulation solution that enables a reduced panel thickness while maintaining the required thermal separation between compartments. The reduced thickness contributes to lower weight, easier handling and improved operational ergonomics.

To maximize cargo space utilization, the partitions are equipped with a dedicated hinge and folding mechanism that allows them to be collapsed and stowed when not required. This solution minimizes the space occupied by inactive partitions and provides operators with greater flexibility in configuring the internal cargo volume. Depending on transport requirements, the cargo body can therefore be rapidly converted between different compartment layouts without the need for tools or complex operations.

The temperature setpoint of each compartment can be independently managed through an intuitive control interface accessible directly from the vehicle cab. This enables the driver to adapt temperature conditions to the specific products being transported, improving operational flexibility while maintaining cold-chain integrity throughout the distribution mission.



Figure 5. Reconfigurable insulated bulkheads allowing rapid adaptation of cargo volume and temperature-controlled areas

The combination of reconfigurable insulated partitions, independently controlled temperature zones, eutectic thermal storage and smart monitoring technologies creates a highly adaptable refrigerated transport solution capable of responding to variable logistics demands while maximizing vehicle utilization and energy efficiency.

3.3.2 Swap box modular solution enabling seamless transhipment

The modular swap box concept supports standardised transhipment across vehicles of different sizes and OEMs. The proposed units are intended to be traceable, lightweight, durable, lockable and foldable, enabling transfer between vehicles or temporary storage at hubs without modifying the external vehicle body. Foldability is intended to reduce the burden of empty returns and support reverse-logistics operations.

The PAX swap box concept is a cabinet placed on wheels. The size follows the Euro pallet standard and corresponds to a half Euro pallet size (800x600x1000mm). The PAX swap box is able to be rolled directly into small cargo-bikes, electric delivery vehicles like

PAX and small N1 vehicles like ALK. The idea is that these swap boxes could be pre-packed at the logistics partner's terminal, be shipped out with larger vehicles and rolled directly from larger trucks and vans into smaller vehicles. The cabinet could then be opened and be looked into position in the small vehicle in open position, like the middle picture below. When the swap box is empty, it could be collapsed and stacked for efficient return to base/ Terminal.

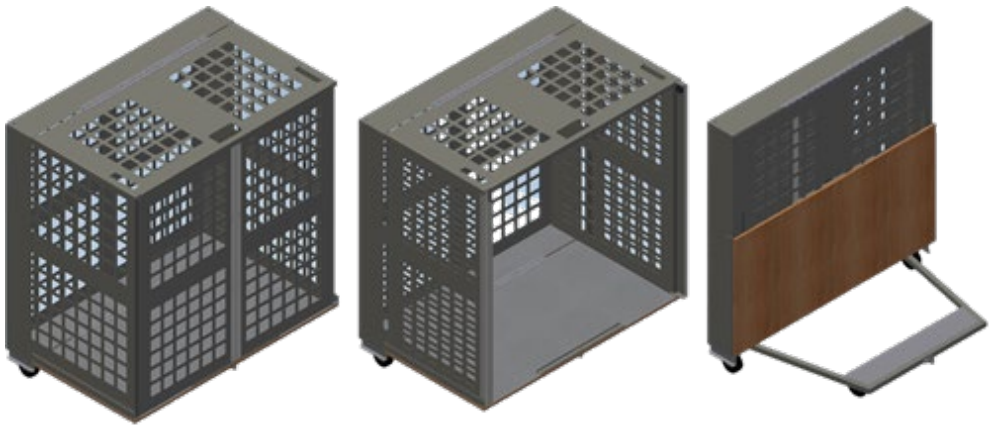


Figure 6. Different positions of swap box: fully closed, with doors open and folded

Also, some accessories are being tested out to make the transfer of swap box easy between different vehicles. A ramp/platform that is possible to fix at the back wall of the swap box is being evaluated (Figure 7).



Figure 7. Left: testing a loading ramp in a PAX vehicle from DHL; right: ramp (brown) hanging on the backside of a swap box

Different materials were evaluated, and a combination of sheet aluminium, a steel frame, and a plywood bottom emerged as the best balance of weight, function, and sustainability. LCA on this material combination is in progress in the project.

To be able to transport a higher amount of swap boxes in larger vehicles, stacking alternatives are also evaluated. By using a pallet, 4 swap boxes could be stacked to a height suitable for truck transport (Figure 8).

The PAX swap box also has a smart sensor included. This sensor tracks if the swap box are closed or open. It also tracks position based on connected vehicles (when it is close to a vehicle). The sensor also has temperature and humidity tracking. The swap box

could have an EN12830-certified sensor if tracking of temperature-sensitive goods is shipped. The sensor also tracks movement. This is all implemented into Paxter Connect, where all the swap boxes could be tracked and managed in a fleet system. Paxster Connect have API's for connecting to larger systems or existing fleet or logistics systems (Figure 9).



Figure 8. Stacking alternative for 4 swap boxes

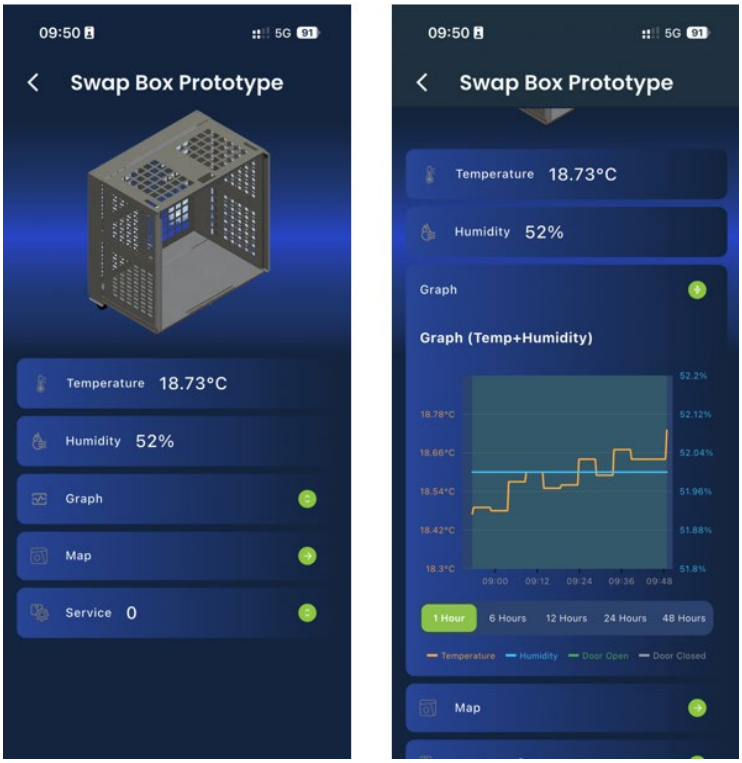


Figure 9. Swap box shown in the Paxster Connect app where data from swap box are shared

A short presentation of the first swap box concept prototype is presented in a YouTube video from Bergen, where one of the Norwegian pilots will be run.

3.3.3 Dual transport of goods and people

The dual-transport concept explores a flexible vehicle configuration in which passenger capacity and cargo volume can be adapted to different operational scenarios. The proposal baseline envisaged a 6-seater configuration with foldable seating, a movable protective partition and a system able to accommodate the project swap box concept.

During WP3, ALK proposed moving towards a 4-seater configuration, as this represents a more common and practical vehicle layout for the targeted applications and provides a better balance between passenger capacity, cargo space, vehicle dimensions and operational flexibility.

The main innovation of the concept is the possibility to dynamically reconfigure the space available for passengers and goods within the same vehicle platform. In its standard configuration, the vehicle can accommodate up to four occupants while retaining a dedicated cargo area. When the full passenger capacity is not required, the space allocated to the rear passengers can be rapidly converted into additional cargo capacity.



Figure 10. ALK ATX440 platform used for the integration of the dual-transport concept

Different technical solutions were assessed during the design phase. The selected concept retains the original independent rear seats, which can be managed individually according to the required passenger/cargo configuration. A movable protective partition separates the passenger compartment from the cargo area and can be repositioned when the rear passenger space is converted into cargo space. The vehicle layout also incorporates a pass-through tunnel, allowing the available longitudinal space to be used efficiently and supporting the transport of longer items while maintaining a compact vehicle footprint.

Compared with a dedicated foldable bench solution, the selected configuration provides advantages in terms of modularity, passenger comfort, ergonomics and integration with the base vehicle architecture. Retaining the original seating concept also limits modifications to safety-related vehicle components and facilitates the integration of the dual-transport functionality into the existing platform.

Particular attention has been given to ensuring that the different configurations provide appropriate separation and protection between occupants and transported goods, while allowing the transition between passenger-oriented and cargo-oriented layouts to remain simple and suitable for daily operations.



Figure 11. Dual-transport concept: different rear-seat configurations during the conversion from passenger to cargo space

The resulting concept therefore enables a single zero-emission vehicle to address missions that would otherwise require different vehicle configurations: personnel transport, combined transport of personnel and equipment, and cargo-oriented operation. This flexibility is particularly relevant for urban and last-mile applications where vehicle utilisation can vary significantly during the working day.

The selected design is also conceived to support the swap box concept developed within S2Z, further extending the modularity of the vehicle and allowing the cargo configuration to be adapted to different logistics tasks. Overall, the selected solution provides a practical compromise between passenger capacity, usable cargo volume, safety, comfort and operational flexibility, while minimising the impact on the existing vehicle platform.

3.4 Vehicle control strategies for energy efficiency and tyre & brake emission reduction

Task T3.5 integrates models and component-level developments into vehicle-level strategies. It covers intelligent cabin thermal-management strategies (ST3.5.1), Digital Twin models for tyre and braking systems (ST3.5.2), and a holistic powertrain/control strategy intended to improve average efficiency while reducing non-exhaust emissions (ST3.5.3).

The task T3.5 therefore provides an important integration layer between T3.2 hardware developments and the final vehicle concepts.

3.4.1 Thermal management strategies

Building on the simulation models and IR-heating concept developed in T3.2, the thermal-management strategy coordinates the novel radiant heating solution with the existing HVAC system under different environmental conditions. The objective is to reduce cabin thermal-energy demand while maintaining or improving passenger comfort, and to demonstrate the transferability of the approach across the two OEM platforms.

Task T3.5 extends the T3.2 thermal models from component and system assessment towards an implementable control strategy for the combined HVAC and infrared-heating system. The control-development activity was performed numerically with the same user-centred logic as the hardware work: technical options were developed in close collaboration with the OEM partners and continuously checked against the operating expectations collected from end users. The resulting strategy therefore balances energy efficiency and thermal comfort with safety, ease of use, low distraction and transferability across the demonstrator vehicle platforms.

At system level, the baseline HVAC remains responsible for cabin-air temperature regulation. In the simulation environment, a proportional-integral controller adjusts the PTC heating power according to the difference between the cabin temperature setpoint and the measured cabin temperature. The IRPs complement this function by supplying directional radiant heat to selected occupant zones. The combined architecture allows the HVAC setpoint and power demand to be reduced while local comfort is maintained through the faster thermal response of the radiant panels. The comparative model results (Figure 12) illustrate this effect: the configuration combining insulation and IR heating has the lowest heating-energy demand among the investigated cases.

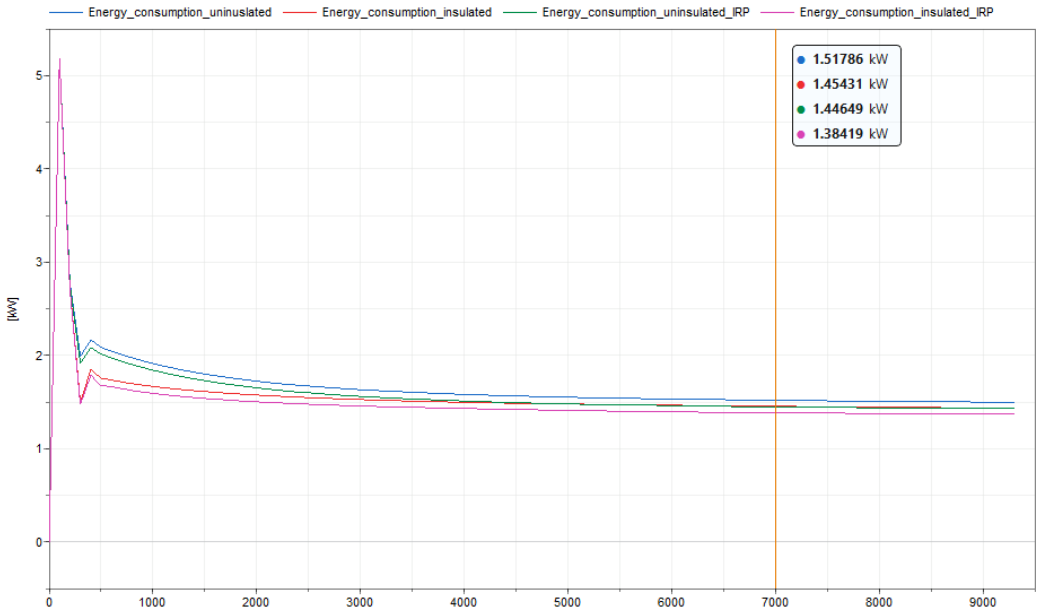


Figure 12. Simulated heating-energy demand for the investigated cabin configurations

In parallel with the baseline control, a more advanced comfort-oriented solution was numerically investigated using a zonal approach. Instead of commanding all IR panels identically, the cabin is divided into comfort-relevant zones associated with the head, torso and leg regions. Individual panel groups can be assigned different temperature levels, and the modelling framework supports closed-loop control based on local equivalent temperature or other comfort indicators. In a fully automatic implementation, dedicated controllers could adapt the radiant heat delivered to each body region according to local thermal demand, environmental conditions and the interaction with the conventional HVAC system. This approach demonstrated the potential for personalised comfort management and further energy optimisation without requiring uniform heating of the complete cabin volume.

Table 3. Control-strategy development and selected implementation direction

Control level	Technical concept	Role in S2Z implementation
Base HVAC control	Closed-loop control of conventional cabin heating using measured cabin temperature.	Robust baseline for cabin-air temperature management.
Zoned IRP control	Independent head, torso and leg zones with user selection, temperature limits and hysteresis.	Selected for first demonstrator integration because it is simple, stable, safe and aligned with user requirements.
Advanced comfort control	Automatic zonal regulation using local equivalent-temperature or comfort feedback.	Advanced approach investigated and retained as a future refinement after vehicle-level sensing and validation.

Although this advanced zonal strategy was numerically investigated and retained as a technically viable development path, the solution selected for the first vehicle implementation is deliberately simpler. The final implementation direction uses user-selectable heating zones together with temperature-based on/off regulation and hysteresis. This choice directly reflects the user requirements established in WP2 and refined together with the OEMs: the heating function should provide an immediate and clearly perceptible response, remain intuitive to operate, minimise driver distraction, be usable under realistic delivery conditions including operation with gloves, and avoid unnecessary safety-critical complexity. The simpler strategy therefore provides the most appropriate balance between thermal benefit, robustness, usability and applicability for the demonstrator phase.

The selected control philosophy also supports practical OEM integration. A limited number of clear temperature-based commands reduces software and hardware dependencies, simplifies calibration and facilitates application across different demonstrator architectures. Safety-related constraints, including panel-temperature limits and avoidance of local overheating, can be implemented directly at zone level. At the same time, the architecture remains extensible: once vehicle testing provides validated local comfort measurements and representative operating data, the same zonal structure can be upgraded to automatic comfort-based control without changing the fundamental IRP/HVAC integration concept.

Overall, the T3.2 and T3.5 developments establish a coherent progression from thermal-system design to vehicle-oriented control. Complementary virtual analyses demonstrate the energy-saving and comfort potential of combining cabin insulation, targeted IR heating and conventional HVAC, including repeated thermal disturbances representative of delivery missions. The selected control solution translates this potential into a practical implementation shaped by OEM integration constraints and, above all, user expectations. WP4 will complete demonstrator integration and calibration and quantify thermal comfort, heating-energy demand, HMI usability and the contribution to vehicle energy efficiency under representative conditions.

3.4.2 Tyre and brake system models

Digital Twin models of tyre and brake systems are developed to identify the factors influencing particle emissions and to provide the modelling basis required by the holistic control strategy.

The tyre work combines Finite Element Analysis (FEA) and functional modelling, while the brake model captures the relevant behaviour needed to optimise regenerative and friction-braking use. These models support both design assessment and later control-strategy development.

For the brake system, BRE developed the component design and control logic required to coordinate friction braking with vehicle-level regenerative-braking requests. The work includes validated brake components, completed corner-control logic and vehicle-control functions supporting Anti-lock Braking System and Electronic Brakeforce Distribution (ABS/EBD) and brake blending. The resulting model and control framework represents the brake system behaviour needed by the holistic vehicle-control strategy, allowing different braking-demand distributions to be assessed while maintaining braking performance and stability. Its outputs support the optimisation of regenerative-braking utilisation, reduction of friction-brake use and estimation of the corresponding effects on wear, particulate emissions, energy efficiency and component lifetime.

MIC developed functional models describing the evolution of tyre performance under representative vehicle operating conditions. The models aim at predicting the rolling-resistance coefficient as well as the thermal and wear-related phenomena, with the objective of quantifying their influence on vehicle energy consumption and tyre and road wear particle emission. The models use vehicle and tyre operating conditions, such as speed, load and thermal state, and are calibrated and progressively updated using available test and usage data.

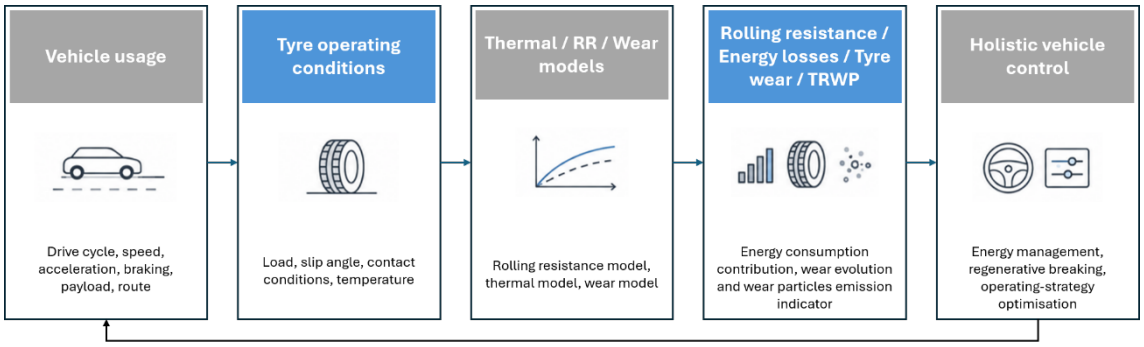


Figure 13. Scenarios optimization

The tyre models provide mission-level estimates of rolling-resistance losses, tyre thermal behaviour and wear evolution. Their outputs can therefore be used to compare operating scenarios, identify conditions associated with higher energy losses or wear, and provide tyre-related inputs to the holistic vehicle-control strategy developed in T3.5, as shown in Figure 14. The models could subsequently be further validated and integrated at vehicle level within WP4.

3.4.3 Holistic vehicle control strategy

The holistic control strategy combines powertrain efficiency, regenerative braking and tyre/brake emission considerations in a common vehicle-level approach. The strategy aims to maximise recuperation and optimise drive-cycle and powertrain behaviour while using the tyre and brake models to avoid operating conditions associated with increased non-exhaust emissions.

Within T3.5, IKA implemented this strategy as a simulation toolchain that connects route, vehicle and driver. Routes at the pilot sites are converted from map data into drivable cycles that include road gradient, stops and curve speeds limited by lateral acceleration to keep manageable tyre loads. A symmetric power limit keeps braking within the regenerative capability of the drivetrain. These cycles are then optimised using dynamic programming over the feasible speed profiles. The cost function considers battery energy, friction brake use, tyre wear and travel time in one common unit, the Energy Equivalent Point. This lets the trade-off between energy demand, non-exhaust emissions and productivity be tuned for each vehicle use case and site.

The optimised cycles are evaluated on a reconfigurable digital twin of the pilot vehicles from ALK and IVE. The vehicle twin simulates longitudinal, lateral and vertical dynamics to derive individual wheel loads, and can represent powertrains with up to three e-machines and multi-speed transmissions. A predictive controller selects gear, coupling state and torque split along the cycle, taking into account electrical losses and switching events. Regenerative braking is always used first, and friction brakes only where recuperation is not sufficient. The tyre models provided by MIC run in co-simulation and return rolling resistance and tread wear for every wheel, which links each control decision to its effect on tyre emissions. The twin was also used to compare powertrain variants, such as additional gears or a split into two smaller e-machines, under the same optimised cycles. In simulation, the optimised cycles reduced energy demand by a significant percentage for both vehicles and lowered the tyre wear indicator, and multi-speed and multi-motor layouts gave further gains.

Because the control software of the pilot vehicles is not modified, the strategy reaches the vehicle through the driver. For this, the optimum was translated into a speed-dependent acceleration envelope. At each speed, it limits longitudinal acceleration by efficient traction and by regenerative braking capability, and lateral acceleration by tyre wear. The driver's current state is scored by its distance to this envelope and by any exceedance, and the result is reduced to a single cue, a status and a trip score. Unlike a fixed target speed profile, this guidance remains valid on any route and in traffic. Figure 14 shows this chain from model output to driver display. The concept will be implemented and tested with drivers in WP4.

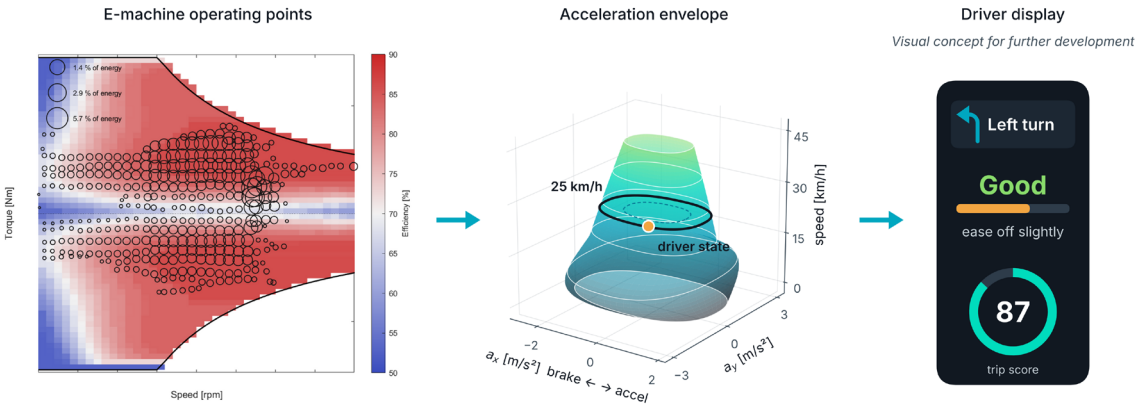


Figure 14. Holistic control strategy from model output to driver guidance concept: simulated e-machine operating points weighted by their share of cycle energy (left), speed-dependent acceleration envelope with the current driver state (centre, illustrative values) and driver display concept (right)

Geofencing-related capabilities can also be considered in the strategy to adapt vehicle behaviour in specific operating zones. Paxster Connect is a fleet-management solution that gives operators a consolidated view of vehicle location, availability, status, diagnostics, warnings and operational events. Depending on the data available from the vehicle, it can also support maintenance notifications, charging reminders and safety-related alerts. The app also provides a mobile overview of individual vehicles, their current condition and the operating zones relevant to them.

Geofencing links the reported vehicle position to digitally defined operating zones, including speed-limited areas and restricted-access or no-go zones. Paxster Connect evaluates the latest position against the applicable zone definitions and can send the relevant requirement to a connected vehicle, enabling a compatible vehicle-control system to apply a speed limit or other permitted response. The app visualises the zones using distinct map overlays and shows the applicable restriction for the selected vehicle. The server-driven approach allows zones and rules to be updated close to real time, although it depends on reliable vehicle connectivity.

The integration adapts the Mobility Data Specification (MDS) 2.0 maintained by the Open Mobility Foundation (OMF). MDS 2.0 is an open standard for two-way communication and data sharing between public authorities and mobility providers. It extends the specification beyond shared bicycles and scooters to additional mobility modes, including delivery robots, and provides common data structures and Application Programming Interface (API)s for vehicle information, operational events and digital policy. Through the Policy API, public authorities can digitally define and communicate rules such as speed limits, restricted or exclusion zones and other location-dependent operating requirements (Figure 15). Integrating MDS 2.0 into Paxster Connect enables these machine-readable rules to be interpreted as operator information and, where supported, translated into vehicle responses. This approach is particularly relevant to delivery robots and other connected last-mile vehicles operating in public spaces, where authorities may need a consistent way to communicate where and how the devices may operate.

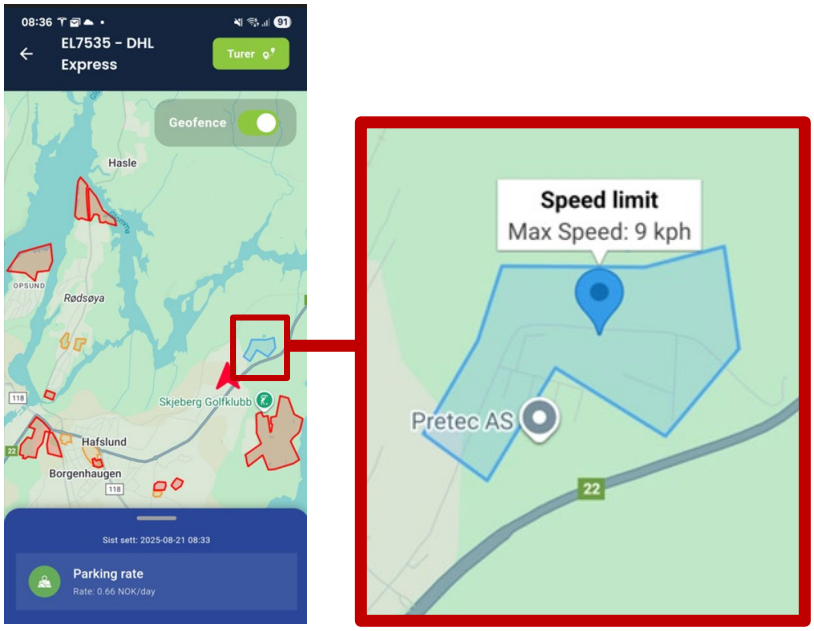


Figure 15. Representative overview of Paxster Connect, the Paxster Connect app and geofencing functionality

Paxster Connect is not limited to PAX vehicles: vehicles from any manufacturer, including delivery robots, can be connected when suitable positioning, vehicle data and communication interfaces are available. Automated geofencing functions require additional vehicle-specific integration so that commands can be received and safely applied by the telematics and control systems. This public description excludes proprietary interfaces, detailed control parameters and security-sensitive implementation information.

4. Consolidated WP3 innovation portfolio and design assessments

WP3 combines several technological developments that cut across individual tasks and are ultimately assembled into the six S2Z vehicle concepts (reported in chapter 5). Table 4 provides a concise public overview of the innovation portfolio and makes visible the contribution of each technical task without reproducing the detailed content of the sensitive deliverables.

Table 4. Overview of innovations developed in WP3

Innovation	Main task(s) in WP3	Public description	S2Z Concept
Design assessment framework	**T3.1**	Structured assessment and trade-off process for WP3 designs	**All**
IR cabin heating + thermal management	**T3.2 / T3.5**	Radiant heating integrated with HVAC and intelligent thermal management	**Concept 2**
Optimised brake hardware / regenerative braking	**T3.2 / T3.5**	Brake solution and control approach supporting recuperation and reduced friction use	**Concept 3**
Optimised tyres for best performance	**T3.2 / T3.5**	Tyre selection addressing efficiency and particle emissions	**Concept 3**
Bidirectional charging	**T3.2**	Vehicle-to-external-load energy transfer using relevant standards/protocols	**Concept 3**
Safety-oriented bonnet / bumper / door trim	**T3.3**	Optimised vehicle/cabin components for pedestrian and occupant safety	**Concept 2**
Multi-temperature modular cargo body	**T3.4**	Variable cargo volumes and temperature zones with thermal-management features	**Concept 1**
Foldable modular swap box	**T3.4**	OEM-neutral modular unit supporting standardised transhipment and returns	**Concept 4**
Dual transport layout	**T3.4**	Flexible passenger/cargo configuration with safety separation	**Concept 6**
Holistic vehicle control strategy	**T3.5**	Integrated strategy for driving efficiency, recuperation and non-exhaust emissions	**Concept 3**
Geofencing-ready vehicle control and driver-information interface	**T3.5**	Vehicle-side interface supporting location-based driver warnings and control responses	**Concept 5**

4.1 Design assessments applied in WP3

Table 5 is the working registry of design assessments used to support WP3 selection decisions. For each assessment, the innovation partners completed the number of alternatives or design versions evaluated. Public comparative outcomes of the selected option and the location of the full technical evidence.

The public result of each assessment is integrated in D3.6 in two places: the comparative outcome is summarised in this section or in the relevant technical subsection, while the selected option and rationale are carried into the corresponding concept-selection record in Section 5. The full report location is retained only as a traceability reference.

Table 5. Design assessments applied in WP3

ID	Assessment description	Alternatives	Evidence location
A1	Material for multipurpose cargo-body partitions (bulkheads)	Vacuum Insulation Panels (VIP) vs. Aerogel	D3.4 technical annex
A2	Material for the swap box	Steel vs. aluminium	D3.4 technical annex
A3	Cabin configuration	Cabin with insulation vs. without insulation	Assessment framework table in WP3 SharePoint folder
A4	Position of e-bike batteries in the vehicle considering available space and safety	Inside cabin vs. external compartment	Assessment framework table in WP3 SharePoint folder
A5	Materials and manufacturing methodologies for the new door trim	Lattice structure configurations for energy absorption optimization Biodegradable foam formulations vs. conventional padding materials Modular vs. integrated architectures for circular design	Assessment framework table in WP3 SharePoint folder
A6	Options for the retractable second row of seats	New rear bench vs. adaptation of original ATX4 rear-seat layout with minor modifications	Assessment framework table in WP3 SharePoint folder
A7	HMI options to improve driving using the holistic energy-management models	Vehicle Control Unit (VCU)-based predictive control vs. Eco-assistive driver display	Assessment framework table in WP3 SharePoint folder

4.2 Cross-task integration and synergies

The final S2Z concepts depend on interactions between multiple WP3 developments rather than on isolated components. The most relevant interfaces include the interaction between IR heating and the intelligent thermal-management strategy; the combination of brake and tyre optimisation with digital twin models and holistic vehicle control; the interaction between cargo-body modularity, thermal management and mission requirements; and the combination of swap box, flexible interior layout and safety considerations in dual-transport applications.

5. Optimal designs selected for the six S2Z concepts

This section presents the final design selected for each of the six S2Z concepts and explains how each selection was reached through the WP3 design and assessment process. To ensure a consistent and comparable presentation, all six concept subsections follow the same structure.

5.1 Concept 1 – Multi-temperature controlled, dynamically optimised and energy-efficient cargo-body

Concept 1 addresses logistics missions that require the transport of goods at different temperature conditions while demand and cargo volumes fluctuate.

The S2Z approach combines a multipurpose cargo body with movable internal partitions and a thermal-management concept capable of creating different temperature zones (-20ºC (frozen), from +2 to +8ºC (chilled) and +8ºC (dry)). The concept includes eutectic evaporators, controlled airflow, smart sensing and thermal design optimisation through CFD-related analyses. Table 6 summarises the design-selection process for Concept 1, including the user need addressed, the alternatives and assessment evidence considered, the selected configuration and its rationale, the main trade-offs identified at M22, and the resulting handover to WP4.

Table 6. Design selection summary for Concept 1

Design selection element	Description
User need/target mission	Urban logistics operators require flexible eLCVs capable of transporting fresh, chilled, frozen and dry goods under different temperature conditions and varying demand patterns. The cargo body must adapt the refrigerated volume to each mission, preserve the required storage conditions and reduce the need to use separate vehicles for different types of goods
WP3 innovations contributing to the concept	The concept combines T3.1 **design-assessment framework** with T3.4 **multipurpose cargo-body** developments. The main innovations include movable partition panels, optimised insulation, eutectic thermal storage, controlled airflow between compartments, smart temperature sensing and thermal optimisation through CFD simulations. The main technical partners are COL, EUT, ALK and IVE, with RWTH supporting the assessment framework
Design alternatives/iterations	The design process considered alternative materials and architectures for the movable panels, different sizes of temperature-controlled compartments, alternative access-door positions, and different combinations of insulation, eutectic storage and controlled ventilation. The capacity and arrangement of the eutectic system and the platform-specific integration for the IVE eDaily and ALK ATX were also evaluated.
Related design assessment(s)	A1, **material for multipurpose cargo-body partitions (bulkheads)**. Completed and documented in the technical annex to D3.4
Public assessment outcome	The assessment showed that the candidate partition materials involved different trade-offs between thermal insulation, weight,

Design selection element	Description
	mechanical performance, durability, manufacturability, sustainability and integration requirements. Aerogel provided the best overall balance, particularly regarding weight and integration requirements.
Selected design at M22	The selected design baseline is a modular multi-temperature cargo body with movable partitions that allow the cargo volume to be divided into up to three temperature-controlled compartments. A eutectic thermal-storage system regulates the lowest-temperature compartment, while controlled airflow supplies adjacent compartments operating at higher temperatures. Smart sensors monitor cargo conditions and communicate with the thermal-management system.
Selection rationale	The selected architecture provides a strong combination of operational flexibility, temperature control, cargo-space adaptability and energy efficiency. Adjusting the refrigerated volume to the actual load reduces unnecessary thermal demand, while the combination of eutectic storage and controlled airflow enables different categories of goods to be transported in the same vehicle. The modular design also supports adaptation to different missions and vehicle platforms.
Key trade-offs/limitations at M22	The IVE configuration presents a significant reduction in available payload due to the mass of the eutectic thermal-storage system and its associated components. The current design therefore involves a relevant trade-off between thermal autonomy, multi-temperature flexibility and usable payload capacity. The exact mass breakdown and detailed integration calculations remain in the restricted technical documentation. Alternatives for increasing the payload during the prototyping phase are being studied.
Evidence supporting selection	The selection is supported by the A1 material assessment, CFD and thermal simulations, mass and packaging assessments, and platform-integration design reviews.
Expected benefit/target	The GA establishes a target of a **25% increase in fleet load efficiency** through the multi-purpose cargo body. The selected design is expected to improve operational flexibility and reduce the need for separate vehicles for different temperature-controlled missions. However, this benefit remains a project target and must be assessed together with the reduction in available payload, particularly for the IVE configuration.
Target platform(s)/prototype(s)	IVE eDaily and ALK ATX. The payload limitation is currently more relevant for the IVE configuration and requires further optimisation and validation during vehicle integration.
WP4 handover	WP3 transfers the selected cargo-body architecture, partition-material decision, compartment configuration, thermal-management concept, sensor requirements, simulation results, mass assessment and platform-interface specifications. WP4 will optimise the mass, capacity and integration of the eutectic system and validate the resulting thermal performance, mechanical behaviour, accessibility, operability and usable payload. The final configuration must demonstrate an acceptable balance between thermal autonomy, cargo volume and payload capacity.

5.2 Concept 2 – Optimised thermal comfort and safe ergonomics in N1 vehicle cabins

Concept 2 addresses driver/passenger thermal comfort, energy efficiency, safety and ergonomics. The public concept combines an efficient radiant-heating approach based on IR Heating Panels with user-oriented thermal management, while WP3 safety activities optimise relevant cabin/body components to improve occupant and pedestrian protection. The selected concept should therefore be presented as an integrated cabin solution rather than as a single component. Table 7 summarises the design-selection process for Concept 2, including the thermal-management and safety innovations considered, the assessment evidence supporting the selected configuration, the main trade-offs identified at M22, and the resulting handover to WP4.

Table 7. Design selection summary for Concept 2

Design selection element	Description
User need/target mission	Improve driver and passenger thermal comfort during urban delivery operations, particularly under cold ambient conditions, while limiting the energy demand of cabin heating and its impact on vehicle range. The concept also addresses cabin ergonomics and occupant and pedestrian safety, contributing to safer and more comfortable working conditions for professional drivers performing frequent and repetitive delivery missions.
WP3 innovations contributing to the concept	The concept combines T3.1 **design-assessment framework** with T3.2 **novel cabin thermal-management system,** developing the IR heating panels and associated cabin and HVAC models. T3.3 **safe and ergonomic cabin systems** is also included in this concept, optimising the interior door trim, frontal bonnet and bumper through DoE, FEM simulations and HBM studies.
Design alternatives/iterations	The thermal-management work considered the existing HVAC system as the reference configuration and investigated alternative cabin configurations with and without additional insulation, as well as the integration of flexible IR Heating Panels. Different panel positions, heated surfaces and operating strategies were considered to provide heat closer to the occupants while reducing the need to heat the entire cabin volume. In parallel, the safety work assessed different materials, structural configurations and manufacturing approaches for the interior door trim, frontal bonnet and bumper.
Related design assessment(s)	A3, **cabin configuration with and without insulation** and A5, **materials and manufacturing methodologies for the new door trim**.
Public assessment outcome	The WP3 modelling and design studies indicated that the combination of localised radiant heating and coordinated HVAC operation together with the improvement of the cabin insulation provides the most promising balance between passenger comfort, heating-energy demand and vehicle integration. The safety-design studies progressively narrowed the available options to the configurations offering the best balance between occupant and pedestrian protection, component weight, manufacturability and compatibility with the OEM platforms.

Design selection element	Description
Selected design at M22	The selected configuration combines flexible IR heating panels located close to the relevant occupant areas with the existing vehicle HVAC system. Both systems are coordinated through an intelligent thermal-management strategy and a user-oriented HMI that allows occupants to provide simple comfort feedback. The concept also incorporates the selected safety-oriented design of the interior door trim and recommendations for the optimisation of frontal bonnet and bumper components. The exact number, position and power of the IR panels, the selected insulation configuration and the final component materials should be confirmed during prototyping.
Selection rationale	The configuration was selected because it provides targeted heat directly to the occupants, potentially reducing the need to increase the temperature of the complete cabin volume. It can be integrated with the existing HVAC architecture and offers rapid thermal response, limited component thickness and flexibility in panel positioning. The selected safety components complement the thermal solution by addressing occupant and pedestrian protection while considering component mass, manufacturability, ergonomics and compatibility with the existing vehicle architecture.
Key trade-offs/limitations at M22	The benefit of radiant heating depends strongly on panel position, heated surface, occupant proximity and the coordination between the IR panels and the existing HVAC system. Additional insulation may reduce thermal losses but can introduce weight, cost, packaging or manufacturing implications. The integration is also vehicle-specific and requires confirmation of electrical interfaces, control calibration, durability and safe HMI operation. At the same time, it is a seasonal innovation, given that it will only be used when the outside temperature is cold. Consequently, the final energy-saving and comfort benefits should not be presented as demonstrated results until they have been validated under representative WP6 test conditions.
Evidence supporting selection	Evidence available at the design stage includes virtual cabin and HVAC models, component and subsystem simulations, co-simulation of different physical domains, comparative analysis of cabin configurations, design reviews and assessment of vehicle-integration constraints. The safety selection is supported by DoE, FEM analyses using relevant impact methodologies, and comparative studies using classical impactors and HBM.
Expected benefit/target	The GA identifies a target of reducing the energy consumption associated with cabin heating by **up to 30% under cold-weather conditions**, while maintaining passenger comfort. This value should be presented as a project target unless it has already been demonstrated through validated testing. Additional expected benefits include improved thermal response, increased driver comfort and enhanced occupant and pedestrian safety.
Target platform(s)/prototype(s)	The thermal-management concept and safety improvements were designed to be transferable across the IVE eDaily and ALK ATX platforms. The IVE multipurpose operational prototype is expected to provide the main vehicle-level integration of the IR heating system, HMI and thermal-control strategy. Regarding safety improvements, implementation will primarily take place on the ALK platform.

Design selection element	Description
WP4 handover	The design package transferred to WP4 includes the selected IR heating panel configuration, the associated HMI concept, the thermal-management strategy and the interfaces required for integration with the existing HVAC system. The selected door-trim, bonnet and bumper designs and their manufacturing specifications are also transferred for component prototyping and integration where applicable. WP4 will complete hardware manufacturing, vehicle-specific integration, control calibration and functional, comfort, energy, durability and safety validation under controlled conditions.

5.3 Concept 3 – eLCVs with holistic energy management for optimised charging operations

Concept 3 combines energy-management innovations across the vehicle. The project concept links powertrain control, regenerative braking, tyre technologies, Digital Twin models and bidirectional charging, with the objective of improving overall energy efficiency while reducing non-exhaust emissions.

Following the replacement of InPost by DPD, the external-load use case was changed from supplying APMs to supplying e-bike batteries. The final D3.6 description should clearly distinguish component-level optimization, the battery-position decision and the selected vehicle-level control architecture.

Table 8 summarises the design-selection process for Concept 3, including the energy-management, brake, tyre, control and external-charging solutions considered, the assessment evidence supporting the selected configuration, the main trade-offs identified at M22, and the resulting handover to WP4.

Table 8. Design selection summary for Concept 3

Design selection element	Description
User need/target mission	Improve the overall energy efficiency and operational range of eLCVs used in urban delivery missions, particularly under driving conditions characterised by frequent acceleration and braking. The concept also responds to the need to reduce brake and tyre particle emissions and to use the vehicle battery as an energy source for external equipment.
WP3 innovations contributing to the concept	This concept also combines T3.1 **design-assessment framework** with: T3.2 **brake and tyre hardware optimisation**, developing an optimised braking solution supporting regenerative braking and reduced friction-brake use, and the selection of tyre designs for best performance addressing energy efficiency and particle emissions; T3.2 **vehicle charging strategy**, building the external-energy-transfer architecture and charging approach; and T3.5 **Digital Twins and holistic vehicle-control strategy**, implementing tyre and brake models and their integration into a vehicle-level control strategy.

Design selection element	Description
Design alternatives/iterations	At brake level, alternative strategies for distributing braking demand between regenerative and friction braking were considered. At tyre level, different combinations of tyre architecture, tread pattern and constituent materials were analysed, considering rolling resistance, wear, grip, durability and particle emissions. The vehicle-control work considered different control logics and driving scenarios for balancing energy recuperation, powertrain efficiency and non-exhaust emissions. For the external-charging function, different energy-transfer approaches (HV/LV electric Power Take-Off (ePTO)), charging interfaces and battery locations were considered.
Related design assessment(s)	A4, **position of e-bike batteries in the vehicle, considering available space and safety** and A7, **HMI options to improve driving using the holistic energy-management models developed**.
Public assessment outcome	The WP3 studies identified a combination of optimised brake and tyre components and a coordinated vehicle-control strategy as the most promising approach for simultaneously improving energy efficiency and reducing non-exhaust emissions. The selected control direction prioritises the use of the vehicle's available regenerative-braking capability while maintaining the required braking performance and operational safety. The assessment of the e-bike battery location considered vehicle space, accessibility, integration requirements and safe storage and charging conditions.
Selected design at M22	The selected architecture combines an optimised tyre selection, an advanced brake system supporting increased use of regenerative braking, Digital Twin models of tyre and brake behaviour, and a holistic vehicle-control strategy. The models provide inputs to the control layer and to an HMI intended to support more energy-efficient driving. The concept also includes an external-energy-transfer function for charging e-bike batteries.
Selection rationale	The integrated configuration was selected because component optimisation alone cannot fully address the interactions between energy consumption, regenerative braking, tyre and brake wear and vehicle operation. Combining physical components, predictive models and vehicle-level control makes it possible to manage these objectives simultaneously. The vehicle-to-e-bike charging application maintains the core functionality foreseen in the proposal, using the eLCV as an external energy source, while adapting it to the needs of the current end user and last-mile operating model.
Key trade-offs/limitations at M22	Tyre selection requires balancing rolling resistance and energy efficiency against grip, durability, noise, load capacity and particle emissions. Increasing regenerative braking must remain compatible with braking safety, stability and the availability of the friction-braking system. The control strategy needs to balance energy recuperation against driveability and mission requirements. For the external-charging function, the selected battery position affects available vehicle space, accessibility and safety, while energy supplied to e-bike batteries reduces the energy remaining for the

Design selection element	Description
	vehicle mission. The battery charging system also increases vehicle weight and reduces payload. HMI information must support the driver without increasing workload or distraction.
Evidence supporting selection	The design decision is supported by tyre analysis, brake-system modelling, calibrated tyre and brake Digital Twins, predictive simulations, comparative assessment of alternative tyre and brake configurations, and vehicle-control simulations under representative driving scenarios. Additional evidence includes energy calculations for the external-charging use case, assessment of the available installation space and battery position, safety and integration reviews, and technical discussions with the OEM and end-user partners.
Expected benefit/target	The GA establishes proposal-level targets including at least **3% improvement in energy efficiency**, more than **5% reduction in brake particle emissions**, more than **5% reduction in tyre particle emissions**, and up to **20% increase in eLCV autonomy through global control strategies**. It also refers to maximising use of the available regenerative-braking capability. These values should be presented as targets rather than demonstrated results until validated in WP4 and subsequent pilot tests in WP6.
Target platform(s)/prototype(s)	The Concept 3 developments are distributed across two IVE eDaily configurations: IVE S2Z v2 integrates the brake, tyre and holistic vehicle-control developments, while IVE S2Z v1 integrates the external-charging function for e-bike batteries. The selected tyres and vehicle-control innovations will also be integrated into the ALK platform.
WP4 handover	The package transferred to WP4 includes the selected tyre design, brake hardware and associated control software, the calibrated tyre and brake models, the holistic vehicle-control strategy, the selected HMI concept and the external-charging architecture for e-bike batteries. It also includes the selected battery position and the relevant electrical, communication, mechanical and safety interfaces. WP4 will complete component prototyping, software calibration, vehicle integration and controlled testing of energy efficiency, regenerative braking, tyre and brake performance, non-exhaust emissions and charging functionality.

5.4 Concept 4 – Modular swappable concept enabling seamless standardised transhipment

Concept 4 addresses interoperability and transhipment across heterogeneous fleets. The S2Z solution is based on modular, OEM-neutral swap units intended to move between vehicles and logistics nodes while supporting traceability, foldability and return-logistics efficiency. The final selected design should be described in terms of functional architecture, interfaces and operational benefits, while detailed proprietary construction information remains outside this public deliverable.

Table 9 summarises the design-selection process for Concept 4, including the modular swap box alternatives considered, the assessment evidence supporting the selected configuration, the main trade-offs identified at M22, and the resulting handover to WP4.

Table 9. Design selection summary for Concept 4

Design selection element	Description
User need/target mission	Facilitate the rapid and secure transfer of goods between vehicles of different sizes and manufacturers, reducing handling, loading and unloading times in urban logistics operations. The concept responds to the need for more flexible transhipment between electric Heavy Duty Vehicle (eHDV)s, N1 eLCVs and smaller vehicles, whether performed directly between vehicles or through logistics nodes such as consolidation centres, terminals or mobility hubs. It also supports reverse logistics by reducing the space required to transport and store empty load units.
WP3 innovations contributing to the concept	The concept 4 combines T3.1 **design-assessment framework** with T3.4 **modular swap box** design. The innovation is an OEM-neutral internal swap box solution with standardised dimensions. Among its main features are its foldability and lightweight construction, its locking, securing and vehicle-integration interfaces, and its traceability functionality.
Design alternatives/iterations	The design work considered vehicle-specific versus standardised multi-OEM solutions, rigid versus foldable configurations and alternative materials and construction approaches. Different box dimensions and geometries were examined to ensure compatibility with the available cargo space of the IVE and ALK platforms and with smaller vehicles, such as PAX platform, while maintaining alignment with existing logistics standards (Euro pallet). The iterations also considered alternative folding, handling, locking, anchoring and traceability solutions, as well as different transhipment scenarios, including vehicle-to-vehicle exchange and temporary storage at logistics or mobility hubs.
Related design assessment(s)	A2, **material for the swap box**
Public assessment outcome	The comparison of the candidate solutions identified the selected configuration as the option providing the most suitable balance between low weight, durability, foldability, cargo protection, ease of handling, manufacturability and compatibility across different vehicle platforms. The selected material and construction approach also support repeated folding and handling operations while limiting the volume occupied by empty boxes during return logistics.
Selected design at M22	The selected design consists of an internal, modular and OEM-neutral swap box intended for use in vehicles of different sizes and manufacturers. It has dimensions of half a Euro pallet, and is lightweight, durable, lockable, foldable, traceable and fits within the vehicle cargo compartment without modifying its external appearance. Its standardised interfaces enable transfer between vehicles or temporary storage at logistics nodes, while the foldable configuration reduces the space required when the box is returned empty. Equipment has also been designed to facilitate the loading and unloading of swap boxes in spaces that lack forklifts.
Selection rationale	The configuration was selected because it provides a common load unit that can be used across heterogeneous fleets, reducing dependence on vehicle-specific cargo solutions. Its internal arrangement facilitates integration without significant modifications

Design selection element	Description
	to the vehicle body, while standardised dimensions support interoperability and alignment with Physical Internet principles. Foldability improves return-logistics efficiency, and the locking and traceability functions support cargo security and operational control throughout the logistics chain.
Key trade-offs/limitations at M22	Standardisation across vehicles of different sizes may limit the maximum use of the cargo volume available in each platform. The foldable design must balance compactness against structural stiffness, durability and cargo protection. Reducing the box weight improves payload capacity and manual handling but may affect robustness and service life. The final design must also consider ergonomic handling, anchoring and load-securing requirements, manufacturing cost, cleaning and maintenance, traceability-system integration and compliance with vehicle payload and safety constraints. Another associated issue is loading and unloading at mini-hubs that lack forklifts. This is addressed by designing collapsible equipment specifically for this purpose.
Evidence supporting selection	The selection is supported by the A2 material comparison, Computer-Aided Design (CAD) and packaging studies, compatibility checks against the cargo compartments and interfaces of the target vehicle platforms, and design reviews involving PAX, EUT, TØI and the two OEMs. Operational scenarios provided by the end users were used to assess vehicle-to-vehicle exchange, temporary hub storage, return logistics and compatibility with different fleet configurations.
Expected benefit/target	The GA establishes a target of at least **10% improvement in fleet load efficiency** through transhipment between vehicles of different sizes and manufacturers. It also anticipates a **5% reduction in operational costs** through shorter loading, unloading and idle times. Additional expected benefits include more efficient return logistics, increased fleet flexibility and improved use of the most appropriate vehicle for each part of the delivery mission. These values should be presented as project targets until validated through WP4 testing and subsequent pilot demonstrations (WP6).
Target platform(s)/prototype(s)	The swap box design is compatible with both the IVE eDaily and ALK ATX platforms, demonstrating interoperability between high-volume and purpose-built N1 vehicles. The concept also considers transfer to smaller vehicles, such as the L7 PAX platform, within the Norwegian macro-pilot.
WP4 handover	The package transferred to WP4 includes the selected swap box architecture and material, the main dimensions and standardised interfaces, and the folding, locking, anchoring, handling and traceability requirements. WP4 will complete the manufacturing and assembly of the physical units, their integration into the target vehicles and the validation of structural integrity, cargo securing, folding and handling operations, multi-vehicle compatibility and transhipment performance under controlled conditions.

5.5 Concept 5 – Geofenced N1 right-sized vehicles for safe driving in restricted urban areas

Concept 5 combines vehicle-side capabilities relevant to safe operation in regulated or restricted urban areas. The project concept includes geofencing-triggered functions, driver information and vehicle-to-infrastructure connectivity. WP3 also assesses HMI options that communicate outputs from the holistic energy-management models developed in T3.5 and support more efficient driving. D3.6 should report the selected public HMI concept and clearly identify interfaces that are implemented or validated in later digital and pilot WPs.

Table 10 summarises the design-selection process for Concept 5, including the vehicle-side geofencing functions, driver-information and safety solutions considered, their interfaces with the digital developments of WP5, the main limitations identified at M22, and the resulting handover to WP4 and WP5.

Table 10. Design selection summary for Concept 5

Design selection element	Description
User need/target mission	Enable N1 eLCVs to operate safely and efficiently in restricted or regulated urban areas, supporting compliance with Urban Vehicle Access Regulations, Low Emission Zone (LEZ) and other location-dependent rules. The concept addresses the need to inform drivers as they approach or enter geofenced areas and to support responses such as speed adaptation, compliance with delivery permissions, load restrictions, data-sharing requirements and access to reserved kerbside spaces.
WP3 innovations contributing to the concept	The concept 5 combines T3.1 **design-assessment framework** with T3.3 **safe and ergonomic systems design on vehicle cabin** and T3.5 **Digital Twins and holistic vehicle-control strategy** and **integration of geofencing capabilities**. The idea is the combination of geofencing capabilities within the holistic control strategy, including the vehicle response and powertrain feedback associated with entering or leaving predefined zones. In this sense, it is important to define the driver-information and HMI interface to communicate geofencing warnings, but also relevant control or efficiency information to the driver. The digital geofencing tools, open-data interfaces and platform integration are subsequently developed in WP5.
Design alternatives/iterations	The design work considered different levels of vehicle response, ranging from driver information and visual warnings to possible control or powertrain actions associated with entering a geofenced area. Alternative HMI configurations were considered in terms of warning format, timing, information level and compatibility with safe driving. The concept also considered different geofencing parameters, including speed limits, access permissions, delivery restrictions, load conditions, data-sharing requirements and dynamic kerbside reservations. Alternative connectivity and integration approaches were examined using the existing PAX and ALK platforms.
Related design assessment(s)	A5, **materials and manufacturing methodologies for the new door trim** and A7, **HMI options to improve driving using the holistic energy-management models developed**.

Design selection element	Description
Public assessment outcome	The WP3 assessment identified a progressive and easy-to-interpret driver-information approach as the most suitable basis for communicating entry into or proximity to a geofenced area, while limiting driver workload and distraction. The selected vehicle-side architecture provides the interfaces required to receive location-dependent rules and translate them into driver information or vehicle responses. The assessment of safety-oriented components selected the configurations offering the best balance between occupant and pedestrian protection, component weight and vehicle integration.
Selected design at M22	The selected proposal consists of a geofencing-ready vehicle interface capable of receiving information on the vehicle's position and the applicable rules for predefined urban zones. The concept includes an HMI (PAX app) that provides advance and progressive visual information to the driver when approaching or entering a geofenced area. Depending on the final implementation, the vehicle-side system may also support control or powertrain responses associated with the applicable zone requirements. Connectivity is provided through the existing OEM platforms and the interfaces that will be developed in WP5. The concept is complemented by the selected pedestrian- and occupant-safety components where applicable.
Selection rationale	The final architecture separates the vehicle-side functions from the digital definition and management of the geofenced areas, allowing the concept to be transferred across different vehicles, cities and operational environments. A progressive HMI warning gives the driver sufficient time to adapt vehicle operation while supporting safe manoeuvring and compliance with local regulations. Compatibility with open mobility-data standards and existing OEM platforms reduces dependence on a single proprietary solution and facilitates future integration with urban logistics and traffic-management systems.
Key trade-offs/limitations at M22	The reliability of the concept depends on positioning accuracy, connectivity, communication latency and the availability of up-to-date information on urban access rules. HMI warnings must be sufficiently clear and timely without distracting or overloading the driver. Automatic vehicle-control actions, if implemented, require additional safety, legal and homologation assessment and must allow appropriate management of exceptional situations. Data sharing also introduces cybersecurity, privacy and General Data Protection Regulation (GDPR) requirements. At M22, the vehicle-side interface is defined within WP3, but complete digital integration and operational validation remain dependent on WP5 and WP6.
Evidence supporting selection	The selection is supported by the HMI-option assessment, vehicle-control architecture developed in T3.5, review of the interfaces with the OEMs cloud services platforms, and analysis of the geofencing requirements provided by the pilot cities and logistics providers. Full validation of the geofencing functionality in representative urban conditions is outside the WP3 scope and will be completed in later work packages.

Design selection element	Description
Expected benefit/target	The concept is expected to improve driver awareness and compliance with location-specific urban regulations, support safer vehicle operation in areas with vulnerable road users and facilitate access to restricted areas or extended delivery time windows for zero-emission vehicles. It should also support more efficient use of dynamic kerbside space and improve information exchange between vehicles, logistics operators and public authorities. No specific quantitative geofencing-performance target has been demonstrated at M22; operational benefits will be evaluated during WP5 simulations and WP6 pilot activities.
Target platform(s)/prototype(s)	The geofencing functions are intended for the ALK S2Z v1 and v2 configurations. The selected safety-oriented door-trim components are expected to be integrated into ALK S2Z v3.
WP4 and WP5 handover	The package transferred to WP4 includes the selected vehicle-side HMI and control-interface requirements, the definition of the relevant vehicle signals and responses, and the selected safety-component designs where applicable. WP4 will address their prototype integration and vehicle-level verification. The definition of geofenced areas, urban rules, data exchange, platform connectors and operational-management tools is transferred to WP5 for software development and integration. The complete system will subsequently be validated under real-life conditions in WP6 pilot tests.

5.6 Concept 6 – Dynamically optimised modular vehicle for dual transport of goods and people

Concept 6 addresses flexible use of the same vehicle for passenger and freight missions. The selected WP3 direction is a 4-seater configuration, adapted from the 6-seater proposal baseline following ALK input that the 4-seat arrangement is more representative of commonly used vehicle configurations.

The concept combines a retractable second row, a reconfigurable seating/cargo layout, a movable separation between passenger and cargo areas and compatibility with the foldable swap box. Table 11 summarises the design-selection process for Concept 6, including the alternative seating and cargo configurations considered, the assessment evidence supporting the selected 4-seater design, the main trade-offs identified at M22, and the resulting handover to WP4.

Table 11. Design selection summary for Concept 6

Design selection element	Description
User need/target mission	Enable the same vehicle to perform passenger, freight or combined transport missions, adapting its internal configuration to changing operational demand. The concept responds to the needs of shared-mobility operators and users requiring an affordable vehicle that can transport people during passenger-demand periods and provide increased cargo capacity for delivery operations at other times. It is particularly relevant to the shared eLCV service planned for the Brussels pilot.

Design selection element	Description
WP3 innovations contributing to the concept	This last concept combines T3.1 **design-assessment framework** with T3.4 **Dual transport of goods and people**, reconfiguring the ALK ATX interior layout, incorporating a retractable second row of seats that can be retracted to increase the available cargo volume. A movable passenger–cargo partition is developed as a protective separation system that changes position according to the selected passenger and cargo configuration. A safety assessment of the dual-transport configurations and their implications for occupant protection, cargo separation and vehicle integration began during WP3 and will be completed throughout WP4.
Design alternatives/iterations	The design process considered different combinations within the 4-6-seat range foreseen in the GA. The initial development baseline was based on a 6-seater configuration that could be converted into a 4-seater arrangement with increased cargo capacity. Following the assessment and input from ALK, a 4-seater configuration with a retractable second row was selected as the most representative and suitable solution. Different alternatives for retracting the second row, positioning and type of the protective partition were also considered.
Related design assessment(s)	A6, **options for the retractable second row of seats**
Public assessment outcome	The comparison showed that the 4-seater configuration provides the most suitable balance between passenger capacity, usable cargo volume, operational relevance, safety and integration complexity. Compared with the 6-seater baseline, the selected arrangement is more representative of commonly used vehicle configurations while retaining the ability to increase cargo capacity by retracting the second row of seats. The selected retractable-seat solution also provides the most suitable integration with the movable protective partition system.
Selected design at M22	The selected design is based on a 4-seater ALK ATX configuration, with two front seats and a retractable second row. In passenger or combined-transport mode, the vehicle can accommodate up to four occupants while retaining a separate rear cargo area. When additional cargo capacity is required, the second row is retracted, and the protective passenger–cargo partition is moved forward, increasing the available cargo volume while maintaining separation between occupants and goods.
Selection rationale	The 4-seater configuration was selected because it represents a realistic compromise between passenger capacity and freight flexibility and is better aligned with common user and shared-mobility requirements. It preserves the main functionality of the original concept - dynamic adaptation between passenger and freight missions - while reducing the packaging and integration complexity associated with a 6-seat arrangement. The solution also supports safe separation of passengers and goods and maintains compatibility with the modular swap box concept.
Key trade-offs/limitations at M22	Increasing passenger capacity reduces the volume available for freight, while maximising cargo space requires retracting the second row. The seats, rails and movable partition introduce additional mass, cost, mechanical complexity and maintenance re-

Design selection element	Description
	quirements and may affect the vehicle's usable payload. The design must also ensure appropriate seat anchorage, restraint-system performance, occupant protection, cargo securing and separation between passengers and goods in every configuration. Reconfiguration time, handling ergonomics and the prevention of incorrect locking or positioning must be validated. Homologation requirements can be difficult to determine, given that it is a hybrid vehicle not yet on the market.
Evidence supporting selection	The selection is supported by the A6 comparison of retractable second-row options, CAD and packaging studies, assessment of alternative seating and cargo layouts, reviews of the movable-partition interface, and design discussions involving WP3 partners. Additional evidence includes the safety review of the dual-transport configurations (IDI), compatibility assessment with the foldable swap box and comparison with existing ALK vehicle configurations. Physical and vehicle-level validation remains part of WP4 and WP6.
Expected benefit/target	The selected concept is expected to improve vehicle utilisation by allowing a single vehicle to cover passenger, freight and combined missions, potentially reducing the number of specialised vehicles required by an operator. It should increase operational flexibility, improve affordability for shared users and support new shared-mobility business models. The GA anticipates a potential **20% increase in business volume** for the shared-mobility operator following adoption of the dual-transport service; this is a market-level project target and not a result demonstrated at M22.
Target platform(s)/prototype(s)	The selected concept is designed specifically for the ALK ATX platform and will be implemented in the dedicated dual-transport prototype. Its main operational demonstration is planned within the shared eLCV service in the Brussels pilot.
WP4 handover	The package transferred to WP4 includes the selected 4-seater layout, the retractable second-row design, the movable passenger–cargo partition, the swap box interfaces and the relevant structural, mechanical, safety and homologation requirements. WP4 will manufacture and integrate the selected configuration and validate the seat and partition mechanisms, locking functions, occupant protection, cargo securing, reconfiguration process, ergonomics, payload implications and overall vehicle functionality.

6. Consolidated vehicle configurations and handover to WP4

The selected WP3 innovations are combined differently across the IVE eDaily and ALK ATX-based S2Z vehicle configurations. Figure 16 provides a consolidated visual overview of these configurations, using the six S2Z concepts as a common reference to identify the innovations assigned to each vehicle version and their intended validation or pilot activities.

The figure should be interpreted as a configuration map rather than as an indication of design maturity or as a direct representation of the number of physical prototypes. Different vehicle versions may correspond to alternative configurations or uses of the same platform. Table 12 complements the figure by reporting the integration level achieved at M22 and specifying the components, systems and design packages transferred to WP4 for prototyping, vehicle integration and validation.

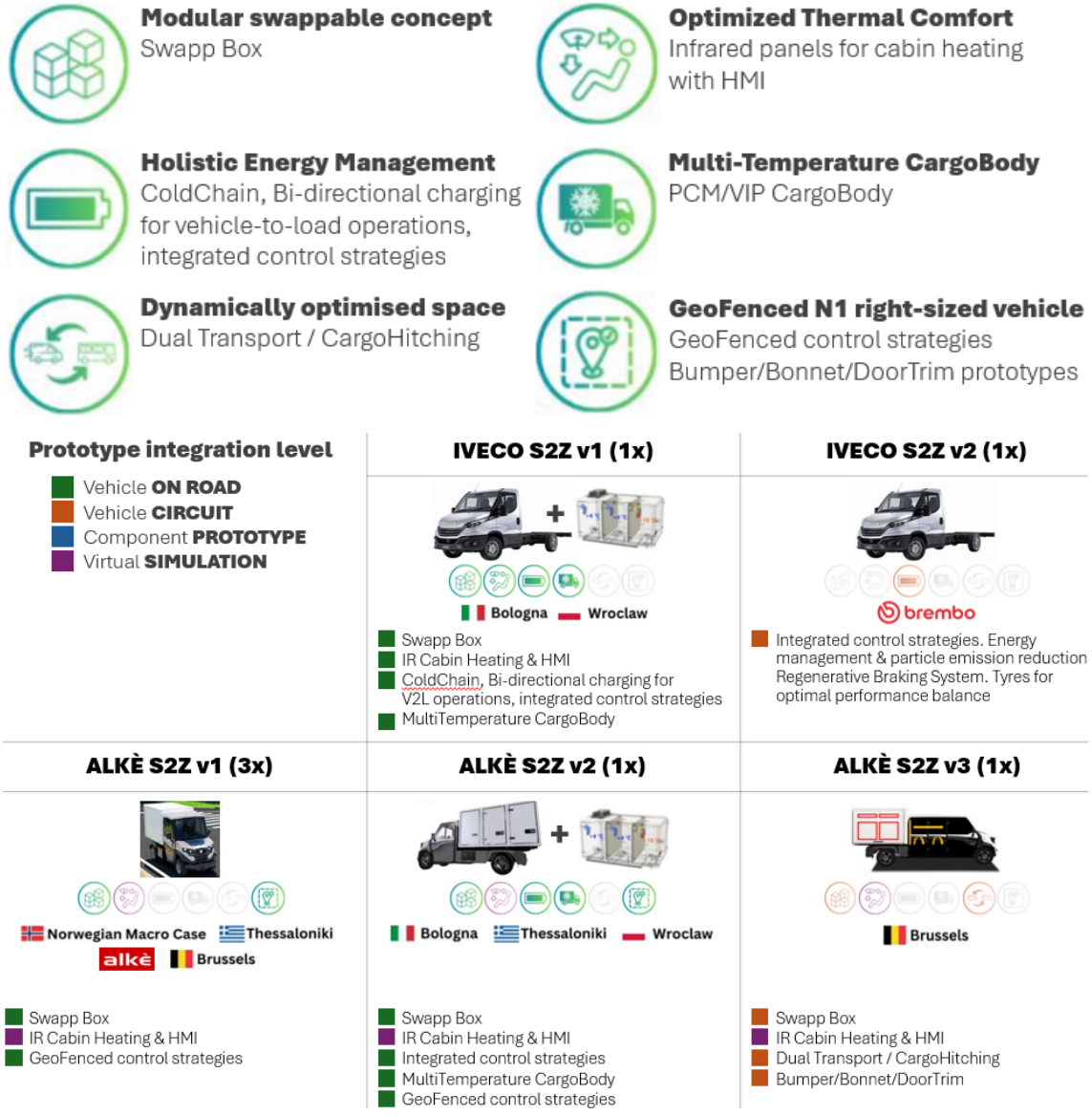


Figure 16. S2Z vehicle configuration map showing the six-concept legend, the innovations assigned to each vehicle, and the corresponding target pilot sites

Table 12. WP3 innovations included to S2Z vehicle configurations, integration status at M22, target pilots and WP4 handover activities

Vehicle /version	Selected WP3 innovations	Integration level at M22	Target pilot(s)	WP4 handover
IVE S2Z v1 Multipurpose operational vehicle	Multi-temperature modular cargo body with all its features; swap box; IR cabin-heating system; intelligent thermal-management strategy; vehicle-to-e-bike charging interface; vehicle communication and monitoring interfaces	Designs completed and main component specifications defined. Component prototypes available or under preparation; vehicle-level integration ongoing in WP4	Bologna and Wrocław	Manufacture and integrate the multi-temperature cargo body, swap box interfaces, IR panels, HMI and thermal-control system. Complete the vehicle-to-e-bike charging integration and validate electrical compatibility, thermal performance, communication interfaces, cargo-body functionality and vehicle-level operation
IVE S2Z v2 Energy-optimisation vehicle	Optimised tyre selection; advanced brake hardware; increased use of regenerative braking; tyre and brake Digital Twins; holistic vehicle-control strategy; energy-management HMI	Selected hardware and control architectures defined. Tyre and brake solutions and simulation models available at component or virtual-prototype level; calibration and vehicle integration ongoing	No operational pilot assigned. Controlled proving-ground and specialised laboratory validation (BRE)	Integrate the selected tyres, brake-system and control software. Calibrate the Digital Twin models and holistic control strategy and validate regenerative braking, powertrain efficiency, tyre and brake performance, and non-exhaust emissions
ALK S2Z v1 Modular and geofencing-ready vehicle	Modular swap box; geofencing-ready vehicle interface; driver-information HMI; interfaces	Designs and vehicle interfaces defined. Component-level integration completed or ongoing; final connection with WP5 geofencing tools and vehicle-level validation remain pending	Bergen/Oslo, Thessaloniki and Brussels	Integrate and verify the swap box securing system and the vehicle-side geofencing interface. Confirm communication with the OEM platform and provide the vehicle signals and interfaces required for WP5 and WP6 validation
ALK S2Z v2 Multi-temperature cargo-body vehicle	Multi-temperature modular cargo body; movable internal partitions; eutectic thermal-storage system; ventilation and temperature-control	Cargo-body design selected and supported by CFD and thermal analyses. Subsystem or cargo-body prototyping ongoing; full vehicle integration	Bologna, Thessaloniki and Wrocław	Manufacture and integrate the selected cargo-body configuration and its thermal-management, ventilation, sensor and communication systems. Validate structural integration, temperature distribution, movable

Vehicle /version	Selected WP3 innovations	Integration level at M22	Target pilot(s)	WP4 handover
	system; smart sensors and IoT monitoring; modular swap box; geofencing-ready interface	and thermal validation remain within WP4		partitions, cargo securing, payload implications, energy consumption and the relevant cold-chain requirements
ALK S2Z v3 Dual-transport vehicle	4-seater dual-transport configuration; retractable second row; movable passenger–cargo partition; compatibility with the foldable swap box; safety-oriented bonnet, bumper and interior door trim	Final 4-seater design selected, and main mechanical and safety interfaces defined. Component prototyping and vehicle integration ongoing; full functional, safety and homologation validation remain pending	Brussels shared-mobility pilot	Manufacture and integrate the retractable-seat system, movable partition, rails, swap box interfaces and selected safety components. Validate locking and reconfiguration mechanisms, occupant protection, cargo separation and securing, ergonomics, payload implications, shared-operation functions and homologation requirements

6.1 Main critical interfaces and cross-configuration dependencies

Once the allocation of innovations to the different vehicle configurations has been established, the main integration challenge concerns the interfaces between components and systems developed in different WP3 tasks. These interfaces include mechanical and structural connections, power supply, vehicle communication, control software, thermal management, HMI functions and data exchange with external platforms.

This section does not repeat the innovations assigned to each vehicle. Instead, it identifies the main cross-task dependencies that must be managed during WP4, WP5 and WP6. Table 13 records the design baseline available at M22 and the remaining activities required to ensure that the individual innovations can operate as part of an integrated vehicle configuration.

Table 13. Main critical interfaces between selected WP3 innovations and remaining integration activities

Critical interface	Affected configuration(s)	Design baseline at M22	Remaining integration or validation activity	Main responsible partners / WP
IR Heating Panels; existing HVAC; HMI; thermal-control strategy	IVE S2Z v1	The functional architecture, main component requirements and control approach have been defined	Confirm panel positioning and electrical interfaces; calibrate the combined IR/HVAC strategy; validate thermal comfort, energy demand, HMI operation and	AIT, IVE and ALK; WP4

Critical interface	Affected configuration(s)	Design baseline at M22	Remaining integration or validation activity	Main responsible partners / WP
			vehicle-specific performance	
Brake and tyre models; vehicle-control strategy; driver HMI	IVE S2Z v2	The selected brake and tyre solutions, Digital Twin models and overall control architecture have been defined	Complete model calibration and software integration; verify communication with vehicle systems; validate braking performance, recuperation, driveability, energy efficiency and non-exhaust emissions	IKA (RWTH), BRE, MIC and IVE; WP4
Multi-temperature cargo body; vehicle chassis; power and communication systems	IVE S2Z v1 ALK S2Z v2	The cargo-body geometry, thermal architecture, movable-volume concept, sensor requirements and main vehicle interfaces have been defined	Validate mechanical attachment, power demand, communication, temperature distribution, movable partitions, payload implications, structural performance and cold-chain compliance	COL, EUT, IVE and ALK; WP4
Swap box; vehicle cargo compartment; anchoring and rail systems	IVE S2Z v1 ALK S2Z v1, v2 and v3	The main dimensions, material selection and functional requirements for folding, locking, securing and traceability have been defined	Verify compatibility with each cargo compartment, rail and anchoring systems; validate handling, load securing, folding operations, durability and interoperability between vehicles and distribution warehouses	PAX, EUT, TØI, GRU, DHL, DIA, DPD, IVE and ALK; WP4 and WP6
External charging interface; vehicle battery; e-bike battery location	IVE S2Z v1	The vehicle-to-e-bike charging use case, preliminary energy-transfer architecture and battery-position requirements have been defined	Complete electrical and mechanical integration; validate charging functionality, available energy, battery accessibility, safe storage and the impact on the vehicle mission and remaining driving range	LPIMOT, IVE and DPD; WP4 and WP6
Vehicle-side geofencing interface; OEM cloud services;	ALK S2Z v1 and v2	The required vehicle inputs, driver-infor-	Develop and validate platform connectors, geofence definition and rule	PAX, CER, IKA (RWTH), ALK, relevant

Critical interface	Affected configuration(s)	Design baseline at M22	Remaining integration or validation activity	Main responsible partners / WP
S2Z digital platform		mation functions and potential vehicle responses have been identified	management, data exchange, positioning accuracy, HMI warnings and any authorised vehicle-control responses	pilot cities; WP5 and WP6
Retractable seats; movable partition; rail system; swap box; safety systems	ALK S2Z v3	The 4-seater layout and the main mechanical, packaging and safety interfaces have been selected	Manufacture and integrate the mechanisms; validate seat and partition locking, occupant protection, cargo separation, load securing, reconfiguration ergonomics, payload and homologation requirements	ALK, EUT, IDI and PAX; WP4

The interfaces identified above constitute the main coordination points between the WP3 design packages and the subsequent prototyping, integration, digital-development and validation activities in WP4, WP5 and WP6. Detailed technical specifications may remain in the restricted project documentation, while this public deliverable records the principal dependencies, the responsibilities transferred and the validation still required.

6.2 Validation route beyond M22

M22 marks the completion of the WP3 design-selection phase and the establishment of the technical baseline transferred to subsequent work packages. It does not represent the completion of physical vehicle integration or final validation. The maturity reported in this deliverable must therefore distinguish between the evidence used to support a design decision and the results that will be generated later through component, vehicle or operational testing.

Table 14 summarises the validation route from the selected WP3 designs to the real-life demonstration of the S2Z concepts. Rather than repeating the maturity of each individual innovation, already reflected in the consolidated vehicle table, it explains the purpose and expected evidence associated with each successive validation stage.

Table 14. Validation route from the WP3 design baseline to real-life demonstration

Validation stage	Main purpose	Expected evidence or output	Contribution to final validation
WP3 design selection. M22 baseline	Select the preferred designs and configurations and define the main technical and vehicle interfaces	Design assessments, simulations, comparative analyses, CAD models, selected architectures, interface	Provides the justified design baseline and technical handover to WP4 and WP5

Validation stage	Main purpose	Expected evidence or output	Contribution to final validation
		requirements and design-review decisions	
T4.1. Component and system prototyping	Manufacture and initially verify the selected components and subsystems before vehicle integration	Component prototypes, functional tests, preliminary safety tests, subsystem checks and updated integration specifications	Confirms that the selected designs can be manufactured and function at component or system level
T4.2. Vehicle integration	Install the selected components and systems in the IVE and ALK vehicle platforms and resolve physical and digital interfaces	Installation records, interface verification, software and communication integration, packaging checks and subsystem commissioning	Demonstrates compatibility between the innovations and the target vehicle platforms
T4.3. Controlled vehicle-level validation	Assess the integrated configurations under controlled laboratory, test-track or proving-ground conditions	Vehicle-level thermal, energy, braking, tyre, safety, charging, cargo-body and functional test results, as applicable to each configuration	Provides validated vehicle-level performance and identifies any adjustments required before pilot operation
T4.4. Cross-OEM cooperation and compliance	Address common integration challenges and review applicable safety, homologation and standardisation requirements	Cross-OEM recommendations, compliance reviews, homologation inputs and knowledge-transfer records	Supports safe and compliant deployment and the transferability of selected solutions between vehicle platforms
WP5. Digital integration and simulation	Integrate vehicle data with the S2Z digital platform and optimise pilot configurations before physical demonstration	Platform connectors, geofencing and decision-support tools, data-stream integration, digital interfaces and large-scale simulation results	Validates the digital and operational layer that cannot be assessed through vehicle hardware testing alone
WP6. Real-life pilot demonstration	Demonstrate the selected concepts in representative logistics missions and urban environments	Operational KPIs, user feedback, reliability evidence, mission-level performance and results from the target pilot sites	Provides the final evidence needed to assess operational suitability, scalability and project impact

Only evidence available by M22 is presented in D3.6 as supporting the selection of a design. Component-level, vehicle-level and operational results generated after M22 will be identified as subsequent validation evidence and reported in the corresponding WP4, WP5 and WP6 deliverables.

7. Evolution from the proposal baseline and relevant design changes

WP3 is an iterative design work package, and changes from the proposal baseline can be expected when new technical evidence, integration constraints, safety considerations or user feedback become available.

This section focuses on technically meaningful changes rather than minor drafting differences. For each change, the deliverable states the original baseline, the final WP3 decision, the reason for the change and whether it affects prototype integration, pilot implementation or project targets.

7.1 Evolution of the dual-transport concept

The original S2Z proposal envisaged a modular 6-seater vehicle based on the ALK ATX platform, enabling the combined transport of passengers and goods. During the design phase, the concept was adapted to a 4-seater configuration following input from the vehicle manufacturer.

This configuration was identified as more representative of commonly used vehicle arrangements and better aligned with existing vehicle architectures and potential future applications. The revised concept maintains the original objective of adapting passenger and cargo capacity to different operational requirements.

7.2 Evolution of the bidirectional charging use case

The original proposal included the use of bidirectional charging to supply energy from an eLCV to APMs, addressing InPost's operational requirements. Following the replacement of InPost by DPD as the logistics partner, the use case was adapted to supply electric cargo-bike batteries.

The revised vehicle-to-e-bike application maintains the original objective of extending the functionality of electric commercial vehicles as mobile energy sources within urban logistics operations. The technical requirements and selected charging configuration are consequently adapted to the revised operational scenario.

8. Conclusions and next steps

WP3 has translated the user, mission and technical requirements established in WP2 into a consolidated set of vehicle designs, components, functionalities and control strategies. D3.6 brings together the developments completed in tasks T3.2, T3.3, T3.4 and T3.5 and applies the common assessment and selection approach defined in T3.1 to establish the design baseline for the six S2Z concepts at M22.

The selected concepts cover complementary areas of innovation: multi-temperature cargo management; cabin thermal comfort and ergonomics; holistic energy management and external charging; modular transhipment; geofencing-enabled urban operation; and the combined transport of goods and people. These concepts have been allocated in different combinations across the IVE eDaily and ALK ATX-based configurations, providing the technical basis for their subsequent prototyping, integration and demonstration.

The selection process has highlighted that the optimal vehicle configuration cannot be defined by considering each innovation independently. Relevant design decisions involve trade-offs between thermal autonomy and payload, energy efficiency and vehicle performance, modularity and cargo-space utilisation, passenger capacity and freight volume, safety and component weight, and standardisation and platform-specific integration. The selected solutions represent the most appropriate balance identified at M22 based on the available assessments, simulations, design reviews, technical analyses and partner input.

The work also resulted in several refinements with respect to the proposal baseline. These include selecting a 4-seater configuration within the originally defined 4-6-seat range and adapting the external-charging use case from APMs to e-bike batteries following the change in end-user. These developments maintain the main functions and objectives of the corresponding concepts, while their rationale and implications are documented in the section addressing evolution from the GA baseline.

D3.6 closes the WP3 design-selection phase but does not constitute final validation of the integrated vehicles. At M22, the selected architectures and main interfaces are sufficiently defined to support their transfer to the subsequent technical activities. Remaining work includes component manufacturing and testing, vehicle integration, software calibration, safety and homologation checks, controlled vehicle-level validation and the connection of vehicle-side functions with the digital tools developed in WP5.

The next stage will therefore focus on implementing and validating the selected designs in WP4, completing the digital and operational integration in WP5 and demonstrating the resulting concepts in representative logistics missions in WP6. The evidence generated during these activities will subsequently support the assessment of the operational, environmental, economic, societal and safety impacts of the S2Z solutions.