Deliverable D 4.1
Description of use cases

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Responsible/Author:	Sophie Nägele, DLR
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Report contributors		
Name	Beneficiary Short Name	Details of contribution
Sophie Nägele	DLR	Task lead, content (Chapters 1-10)
Yannek Karim Adams	DLR	Content (Chapters 3, 4, 5)
Maria Traunmüller	MID	Content (Chapters 5, 6, 7, 10)
Aaron Paz Martinez	DLR	Content (Chapters 1-5)
Nicolai Schmauder	DLR	Content (Chapters 1, 2, 3, 5, 6)
Manuel Osebek	DLR	Content (Chapters 1-10)
Mahnam Saeednia	TUD	Content (Chapters 1- 5)
Dirk Winkler	SMO	Content (Chapters 8, 10)
Walter Struckl	SMO-AT	Content (Chapters 6, 7)

Reviewed: Yes
Reviewers: TRV, SMO, UPM

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1. Executive Summary

The aim of the Deliverable 4.1 “Description of use cases” is to identify and describe potential use cases (UC) for Pod systems. The definition of the UCs considers technological feasibility, environmental impact, economic viability as well as user- and society-centred design and operation. The main advantage of Pod systems is the user-friendly transport of people and goods. Hence, the significance of UC lies in their ability to pinpoint user requirements, emphasizing the essential fulfilment of system functionalities aligned with user needs.

The approach of this task is to use diverging and converging methods to iterate from a wide spectrum of possible use cases to a more specific description of the most valuable UC. As diverging method morphological charts were used to create a list of various UCs that were further detailed by mobility journeys. Through classifying and prioritising several parameters, each UC could be characterized. This converging method was used to manage the large number of UC. Additionally, an analysis of synergies between identified UCs and derivation of technical parameters for transport unit (TU) and carrier was carried out.

Task 4.1 shows that mainly three kinds of transport solutions have to be considered for Pod systems. Passenger transport UCs such as premium and individual transport services are highly relevant, since they can offer new services and better comfort for several user groups. For freight transport and combined (passenger and freight) transport, Pod systems offer new solutions for more effective, flexible freight transport and also for specific event-driven UC. The identified use cases represent possible and feasible scenarios, although with such a flexible system, even more use cases can be realised.

Based on the technical overview of Pod systems conducted for D2.2, D4.1 determines potential UC and their specific characteristics, which gives valuable input for the subsequent Task 4.2 (SWOT analysis), Task 4.4 (Functional Requirement Specification) as well as several follow-up work packages (WPs) such as WP5 (Business Case Development), WP7 (Pod Technical Concept), WP8 (Design Variants) or WP11 (traffic coordination).

2. Abbreviations and acronyms

Abbreviation / Acronym	Description
3PL	Third-Party Logistics (provider)
4PL	Fourth-Party Logistics (provider)
BMI	Body Mass Index
B2B	Business-to-Business
B2C	Business-to-Consumer
CU	Carrier unit
D	Deliverable
D2.2	Deliverable “Evaluation/Benchmark of available and conceptional multimodal mobility systems” in Pods4Rail
DG	Dangerous goods
ETCS	European Train Control System
EU	European Union
EU-Rail	Europe’s Rail Joint Undertaking
HVAC	Heating, ventilation and air conditioning
ID	Identification number
km	Kilometre
LGBTQI+	Lesbian, gay, bisexual, transgender/ transsexual, queer/ questioning, inter-sex, asexual.
LU	Loading unit
MaaS	Mobility as a Service
MAWP	Multi-Annual Work Programme
MMP	Mobility management platform
PI	Physical Internet
Pod	Decentralized, fully autonomous transport system
PRM	Person with Reduced Mobility
PT	Passenger transport
T	Task
TU	Transport Unit
UC	Use case / Use cases
WP	Work package

3. Background

The present document constitutes the Deliverable D4.1 “Description of use cases” in the framework of the Flagship Project 7 Pods4Rail as described in the EU-RAIL MAWP.

In today’s era of increasing transportation demand (freight as well as passenger), traditional transportation systems fall short in meeting requirements for faster, more cost-effective, and environmentally sustainable transportation [1]. As a response to this pressing need, disruptive approaches have emerged as potential alternatives or complements to conventional systems. These innovative solutions emphasize the utilization of railway systems as a sustainable mode of transportation in combination with cutting-edge technologies. The need for change is evident and is also recognized by the European Union by supporting such innovative ideas for shaping the future of railway transport in the newly launched Europe’s Rail Joint Undertaking (EU-Rail). The main aim of the project Pods4Rail is to provide a concept of a fully automated intermodal mobility system for passengers and goods which is sustainable, collaborative, interconnected, digital, on-demand, standardised, scalable and suitable for several transport modes with focus on rail. Such systems allow higher flexibility through intermodality, building on the concept of considering mobility as a service (MaaS) and utilizing the existing infrastructure. Hence, it becomes imperative to consider various aspects of necessary modifications. Such aspects are crucial for ensuring full deployment of the system.

Building on the results of WP2, Task 4.1 augments the insights gained so far by defining potential UCs for the new and innovative system introduced in this project. While technology assessment for passenger and freight were at the heart of WP2, the focus of Task 4.1 is to identify viable solutions from the design space that address real user needs, while also being technologically feasible. To that end, the findings from the technology assessment will directly influence the decisions made in this WP. Both technology and user requisites need to be addressed concomitantly for the definition of feasible and desirable UCs. Additional factors that were considered for the formulation of application scenarios were energy demand, environmental impact and economic viability. For freight applications the demand side was considered by assuming a demand-driven system design and dividing the demand into different categories, which are the basis for defining the UCs. Furthermore, combined solutions will also be considered. Combining freight shipments with passenger services is not a novelty. Worldwide, railways have been running so-called mixed trains for a long time [2]. In Australia and the US, the Greyhound company has been running mixed bus services for over four decades [3]. Recently, the concept of combining passenger and freight transportation has been gaining new momentum in the research arena because of the potential environmental and economic benefits it offers (see also the examples of cargo trams described in D2.2 of this very project). In addition, the recent growth of e-commerce and parcel delivery provides new opportunities for combining parcel delivery and passenger transport, since they have similar geographically distributed demand patterns [4]. The technological availability has unlocked the potential to enhance this concept, which was previously confined to specific cases.

D4.1 contributes to Flagship Area 6 project FutuRe [5], e.g., by sharing insightful discussions on secondary lines through its outcomes.

4. Objective/Aim

The objective of D4.1 is to provide UC descriptions of some potential applications of intermodal Pod system concepts. These UC will be the input for subsequent tasks and work packages by providing detailed information about potential needs and requirements.

The use cases are examined and described in terms of technical feasibility, economic viability, environmental impact, and user- and society-centred design and operation, with focus on rail, and with interfaces to road and eventually rope-way. The UCs reflect not only the needs of various users, but also the preliminary examination of the feasibility of meeting those needs with available and future technologies.

Pods4Rail is a showcase project that aims to develop scalable solutions for Pod system UC, i.e., the UC developed are to be consolidated and evaluated in task 4.2 (SWOT analysis).

5. Methodology for the collection of use cases for Pods systems

In this document, a UC is defined as a technically feasible combination of identified applications of intermodal, autonomous Pods, with the focus on rail-based systems and the system infrastructure to enable a demand-based transport and logistics supply for moving people and/ or goods.

From the Pods4Rail perspective, the interdependent elements of any mobility system include, but are not limited to, physical space, travellers or users, vehicles, system designers and manufacturers, operators and maintainers.

To arrive to a set of potential UC for the system under investigation in the Pods4Rail project, a multi-methodological approach was followed. In a first step, morphological charts [6] were established. In a second step, based on the morphological charts, as well as on the expertise of the project partners participating in Task 4.1, a collection of potential UC was established via an ideation process. In a third step, the identified UC were clustered and described. The description includes technological, environmental and economic as well as user- and society-centred criteria.

5.1. Morphological charts for use case collection

In Task 2.2, a variety of existing and developing Pod concepts were characterised and evaluated by specifying several technical, economic, environmental, societal and user features. Since the technology is still under development, it was sensible to expand the solution space in Task 4.1 to examine novel application scenarios in a systematic manner. For this reason, the following morphological charts were created (see Tables 1, 2 as well as Tables A1 and A2 in the Appendix 10.1) to show possible design options (rows) for a specific category (columns). In the following, the two most important charts are explained in detail, since they introduce the key characteristics of each UC in case of transport type and user group. Meanwhile, the other charts can be found in the Appendix 10.1. Morphological charts are matrices that map system functions and possible implementations of these functions across its rows and columns. They are used extensively to systematically develop design options within a given solutions space [7, pp. 105]. Key design features and options for their implementation are presented in a table, from which the dependencies of the key design features are tied together to form integrated design concepts. This approach is particularly appropriate for a first evaluation when creating design concepts in the early phases of a project. The method aligns ideally with the current stage of development in this project concerning pod design options.

In this report, morphological charts are used for providing a detailed description of the design concepts, to form the basis of UC and to map the user perspective as well as relevant technical details to each specific UC. While the inclusion of technical parameters sought to investigate various technical components for Pods, the integration of user characteristics aimed to diversify the primary user group and to thereby increase the inclusiveness of the concept.

The first morphological chart describes the general characteristics of a mobility UC according to

the scope of the project (see Table 1), to identify its main aspects, such as transport purpose or operational area. Another important aspect is to define the type of service as well as the main transport modes that should be available in the UC. Some of the listed characteristics are out of the scope of this project and are therefore not subject for further development (e.g., waterway transport or aerospace). This chart helps to categorise a UC in a general manner.

Table 1. Morphological chart for transport type characteristics

Transport aim	Operational area	Service	Transport mode
Passenger transport	Urban mobility	Regular service	Railway (Train infrastructure)
Freight transport	Suburban mobility	On-demand service	Road (Road infrastructure)
Passenger and freight combined (in same TU)	Rural mobility		Ropeway (Cable car/ funicular infrastructure)
Passenger and freight combined (in separate TU)			Tram
Separate freight box attached to TU			Magnetic rail (out of scope)
Others (e.g., Services)			Water (out of scope)
			Air mobility (out of scope)
			Dedicated new infrastructure

The second morphological chart “Description of general transport unit usage for the use cases” (see Table A1 in Appendix 10.1Fehler! Verweisquelle konnte nicht gefunden werden.) describes how the TU is being used in each UC. This is to identify the specific type of transported entities like the type of passengers or freight. Moreover, it is necessary to categorise details such as the trip distance and dimensions of each TU to define requirements of the TU design at a later stage.

The third morphological chart “Technical details regarding the use case” (see Table A2 in Appendix 10.1Fehler! Verweisquelle konnte nicht gefunden werden.) highlights important technical specifications of the UC. Due to a further check of the technical feasibility, it is important to describe their most suitable technical set-up. This chart also provides information about the possible business model description. This chart contains a description of, for example, the automation technology, power and battery characteristics and the integration of the Pod system in different infrastructures.

The last morphological chart (see Table 2) concerns relevant user group characteristics. Those are important for the detailed description of each UC, since they provide information about specific needs for the desired user group. Therefore, the chart gives criteria options about socio-demographics, geographical factors or mobility behaviours of the addressed user groups. In the following UC descriptions, those details can be used to define and match the needs.

Importantly, the UC description is not limited to the contents of these morphological charts. However, the charts support grouping and combining solutions for each category. Therefore, the UC description in chapter 6 will be extended by additional details and further information.

Table 2. Morphological chart for user group characteristics

Socio-demographics	Diversity dimensions	Geographical factors	Mobility behaviour	Psychological factors	Needs
Age [9], [10], [11]	Age [9], [10], [11]	Time to closest public transport [8], [11]	Trip purposes [9], [11], [14]	Attitudes: sustainability [12], [13]	Affordability [8]
Gender [10], [11]	Gender [10], [11]	Distance to closest public transport [8]	Mode choice [12]	Subjective norm: mobility behaviour [12]	Short travel time [8]
Income [10], [11], [13]	Ethnicity [10]	Degree of urbanisation [10]	Trip distance [11]	Perceived behavioural control [12]	Reliability [8]
Family status [9], [10]	Migration background [10]	Population density [12]	Travel time index [13]	Perceived compatibility (e.g., with values or lifestyle) [12]	Safety and Security [8]
Field of work [10], [12]	Family status [10]	Geographically isolated location [10]	No. of means of transport per household [11]	Reasons for (e.g., ease or money saving) [11]	Accessibility [8]
Participation in sport [14]	LGBTQI+ [10]		MaaS usage frequency	Reasons against (e.g., risk or uncertainty) [12]	Comfort [8]
Body proportions [10]	Persons with disability [9], [10]		Has driving licence [12]	Technical prowess	Sanitary facilities [8]
Cost of living [12]	Person with reduced mobility [9]		No. of different modes used	Public transport satisfaction [12]	Easy ticket purchase [8]
Housing situation	Guide dog, walker etc. [9]		Public transport subscription [15]	Safety concerns [16]	Good disturbance and complaint management [8]
	Education [10]		Availability of sharing mobility concepts [12], [14]	Stress [17]	Minimal health risks [8]
	Socio-economic status [10]			Privacy [8], [18]	Entertainment [8]
	Field of work			Comfort [8], [17]	Usability [8]
	Obesity/ BMI [10]			Desire for Social relatedness [19]	Silence [8]
	Religion and world views [10]			Flexibility in mobility	Privacy [8]

5.2. Categorization of identified use cases

Based on the morphological charts, as well as the expertise of all project partners, a collection of potential use cases was established via an ideation process. The resulting list of UC is grouped in the main categories of the transport type “Passenger transport services”, “Combined passenger and freight transport services”, “Freight transport services” and “Other transport services”. Figure 1 depicts these four broad categories, indicates that the TUs can be of different size and capacity, that Pods can be employed for railway, road and rope-way transport and that they should meet the mobility needs of (sub-)urban and rural regions. The complete list of all collected UCs, including a brief description of each UC, can be found in Appendix 10.2.

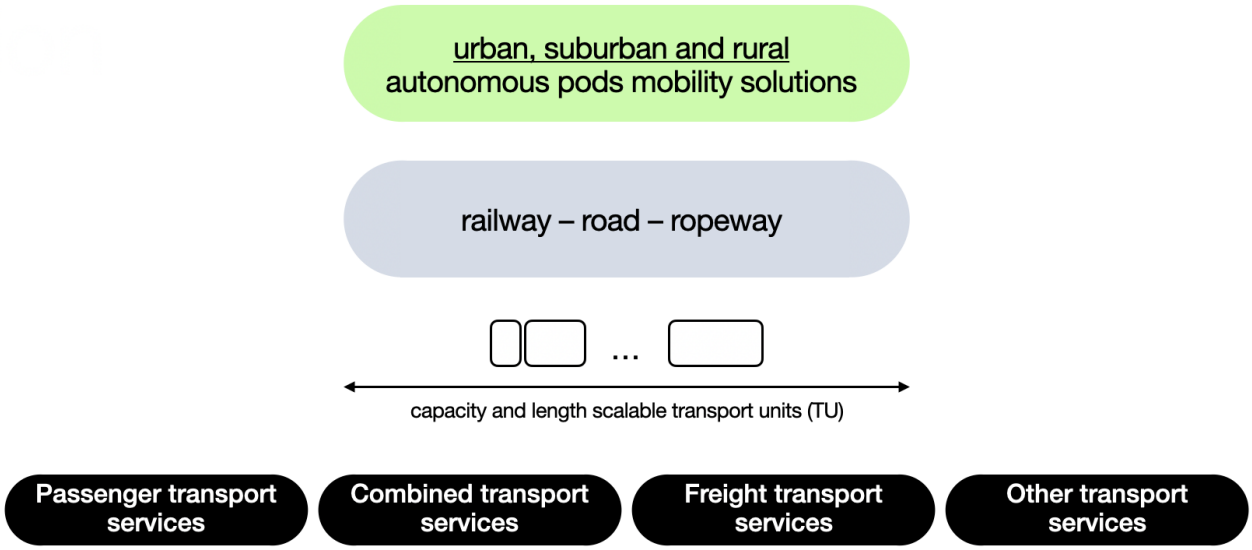

Figure 1. Categories of identified UC

The group “Passenger transport services” contains all UC ideas with the main focus on transporting individual passengers or groups of passengers on a door-to-door or station-bound basis. These include, for example, UC that fulfil certain requirements for Persons with Reduced Mobility (PRM) or address the various circumstances of public or individual transport.

Use case ideas whose main focus is transporting various types of freight and loading units are gathered in the group “Freight transport services” (e.g., time-critical deliveries or personalized door-to-door transport).

The group “Combined transport services” contains all UC ideas where both (passengers and freight) are transported within the same TU. For example, this could include a TU with explicit freight space, or a platoon of Pods composed of both passenger and freight, as opposed to the uni-purpose trains of today.

As the last group of use cases, the group “Other transport services” contains a UC idea, which is

not directly categorized as a passenger, freight or combined solution. Nevertheless, this UC provides inspiration for a broader application of Pod systems and aligns with the research scope of the Flagship Area 6 project FutuRe.

On top of that two further aspects were considered in UC description. Firstly, the possibility of fast switching from one mode of transport to another without getting out of the vehicle enables a seamless door-to-door transport experience and new transport and logistics services. Secondly, the temporary use of TUs as living space or mobile offices, so-called "temporary spaces", or even further services to the doorstep, so-called "service-to-people solutions", are distinct possibilities. Therefore, the following key fields of applications were considered in the UCs:

Table 3. Key fields of application of the Pod system

Key field number 1	Key field number 2	Key field number 3
The migration to the pod system from conventional rail transport for people and/or goods transport.	The transfer of TUs between railway and road (cable cars/funiculars).	The temporary use of the TUs as living space – temporary space.

Taking a comprehensive viewpoint when formulating the UC, users not only consider passengers, but also different stakeholders. The stakeholder list includes freight customers (industry, healthcare, retail, grocery, 3PL/4PL providers), vehicle rental companies, service operators, tech companies, investors and creditors as well as governments, regulators and non-governmental organisations. Thus, the holistic analysis focused on finding a variety of possible applications for the Pod system across the following areas:

Figure 2. Identified fields of the UC ideation process

5.3. Introduction to potential use cases

Based on the procedure described in the previous section, all collected and potential UCs were subsequently clustered to eliminate overlapping or similar UC. The UC presented here reflect primary applications of a Pod system. Please note, however, that they are not exhaustive. The following clustering structure was identified:

A. Passenger transport services
    a. Public transport
        i. UC1: Basic passenger transport
        ii. UC2: Premium passenger transport
        iii. UC3: First class passenger transport
        iv. UC4: Mass passenger transport
    b. Private transport
        i. UC5: Basic passenger transport
        ii. UC6: Premium passenger transport
        iii. UC7: Luxury passenger transport
    c. Special applications
        i. UC8: PRM application
        ii. UC9: Ambulance application
        iii. UC10: Tourism application
B. Combined (passenger and freight) transport services
    a. Service-to-people transport
        i. UC11: Transport services
        ii. UC12: Shopfloor
    b. Temporary space
        i. UC13: Rescue application
        ii. UC14: Housing application
        iii. UC15: Event application
C. Freight transport services
    a. Parcel delivery
        i. UC16: Parcel delivery
        ii. UC17: Night logistics
    b. General freight
        i. UC18: (10'/20') container — individual or combined with other passenger Pods
    c. Special applications
        i. UC19: Temperature sensitive application (serving demand with 10'/20' containers)
        ii. UC20: Individual Pods dispatching (e.g., Hazardous application)
D. Other transport services
    a. Service-to-people transport
        i. UC21: Energy supply application

5.4. Short description of the use cases: Mobility journeys and related use cases

Each UC has a specific operational area, utilised infrastructure and specific user groups and therefore is subject to various needs. Based on the results of D2.2 "Technology assessment", a list of parameters relating to technological feasibility, environmental impact, economic viability and user- and society-orientated design and operation was developed to identify vehicle- and system-relevant aspects from a holistic perspective. This overview (see table A3-A6 in appendix 10.3) was used to describe the UCs in more detail. To that end, all parameters listed in A3-A6 were assessed for all UCs displayed in table 4. The necessity of each parameter was rated for every UC to develop the composition of the required characteristics. For example, the parameter “secondary/ branch line” of the system element “operational area I” (see ID 3 in table A3) was rated as essential for the UC “basic passenger transport” because serving passengers in a wide area would require the Pod system to have access to branch lines. Based on this assessment procedure, the most important parameters were derived for every UC and utilised as a basis for formulating the mobility journeys listed in table 4.
The mobility journeys serve to illustrate a specific sample application of the Pods system, providing a detailed explanation of each use case to enhance comprehension and describe a potential scenario. This does not imply that other mobility journeys cannot be implemented with the system. Additionally, some use cases are related to each other due to similar needs of different user groups. Those related UC are shown (see table 4) to give information about potential users and socio-demographic backgrounds, the way of using the transport solution and important needs of the users.

Because of the low TRL of existing Pod systems, technological feasibility, environmental impact, economic viability as well as implications for user- and society-centred design could only be estimated. With regards to the expected energy demand of the system, it is reasonable to assume that it will be lower than currently existing means of transport, given the expected increase in efficiency which the technology will provide. The energy demand is expected to be lower compared to current systems, due to a reduction of vehicle size and due to adoption of an on-demand transport scheme. However, since the energy demand of the system depends on its technical implementation, it could not be determined precisely at this stage. Table A3 provides a broad overview of the relevant technical parameters. In it, the most important system elements are outlined. Exceeding the expressed level of detail would require extrapolating currently available data, which might lead to vague estimates.

In accordance with the low TRL of the technology, a prospective user research method had to be employed in T2.2 for the exploration of user-needs. Due to the lack of access to a demonstrator, actual user behaviour could not be studied. Instead, scenario-based future thinking interviews were conducted to gauge participants’ attitudes towards the system. The insights gained in these interviews were utilised for informing the development and selection of use cases in this task.

Due to the current state of the art, the technical feasibility of the system cannot be guaranteed. The concept aims to investigate the feasibility of a system as described in D2.1 and to define the necessary technology as well as describe the requirements for the system in all its components.

Some of the technical requirements necessary for the system have yet to be developed or are currently under development, such as the technology for autonomous driving, more powerful batteries and new, sustainable materials. The aim of the project is to address and analyse these advancements and, if necessary, to seize and develop them in future project phases or to build on the development of the necessary technologies from other ERJU FP and other projects.

The proposed system could have a positive environmental impact. For one, existing infrastructure would be used. The proposed door-to-door on-demand transport scheme could relieve the current transport system and usage of public and, above all, private Transport Units for passenger transport could reduce the current number of cars. Moreover, the constant availability and constant operation of the carriers (moving infrastructure) should reduce the number of vehicles currently in existence, which would have a positive impact on the environmental balance as fewer vehicles with a drive unit would have to be produced.

The user- and society-centred design and operation is promoted in the new concept to the extent that inclusiveness, accessibility and convenience should be at the forefront of the design concept. Door-to-door transport in general, but especially in rural areas, can increase social inclusion and comfort while reducing mobility poverty. Simple booking, consistent information display and a high level of safety are among the key aspects that will be elaborated in the general specifications in work packages 4 (D4.3) and 7 to 11.

The list of use cases is grouped by the main categories of transport type: “Passenger transport services”, “Combined transport services”, “Freight transport services” and “Other transport services”.

Table 4. Mobility journeys and related UCs for passenger, combined and freight transport as well as other transport services

A – Passenger transport services				
Group	ID	Name	Mobility journey	Related UC
Public transport	UC1	Basic passenger public transport	Economy class with max. 12 passengers per unit (max. capacity similar to a tram or bus — e.g., Aachener Rail Shuttle, Draisy, NGT-TAXI, activities in FP6-FutuRe). Used in sparsely populated (rural) areas where train connections are not profitable.	UC2-4, UC6
	UC2	Premium passenger public transport	Travelling through all kinds of geographical areas (rural, urban, suburban) on shorter distances. Max. 6 passengers per unit (max. capacity similar to a minibus or van). They are mainly used for commuting to work or running errands in the nearest town. Therefore, it is primarily a specialised mode of transport, which passengers only use for a limited time. A distinction must be made between two applications: • A rail-bound means of transport that transports passengers to central hubs.	UC1, UC3-6

			• A road vehicle that serves remote areas or operates in areas where a rail-based system offers no significant advantage. In general, the system should integrate seamlessly into the existing transport network and serve as a supplement and improvement for local public transport.	
	UC3	First class passenger public transport	Transport services for persons with high privacy and security demand — or a high degree of individualisation. Travelling from home (also with a private TU) in max. 2-persons configurations on very individual routes, e.g., from road to rail and vice versa. A fusion of private and public transport. In special situations, it can make sense to transfer the individual Pod to a cable-guided system in order to utilise synergy effects. Due to the individuality, the area of application should be in suburban or urban areas to ensure the greatest possible utilisation and efficiency of the system. This means that, for the most part, individual routes in the single-digit km range and a maximum travel time of half an hour are expected. A typical application scenario would be for individuals to use it to travel from their door-step via the nearest central transfer point to a larger and faster means of transport or for business travellers or tourists to use it to get from the airport to their hotel. In large cities, a detachable concept is preferable. These individual Pods can then be automatically linked to a cable car, for example, and travel in a network, guaranteeing a transfer-free travel experience to the destination.	UC1, UC2, UC4, UC6-7
	UC4	Mass passenger public transport	Low-cost solution for mass public transport — only stands (no seats, but leaning areas/ seats).	UC1-2
Private transport	UC5	Basic passenger private transport	Economy class, max. capacity similar to a tram or bus (see also Aachener Rail Shuttle for a similar concept). Private A to B transport without stops and no possibility of entering in station.	UC2, UC7-8, UC12, UC15
	UC6	Premium passenger private transport	Business class, max. capacity similar to a van. Private A to B transport without stops and no possibility of entering in station.	UC2, UC5, UC7-8, UC12, UC15
	UC7	Luxury passenger transport	Luxury TU, capacity similar to a private car or taxi, no stops, no additional passengers, focus on privacy. Private A to B transport without stops and no possibility of entering in station.	UC3, UC5-6, UC8, UC12, UC15
Special applica-tions	UC8	PRM application	Pod system to provide transfer-less road- and rail-based door-to-door mobility for elderly people and PRM. The concept is to target people that would want to use public transport and rail but are hindered by reduced mobility. Ride-sharing and intermodal (road-rail) modes of operation are possible. Pod capacity needed is typically 2-6 passengers in a vehicle size like a van or minibus. Possibly some small luggage can be carried. Potential need to provide for guide dogs,	UC1-7, UC9-13, UC15

			walking aids, wheelchairs etc. First-/ last-mile mobility on roads. Typical on-road distance of less than 5 km. Longer distances (regional, possibly national) by rail. Most demand during day-time, typically off-peak. May be a good candidate to combine with night-time goods (parcel) transportation. This user group is typically able to pre-book the day before travel, but with same-day adjustments. Probably a smaller proportion of the demand group would need real-time booking, which should enable better service optimisation.	
	UC9	Ambulance application	Ambulance application from private home to hospitals. Direct transport for quick and transfer-less transport with equipment, luggage or accompanied by additional persons.	UC1-7, UC9-13, UC15
	UC10	Tourism application	The Pod system should be usable for tourism purposes. They travel through cities to sightseeing spots as well as starting points for tourist activities. This means that it should be designed primarily for leisure activities (e.g., carrying skis or cycling equipment) and also for children. Ideally, the system should be integrated into the context of tourism (e.g., by providing information on sights and activities or by the ride providing an "adventurous" experience). The individual distances are not that far (a few kilometres) and the route is usually the same. The goal is to transport single persons as well as tourist-groups. If the ride is part of an activity or sightseeing, it is not important how long the journey takes. User requirements: comfortable, entertaining, enough space for various equipment (hiking, cycling, skiing, luggage etc.) The system should be autonomous. A cable car would be better in the mountains. For regular sightseeing, an intermodal Pod should be preferred. In this way, various existing infrastructure can be utilised, and the system can be seamlessly integrated into the existing transport system.	UC1-3, UC5-7, UC12, UC15
B – Combined transport services				
Group	ID	Name	Mobility journey	Related UC
Service-to-people transport	UC11	Transport services	Private transport for bulky baggage such as strollers, bicycles, parcel service etc. This UC is for when there is no capacity available in passenger TUs or there is enough demand for freight transport. Therefore, the TU capacity should be suitable for daily goods like packages, bicycles and others. Dedicated freight TUs need to be equipped with specific technology, such as freight status monitoring. This UC concerns combining freight TUs and passengers TUs into Pod-sets. The matching occurs based on freight type and origin-destination matching.	UC2-3, UC5-8, UC10, UC12, UC16-20
	UC12	Shopfloor	A combination of transport and commerce services to support customers´ lives: rolling grocery, hairdresser, carpenter, pharmacy etc. primarily in rural areas or residential estates.	UC9-11, UC15, UC21
Tempo-rary space	UC13	Rescue	Emergency transport solution (for catastrophe, rescue,	UC8-9, UC11,

		application	first responder, equipment, etc.)	UC15, UC20
	UC14	Housing application	A room for special purposes. The main purpose is to enhance the living space (e.g., as a tiny house, classroom, business space etc.). No special infrastructure adaptations should be necessary because it is only a small niche. The system should integrate easily into the circumstances. Only for closed groups or individual persons. The user would stay there a long time or a few hour but the travel distances are only short (from the location of last use to the next destination). The users will not travel with the system itself. The vehicle should be designed as comfortable as possible. The application could be implemented in urban and suburban areas due to the increased demand for space. An independent system, that is not tied to any particular transport system (cable car or rail), is preferable. Due to the large number of different users, the system should operate as independently as possible to avoid restrictions due to incorrect operation. This means that the living space extension should be designed for the least possible interaction with users. The system can be charged via a connection to a charging point provided by the user so that the costs can be offset against usage.	UC9-13, UC15, UC18, UC20
	UC15	Event application	A room for special occasions. The main purpose is to enhance the living space by enabling the realisation of events or exhibitions. No special infrastructure adaptations should be necessary because it is only a small niche. The system should easily adapt to the situational demands. Furthermore, it should be possible to use it in private circle and for public purposes. The user would stay there a long time, but the travel distances are only short. Therefore, the vehicle should be designed as comfortable as possible (low noise and vibrations). Such a UC could be implemented best in urban areas due to the density of population and businesses. Ideally, the system is charged at a fixed location when it is not in use and is also prepared there for the next use (cleaning and refilling).	UC1-12, UC14

C – Freight transport services

Group	ID	Name	Mobility journey	Related UC
Parcel delivery	UC16	Parcel delivery	This UC addresses the demand whose specifications (size, type, urgency) allow combined transport with passenger demand, and which can therefore be transported in the same Pod as passengers (see also UC11). Here, factors of synergy (origin and destinations) and size play major roles. In case the volume of the parcels is sufficiently large, an additional TU could be ordered to transport them. Using modular containers of the size of packages or 1 or more Euro palettes may be the key to optimised space utilization. The geographical area can be adjusted from urban, to suburban and to long distance. If existing, the deadlines of parcel deliveries are very important. It can also be planned for special occasions such as new year peak demand.	UC1, UC10-11, UC17-20
	UC17	Night	Especially for newspaper logistics, pharmacy services,	UC1, UC10-11,

		logistics	spare parts, overnight services. Additionally, provision of supermarkets and parcels (e-commerce) are possible. Therefore, TU for small sized goods but with a high amount like newspapers or pharmacy articles have to be provided. Deliveries to supermarkets and other stores are possible with TU´s that can transport Euro pallets and standardised load carriers like market wheel-containers.	UC16, UC18-20
General freight	UC18	Container (10'/20')	This targets customers that have enough goods to fill standard containers. If the carrier design allows (to be checked in the follow-up work packages), containers can be transported directly on a carrier. Two 10' containers can be transported on one carrier belonging to two customers and/ or having two different destinations. The freight type should allow platooning these with passenger and/ or other freight Pods. The distance can be adjusted but would cover a larger range compared to parcels for a higher share. Here, too, deadlines and the next journey of containers is very important. For instance, deadlines imposed on intermodal travel via marine transport come to mind.	UC1, UC10-11, UC16-17, UC19-20
Special applications	UC19	Temperature-sensitive application	This UC fits the scope of parcel delivery and container transport. In such instances, specific vessels equipped with sensors for temperature controlling and monitoring and specialised containers are needed. The dimensions of the TU ranges between parcel size, Euro palette size to small standard container sizes.	UC11, UC16-18, UC20
	UC20	Individual Pods dispatching (e.g., Hazardous application)	This may be included in the scope of the night logistic UC. However, the main difference is that these cannot be combined with other types of demand. They need to be routed according to limitations such as the distance to urban areas, etc. and therefore be transported by an individual carrier.	UC11, UC16-19
D – Other transport services				
Group	ID	Name	Mobility journey	Related UC
Service-to-people transport	UC21	Energy supply application	External energy feeding unit: moving charging station, detachable battery stacks in container, around the clock and far-reaching availability for emergencies, frequent operation of Pods as mobile charger or range extender	UC1-21

6. Use case descriptions and derivatives

6.1. General

The use cases represent possible application scenarios for autonomous railway Pod systems. Those use cases are described to create a common understanding of the system. A use case describes how a system interacts with a specific user to fulfil a particular purpose. Depending on the exact requirements and functions, additional details can be added or adapted.

The use cases refer to the design options for the Transport Units, which can be flexibly transported in standardised basic dimensions and also on standardised carriers (vehicles).

6.2. Use cases for passenger transport services

The use cases are described to create a common understanding of the Pod system.

Table 5. UC description for UC1 "basic public passenger transport"

UC ID	UC1
Title	Basic public passenger transport
Transport mode(s)	Rail Road Funicular (for remote places aviation and maritime)
System actor(s)	Railway undertaking, TU rental company, carrier rental company, mobility management operator, service operator
Operational area(s)	Secondary / branch line railway Main lines railway Roads
Related UC	2, 3, 4, 6
Short description mobility journey (Pod system)	
Transporting people in local and/or long-distance transport from A to B. The basic transport system shall provide small seating compartments (max. capacity 12 passengers, corresponding to 2nd class acc. UIC) and standing areas. Transport is ordered and paid via the Mobility Management Platform (MMP) of the Pods system.	
Key components TU	
• Car Body TU Type B, Side Windows, Side Doors • Seats, indoor design comparable with conventional transport systems (i.e bus or tram) • Lighting, HVAC, Contactless Ticketing, PIS, iCCTV, Emergency Call Facility, Electric Energy Supply, Communication Technology, WiFi Equipment, Sockets and USB charging facility	
Benefits	
• Rapid availability of small TUs • Continuous traffic from door to door	
Examples from current practice and development	
• Multimodal transport with two or more transport modes • Intermodal transport with own/rented car or Taxi • Aachener Rail Shuttle (https://www.zevrail.de/artikel/der-aachener-rail-shuttle-entwicklungsstand-mechanischer-teil) • U-Shift (https://verkehrsforschung.dlr.de/en/projects/u-shift) • FutuRe (https://projects.rail-research.europa.eu/eurail-fp6/)	

Table 6. UC description for UC2 "premium public passenger transport"

UC ID	UC2
Title	Premium public passenger transport
Transport mode(s)	Rail Road Funicular
System actor(s)	Railway undertaking, TU rental company, carrier rental company, mobility management operator, service operator
Operational area(s)	Secondary / branch lines railway Main lines railway Suburban lines Roads
Related UC	1, 3, 4, 5, 6
Short description mobility journey (Pod system)	
Transporting people in local and/or long-distance transport from A to B. The premium transport system shall provide comfortable seating compartments (max. capacity 6 passengers, corresponding to 1st class acc. UIC). Transport is ordered and paid via the MMP.	
Key components TU	
Car body TU Type B, side windows, side doors *depending on the equipment variant:* Indoor design comparable with conventional transport systems (i.e., 1st class aviation) with Armchairs, Sofa, Reclining Seats or Sleeping Compartments, Bar area, Wardrobe, Desk Lighting, HVAC, non-contact ticketing, PIS, iCCTV, emergency call facility, electric energy supply, communication technology, Wi-Fi equipment, sockets and USB charging facility	
Benefits	
• Rapid availability of small TUs transported by small carriers • Continuous traffic from door to door • Special offer for comfortable travel, private travel or business trips	
Examples from current practice and development	
• There is no directly comparable transport case. Most comparable to using chauffeur services.	

Table 7. UC description for UC3 "first class public passenger transport"

UC ID	UC3
Title	First class passenger public transport
Transport mode(s)	Rail Road Funicular
System actor(s)	Railway undertaking, TU rental company, carrier rental company, mobility management operator, service operator
Operational area(s)	Secondary / branch lines railway Main lines railway Suburban lines Roads
Related UC	1, 2, 4, 6, 7
Short description mobility journey (Pod system)	
Transporting people in local and/or long-distance transport from A to B. The basic transport system shall provide comfortable seating compartments (max. capacity 2 passengers, corresponding to private cabin). Transport is ordered and paid via the MMP.	
Key components TU	
Car Body TU Type B, Side Windows, Side Doors *depending on the equipment variant:* Indoor design comparable with conventional transport systems (i.e., 1st class railway) Lighting, HVAC, non-contact Ticketing, PIS, iCCTV, Emergency Call Facility, Electric Energy Supply, Communication Technology, Wi-Fi Equipment, Sockets and USB charging facility	
Benefits	
• Rapid availability of small TUs transported by small carriers • Continuous traffic from door to door • Special offer for comfortable public travel or business trips	
Examples from current practice and development	
• Multimodal transport with two or more transport modes in 1st class • Intermodal transport with own, rented car or taxi • Single modal rail transport, like Japan Railways: Shiki-shima train with deluxe suite room — car 7 (https://www.jreast.co.jp/shiki-shima/en/train.html)	

Table 8. UC description for UC4 "mass public passenger transport"

UC ID	UC4
Title	Mass passenger public transport
Transport mode(s)	Rail Road Funicular
System actor(s)	Railway undertaking, TU rental company, carrier rental company, mobility management operator, service operator
Operational area(s)	Secondary / branch lines railway Main lines railway Suburban lines Roads
Related UC	1, 2
Short description mobility journey (Pod system)	
Transporting people in local and/or long-distance transport from A to B. Low-cost solution for mass public transport – only stands (no seats), but leaning areas/seats.	
Key components TU	
Car Body TU Type B, Side Windows, Side Doors Indoor design comparable with modern metro systems without seats Lighting, HVAC, non-contact Ticketing, PIS, iCCTV, Emergency Call Facility, Electric Energy Supply, Communication Technology, Wi-Fi Equipment	
Benefits	
• Rapid availability of small TUs • Continuous traffic from door to door • High capacity	
Examples from current practice and development	
• Multimodal transport with two or more transport modes (e.g., Metro Melbourne. Heavy capacity train without seats (https://www.theage.com.au/national/victoria/2000-people-per-train-metros-standing-roomonly-future-revealed-20170528-gwettp.html) • Intermodal transport with own, rented car or taxi	

Table 9. UC description for UC5 "basic private passenger transport"

UC ID	UC5
Title	Basic passenger private transport
Transport mode(s)	Rail Road Funicular
System actor(s)	Private undertakings, private persons, organisations, corporates
Operational area(s)	Secondary / branch lines railway Main lines railway Suburban lines Roads
Related UC	2, 7, 8, 12, 15
Short description mobility journey (Pod system)	
Transporting people in local and/ or long-distance transport from A to B. The system will exclusively used by defined persons and owned by a private person. The entire indoor design will be specified for the individual purpose (i.e., meetings, private saloon). Private A to B transport without stops and no possibility of entering in station. There is no ordering needed. Pod will remain at private disposal.	
Key components TU	
Car Body TU Type A, Side Windows, Side Doors Indoor design flexible, special equipment for purpose Lighting, HVAC, non-contact Ticketing, PIS, Emergency Call Facility, Electric Energy Supply, Communication Technology, Wi-Fi Equipment	
Benefits	
• Rapid availability of small TU • Private ownership enables private design of the interior design • Flexible use as an additional living unit possible	
Examples from current practice and development	
• Intermodal transport with own car	

Table 10. UC description for UC6 "premium passenger private transport"

UC ID	UC6
Title	Premium passenger private transport
Transport mode(s)	Rail Road Funicular
System actor(s)	Private undertakings, private persons, organisations, corporates
Operational area(s)	Secondary / branch lines railway Main lines railway Suburban lines Roads
Related UC	2,5,7,8,12,15
Short description mobility journey (Pod system)	
Transporting people in local and/ or long-distance transport from A to B. The system will exclusively used by defined persons and owned by a private person. The entire indoor design will be specified for the individual purpose (i.e., meetings, private saloon) but on a high-end level with valuable materials and special features (i.e., onboard virtual reality room for meetings, relaxing area). Private A to B transport without stops and no possibility of entering in station. There is no ordering needed. Pod will remain at private disposal.	
Key components TU	
Car Body TU Type A, Side Windows, Side Doors Valuable indoor design Lighting, HVAC, non-contact Ticketing, PIS, Emergency Call Facility, Electric Energy Supply, Communication Technology, Wi-Fi Equipment	
Benefits	
• Rapid availability of small TU • Private ownership enables private design of the interior design • Flexible use as an additional living unit possible	
Examples from current practice and development	
• There is no directly comparable rail or road transport case. Most comparable to using chauffeur services.	

Table 11. UC description for UC7 "luxury passenger private transport"

UC ID	UC7
Title	Luxury passenger private transport
Transport mode(s)	Rail Road Funicular (Aviation, maritime)
System actor(s)	Private undertakings, private persons, organisations, corporates
Operational area(s)	Secondary / branch lines railway Main lines railway Suburban lines Roads
Related UC	3, 5, 6, 8, 12, 15
Short description mobility journey (Pod system)	
Transporting people in local and/ or long-distance transport from A to B. The system will exclusively used by defined V.I.P. and owned by a private persons. The entire indoor design will be comparable to the UC 6 but with onboard service team for individual needs (e.g., fine dining, wellness area, bed). Private A to B transport without stops and no possibility of entering in station. The is no ordering needed. Pod will remain at private disposal.	
Key components TU	
Car Body TU Type A, Side Windows, Side Doors Valuable indoor design, Special equipment on-board, kitchen compartment, wellness area Lighting, HVAC, non-contact Ticketing, PIS, Emergency Call Facility, Electric Energy Supply, Communication Technology, Wi-Fi Equipment	
Benefits	
• Rapid availability of small TU • Private ownership enables private luxury design of the interior design • Flexible use as an additional living unit possible	
Examples from current practice and development	
• There is no directly comparable rail or road transport case. Most comparable to using luxury cars with own chauffeur. In the past, the railways had so-called saloon cars that were reserved for a special target group.	

Table 12. UC description for UC8 "PRM application"

UC ID	UC8
Title	PRM application
Transport mode(s)	Rail Road Funicular
System actor(s)	Railway undertaking, TU rental company, carrier rental company, mobility management operator, service operator
Operational area(s)	Secondary / branch lines railway Main lines railway Suburban lines Roads
Related UC	1 -7, 9 -13, 15
Short description mobility journey (Pod system)	
Pod system to provide transfer less road- and rail-based door-to-door mobility for elderly people and PRM. The concept is to target people that would want to use public transport and rail but are hindered by reduced mobility. Ride-sharing and intermodal (road-rail) modes of operation are possible. Pod capacity needed is typically 2-6 passengers. Possibly some small luggage can be carried. Potential need to provide for guide dogs, walking aids, wheelchairs etc. First-/ last-mile mobility on roads. Typical on-road distance of less than 5 km. Longer distances (regional, possibly national) by rail. Most demand during daytime, typically off-peak. May be a good candidate to combine with night-time goods transportation. This user group is typically able to pre-book the day before travel, but with same-day adjustments. Probably a smaller proportion of the demand group would need real-time booking, which should enable better service optimization.	
Key components TU	
Car body TU Type B, side windows, wide side doors 100 % low-floor doorways and gangways, seats for companion (max. 8), PRM toilette Lighting, HVAC, non-contact ticketing, PIS, iCCTV, emergency call facility, electric energy supply, communication technology, Wi-Fi Equipment, safety area for parking of wheelchairs, stroller, walker, guide dog etc.	
Benefits	
• Rapid availability of small TUs transported by specific low-floor carriers • Continuous traffic from door to door • No transfer at stations, pick up from your own doorstep • Designed for PRM (100 % low-floor)	
Examples from current practice and development	
• Multimodal public transport with two or more transport modes in special areas within the vehicles that must comply with the regulations for the transport of people with reduced mobility (e.g., see TSI PRM), inconvenient change of transport mode, sometimes not possible due to local conditions and the existing infrastructure • Intermodal transport with Taxi or on-call bus for PRM transport • Intermodal transport with own special equipped car (e.g., for wheelchair)	

Table 13. UC description for UC9 "ambulance application"

UC ID	UC9
Title	Ambulance application
Transport mode(s)	Rail Road Funicular (Aviation and maritime for remote places)
System actor(s)	Government (first responder, military, hospitals, medical organisations, ...) NGO's (red cross, ...)
Operational area(s)	Secondary / branch lines railway Main lines railway Suburban lines Roads
Related UC	1 -7, 9 -13, 15
Short description mobility journey (Pod system)	
Transporting sick and/ or injured people from A to B in units specially designed for this transport. Ambulance application from private home to hospitals. Direct transport for quick and transfer-less transport with equipment, luggage or accompanied by additional person.	
Key components TU	
Car Body TU Type B, Wide Side Doors special Ambulance Equipment acc. EN 1789 and relevant type (A1, A2, B, C) Lightning, HVAC, Windows, Wi-Fi Equipment, Electric Energy Supply, Communication Technology	
Benefits	
• Continuous and fast transport from A to B for transports over longer or long distances, for example from disaster areas, regardless of the available infrastructure • No reloading of patients between transport options	
Examples from current practice and development	
Reloading patients when transporting them over longer distances, for example from a road vehicle to a helicopter, airplane, or train	

Table 14. UC description for UC10 "tourism application"

UC ID	UC10
Title	Tourism application
Transport mode(s)	Rail Road Funicular (aviation and maritime for remote places)
System actor(s)	Railway undertaking, TU rental company, carrier rental company, mobility management operator, service operator
Operational area(s)	Secondary / Branch Lines Railway Main Lines Railway Roads
Related UC	1 -3, 5-7, 12, 15
Short description mobility journey (Pod system)	
The Pod system should be usable for tourist purposes. They travel through cities to sightseeing spots as well as starting points for tourist activities. This means that it should be designed primarily for leisure activities (e.g., carrying skis or cycling equipment) and for children. Ideally, the system should be integrated into the context of tourism (information on sights or activities, ride as an "adventure"). The individual distances are not that far (a few kilometres) and the route is mostly the same. The goal is to transport single persons as well as a related tourist-groups. If the ride is part of the adventure or sightseeing, it is not important how fast or long the journey takes. User Requirements: comfortable, entertaining, enough space for various equipment (e.g., hiking, cycling, skiing, luggage). Due to the Pod System properties various transport modes and existing infrastructure can be utilised and the system can be seamlessly integrated into the existing transport system.	
Key components TU	
Car Body TU Type B, Side Windows, Wide Side Doors Seats (8 to 10), storage possibilities (for bikes, skis, diving equipment, ...) Space for bulky luggage, charger for e-bikes, ... Lighting, HVAC, non-contact Ticketing, PIS, iCCTV, Emergency Call Facility, Electric Energy Supply, Communication Technology, Wi-Fi Equipment	
Benefits	
• Rapid availability of small TUs • Continuous traffic from door-to-door • No transfer at stations • Pick up from your own doorstep	
Examples from current practice and development	
• Multimodal transport with two or more transport modes • Single mode solutions, like ÖBB night jet with bike storage (https://radkompetenz.at/10265/next-generation-nachtzug-radmitnahme-im-neuen-nightjet/)	

6.3. Use cases combined transport services

Table 15. UC description for UC11 "transport service"

UC ID	UC11
Title	Transport service
Transport mode(s)	Rail Road Funicular (Aviation and maritime for remote places)
System actor(s)	Railway undertaking, TU rental company, carrier rental company, mobility management operator, service operator
Operational area(s)	Secondary / Branch Lines Railway Main Lines Railway Roads
Related UC	2, 3, 5-8, 10, 12, 16-20
Short description mobility journey (Pod system)	
Private transport for bulky baggage such as strollers, bikes, parcels, packed small furniture. This is the case when there is no capacity available in passenger TUs or there is enough demand for freight transport. Dedicated freight TUs need to be equipped with specific technology, such as freight status monitoring. This UC concerns combining freight TUs and passengers TUs into pod-sets. The matching occurs based on freight type and origin-destination matching.	
Key components TU	
Car Body TU Type B, Side Windows, Wide Side Doors Seats (8), storage possibilities (for bikes, skis, diving equipment, ...), Space for bulky luggage, charger for e-bikes, ... Lighting, HVAC, non-contact Ticketing, Emergency Call Facility, Electric Energy Supply, Communication Technology, Wi-Fi Equipment	
Benefits	
• Rapid availability of small TUs • Continuous traffic from door-to-door • Designed for bulky luggage	
Examples from current practice and development	
• Multimodal transport with two or more transport modes • Intermodal transport with own car, rented pickup truck or freight forwarder • Vienna: Parcel transport by tram (https://www.urban-transport-magazine.com/en/vienna-parcel-transport-by-tram/)	

Table 16. UC description for UC12 "shopfloor"

UC ID	UC12
Title	Shopfloor
Transport mode(s)	Rail Road Funicular (for remote places aviation and maritime)
System actor(s)	B2B (industry, agriculture) B2C (service, nutrition, bank, retail, ...) Government (service, communication, ...) Private persons (party / hobby room, meeting places, rental room, ...)
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	9-11, 15, 21
Short description mobility journey (Pod system)	
The shopfloor system is specifically designed for the on-demand MaaS system, which combines technologies such as e-commerce and autonomous operation. The pod system itself is a combination of a real workshop service such as the repair of bicycles or a comprehensive home service (e.g., last mile service, spare parts...). In other words, the store comes to your home or apartment (pedestrian area) and acts as a store for minor repairs or as a retail store for certain items (e.g., cell phones, kitchen appliances, banking services, etc.). The remaining time to stay in the same place is about 1 hour or 1 week or longer (depending on workload or customer demand).	
Key components TU	
Car Body TU Type A (or TU Type B), Side Windows, Wide Side Doors Toilette, specific furniture (e.g., storage for spare parts, repair installations, desks, few seats), depending on the requirements of the service offering Steps or bridge from lower/ higher levels (boardwalk gap) Lighting, HVAC, Electric Energy Supply, Communication Technology, Wi-Fi Equipment, Sockets and USB charging facility	
Benefits	
• Continuous and fast services regardless of the available infrastructure • Availability of services in rural areas • Flexible locations (depending on customer demand)	
Examples from current practice and development	
There is no directly comparable rail or road transport case. Small vans for mobile traders (for example at weekly markets), bakery vans or similar Similar new ideas are existing, like Toyota e-palette (www.toyota-global.com/pages/contents/innovation/intelligent_transport_systems/world_congress/2018copenhagen/pdf/e-Palette_CONCEPT.pdf)	

Table 17. UC description for UC13 "rescue"

UC ID	UC13
Title	Rescue application
Transport mode(s)	Rail Road Funicular (for remote places aviation and maritime)
System actor(s)	Government (first responder, military, fire brigade, B2B → under specific circumstances, …) NGO's (red cross, …)
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	8, 9, 11, 15, 20
Short description mobility journey (Pod system)	
Pod systems for emergency cases are designed to be flexible and autonomous in operation and to support the first responder team in critical situations. The Pod system is used as a hub for coordination purposes (between supporting organizations) and technical support (e.g., drinking water, medical assistance, technical equipment for search and rescue). A typical critical situation can be an earthquake where drinking water and communication network are not available. Civil society and first responder teams can use the TU as a shelter, control centre or storage for technical equipment (e.g., search antennas, shovels).	
Key components TU	
Car Body TU Type B, Wide Side Doors, robust design for rough environmental conditions (-40°C to +40°C, sand or snow storm), stable underframe design (stand-alone solution for muddy, sandy or rocky soils, …), toilette, specific functionalities, like strong communication antenna, on-board power generators for 48h autonomous operation, Sewage function / drinking water filter, on-board communication technology for IT services (all relevant standards for coordination work), descent capacity for first responder team (10 people seated) Electric energy supply Possibly: Lightning, communication technology	
Benefits	
Continuous and fast transport from A to B for transports over longer or long distances, for example to disaster areas, regardless of the available infrastructure, fast responder solution in critical situation where no assistance from air or road can easily be requested, very adaptive for different transport modes with very high payload (road, rail…), easy to install at any kind of location.	
Examples from current practice and development	
• Special equipment and/or vehicles in wide range (e.g., see: https://www.thw.de/DE/Im-Einsatz/Ausstattung/Fahrzeuge/fahrzeuge_node.html) • Off fire and emergency service container (https://www.realmet.com/products/roll-on-off-container/roll-on-off-fire-and-emergency-service-container)	

Table 18. UC description for UC14 "housing application"

UC ID	UC14
Title	Housing application
Transport mode(s)	Rail Road Funicular (for remote places aviation and maritime)
System actor(s)	B2B (industry, agriculture) B2C (service, nutrition, bank, retail, ...) Government (service, communication, ...) Private persons (party / hobby room, meeting places, rental room, ...)
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	9-13, 15, 18, 20
Short description mobility journey (Pod system)	
A room for special purposes. The main purpose is to enhance the living space (e.g., as a tiny house, classroom, kindergarten, business space). No special infrastructure adaptations should be necessary because it is only a small niche. The system should integrate easily into the circumstances. Only for closed groups or individual people. The user would stay there a long time/ a few hours but the travel distances are only short (from the last use to the next destination. Therefore, the TU should be designed to be as comfortable as possible. Possible area for such an application: urban and suburban area due to the narrowness or the increased space requirement. Due to the large number of different users, the system should operate as independently as possible to avoid restrictions due to incorrect operation. This means that the living space extension should be designed with the least possible interaction with a user. The system can be charged via a connection to a charging point provided by the user, whereby the costs could be offset against usage.	
Key components TU	
Car Body TU Type B (or TU Type C), Side Doors, Side Windows that can be opened Interior design to be chosen privately Heating (in special cases: HVAC), Energy storage, charging socket, sewage interface	
Benefits	
• Fast transport from A to B for transports over longer or long distances • Private ownership enables private design of the interior design • Flexible use as an additional living unit possible	
Examples from current practice and development	
There is no directly comparable rail or road transport case. Example: Transport of houses (e.g., https://www.hauslein.com.au/delivery)	

Table 19. UC description for UC15 "event application"

UC ID	UC15
Title	Event application
Transport mode(s)	Rail Road Funicular (for remote places aviation and maritime)
System actor(s)	B2B (exhibitions, concerts, ...) B2C (service, information events, ...)
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	1-7, 8-12, 14
Short description mobility journey (Pod system)	
A room for special purposes. The main purpose is to enhance the living space by making events or exhibitions possible. No special infrastructure adaptations should be necessary because it is only a small niche. The system should integrate easily into the circumstances. Furthermore, it should be possible to use it both in closed groups and for public purposes. The user would stay there a long time/ a few hours but the travel distances are only short. Therefore, the vehicle should be designed as comfortable as possible (low noises/vibrations). The area in which such a UC would be possible is the urban area due to the density of companies and people. Ideally, the system is charged when it is not in use at a fixed location and is prepared for the next use (cleaned, refilled).	
Key components TU	
Car Body TU Type B, Wide Doors, Side Windows Intended for limited passenger use with a special purpose, seats (very simple) HVAC (full comfort)	
Benefits	
• Flexible transport platform	
Examples from current practice and development	
• There is no directly comparable rail or road transport case. Comparable example from railway: ÖBB disco coach (https://www.bb-bluetrain.at/de/waggons/disco.html)	

6.4. Use cases freight transport services

Table 20. UC description for UC16 "parcel delivery"

UC ID	UC16
Title	Parcel delivery
Transport mode(s)	Rail Road Funicular
System actor(s)	Railway undertaking, logistic undertaking, global transport companies, freight
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	1, 10, 11, 17-20
Short description mobility journey (Pod system)	
The UC combines parcel delivery and passenger transport in the same TU if possible or in separate TUs if a specific volume is reached. Here factors of operational synergies (origin, urgency, and destination) and size of parcel plays major roles. In case that the volume of parcels fits the size of one or more Euro palettes or containers, a separate TU can be used. Here, using modular containers may be the key to optimised space utilisation. Therefore, a range of small and medium sized containers is suitable, i.e., in the range of standardised packages (parcels), 1-4 Euro palettes (suitable to integrate into bigger TUs) and small standard containers. The geographical area can be adjusted from urban to suburban to long distance. The urgency of delivery (if existing) a parcel is very important. Because of this, it is also relevant to have suitable carriers specialised on such TUs to deliver urgent goods without dependencies to bigger transport systems.	
Key components TU	
Car Body TU Type B, Wide Side Doors, Side Windows Seats (8 to 10), indoor design comparable with conventional transport systems (i.e., Bus or Tram), special storage for parcels	
Benefits	
• Rapid availability of small TUs and carriers • Continuous traffic from door-to-door • Cost efficiency • Enhance the capacities in crowded urban transport systems	
Examples from current practice and development	
As part of the Vienna Güterbim project of the Wiener Linien, two tramways of ULF type were used as “Packerl-Bim” on this shopping Saturday. Car number 638 was in the ring, and car number 671 was on the road between Floridsdorf and Gerasdorfer Straße. At certain stops you could leave your Christmas packages in the Packerl-Bim, which would then be delivered either directly by tram or the next day using a parcel service should.	

Table 21. UC description for UC17 "night logistics"

UC ID	UC17
Title	Night logistics
Transport mode(s)	Rail Road Funicular
System actor(s)	Railway undertaking, logistic undertaking, global transport companies, freight
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	1, 10, 11, 16, 18-20
Short description mobility journey (Pod system)	
Especially for newspaper logistics, pharmacy services, spare parts, and overnight services. Also, provision of supermarkets and parcels (e-commerce) is possible. The Pod system is used exclusively for freight and parcel services during off-peak hours.	
Key components TU	
Car Body TU Type B, Wide Side Doors Flexible Indoor design for freight transport of parcels, packages, and boxes	
Benefits	
• Rapid availability of small TUs and carriers • Continuous traffic from door to door • Efficient use of railway network 24/7 • High payload in urban areas • Urgent or high priority mail with flexible carriers	
Examples from current practice and development	
• Delivery services, especially with small vans on the street • In rail transport only over long distances with swap bodies or containers • U-Shift concept vehicle for silent night deliveries to supermarkets and other flexible services (https://verkehrsforschung.dlr.de/de/projekte/u-shift)	

Table 22. UC description for UC18 "container (10'/20')"

UC ID	UC18
Title	Container (10‘/20‘)
Transport mode(s)	Rail Road Funicular
System actor(s)	Railway undertaking, logistic undertaking, global transport companies, freight
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	1, 10, 11, 16, 17, 19, 20
Short description mobility journey (Pod system)	
This targets customers that have enough goods to fill standard containers. If the carrier design allows, standard freight containers can be transported directly on a carrier. Two 10-feet containers can be transported on one carrier belonging to two customers and/or having two different destinations. The Pod System allows platooning containers with passenger/other freight TUs. The distance can be adjusted but would cover a larger range compared to parcels for a higher share. Here, too, deadlines and the next journey of containers is very important, for instance, deadlines imposed in intermodal travel via marine transport.	
Key components TU	
See requirements for conventional 10’ or 20’ container acc. to ISO 668	
Benefits	
• Rapid availability of small TUs • Continuous traffic from door to door • Efficient use of freight railway network • On-time delivery • No personal	
Examples from current practice and development	
• Multimodal standard container transport on rail or road New rail-based solutions for container transport, like CargoMover (https://www.railwaygazette.com/news/cargomover-takes-on-the-lorry/25883.article)	

Table 23. UC description for UC19 "temperature-sensitive application"

UC ID	UC19
Title	Temperature-sensitive application
Transport mode(s)	Rail Road Funicular
System actor(s)	Railway undertaking, logistic undertaking, global transport companies, freight
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	11, 16, 17, 18, 20
Short description mobility journey (Pod system)	
Following UC shall meet all technical requirements such as conventional freight or parcel delivery. However, to ensure the quality of the transported goods, real-time monitoring of the payload is implemented. If necessary, the TU can be ordered and observed via Mobility Platform Management. In particular, goods such as fresh nutrition, medication, light- or temperature- sensitive substances should be able to be seamlessly controlled by sensors at anytime and anywhere. If a violation of the required parameter is detected, the TU must be identified (location) within the shortest possible time. In the customs area, the TU can be locked with an electronic door lock seal.	
Key components TU	
See requirements for standard refrigerated container acc. to ISO 1496-2:2018 Real-time data connection (location, traceability and environmental condition of payload) HVAC Unit, CCTV (internal and external observation), electronic customs seal	
Benefits	
• Rapid availability of small TUs and carriers • Continuous traffic from door-to-door • Efficient use of freight railway network • On-time delivery • Realtime control/traceability • Report (automated surveillance protocol)	
Examples from current practice and development	
• Intermodal transport in standard refrigerated container on rail or road • Multi-modal transport with refrigerated wagons on rail, reloading and in refrigerated vehicle on road	

Table 24. UC description for UC20 "individual Pods dispatching"

UC ID	UC20
Title	Individual Pods dispatching (e.g., hazardous application)
Transport mode(s)	Rail Road Funicular
System actor(s)	Railway undertaking, logistic undertaking, global transport companies, freight
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	11, 16, 17, 18, 19
Short description mobility journey (Pod system)	
Dangerous chemicals, biological agents and materials are transported as hazardous substances by road, rail and water for the purposes of further processing or utilization. This may lead to potential risks to health. Safe packaging, logistics concepts, traffic guidance, quality control and accident prevention strategies are all designed to reduce the threat to public safety. The Transport system must be designed in order ensure the best safety to transport goods and the related environment. The TU itself must be tested in a way to protect the payload in the situation of a crash or other disaster.	
Key components TU	
Tank-, Bulk- or Box-Container, see requirements for transport of hazardous substances (ISO 16106:2020, EN 13094:2008-1, EN 14025:2008-08) Real-time data connection (location, traceability and environmental condition of payload)	
Benefits	
• Rapid availability of small TUs • Continuous traffic from door to door • Efficient use of freight railway network • On-time delivery • No personal	
Examples from current practice and development	
• Intermodal transport in special container for hazardous substances on rail or road • Multi-modal transport of individual dangerous goods barrels	

6.5. Use cases other transport services

Table 25. UC description for UC21 "energy supply application"

UC ID	UC21
Title	Energy supply application
Transport mode(s)	Rail Road
System actor(s)	B2B (operators, energy provider, event manager, ...) Government (fire brigade, disaster management, ...)
Operational area(s)	Secondary / branch lines railway Main lines railway Roads
Related UC	All UC (range extender) or UC 9 as external energy storage
Short description mobility journey (Pod system)	
The following UC will consist of two functions: 1) Extending the range of the Pod Carrier (energy storage) through regenerative braking from potential energy of the carrier unit 2) Providing energy sources for other electrical networks (non-Pod infrastructure, events, emergencies, stations, etc.) The energy carrier (pod) can be ordered or is available as movable pod in the operator network. The energy transfer should take place preferable non-contact via inductive coils or in relevant areas via conventional overhead lines/charging facilities. The energy carrier can also be connected to the existing energy infrastructure for re-charging (if energy from regenerative braking is not available). The entire pod system is used for a charging cycle while driving or as a location-based container for specific applications (i.e., energy generator for events or an emergency case).	
Key components TU	
See requirements for conventional 20'-ISO containers, robust design for rough environmental conditions (-40° C to +40° C, sand or snowstorm), stable underframe design (stand-alone solution for muddy, sandy or rocky soil, ...) On-board power generators for 48 h autonomous operation, energy generator for regenerative braking, interfaces for all relevant currents (e.g., 380 V - 1.5 kV, AD/DC converter, frequency inverter)	
Benefits	
• Alternative solution high density energy storage anytime • Energy efficient solution • No extra infrastructure needed • Very adaptive energy source for different transport modes with very high payload (road, rail)	
Examples from current practice and development	
There is no directly comparable rail or road solution. In the past there were several solutions, like Gyrobusses, Battery Electric Multiple Units with Battery Tender. Similar solutions are currently being researched, among other things "Advanced Energy Rail Storage (ARES)" (https://www.asme.org/topics-resources/content/using-trains-send-power-grid)	

6.6. System use case "transport in rural areas”

In recent years in particular, numerous initiatives have emerged to reactivate disused railway lines for regular operations. Especially from the perspective of climate protection, the *"reactivation of branch lines ... is an important contribution to public transport infrastructure, especially in rural areas"* and represents an important political goal [20]. Studies from several European countries show the great potential and the challenges associated with it. Due to that it is also a topic of the ERJU in the Flagship Areas 6. [21–26] Taking into account the system idea for a Pod system, the example of possible traffic in rural areas, using reactivated branch lines, will be used to show how the UCs described above and the other parts of the system could be used.

Table 26. System UC1 "transport in rural areas (reactivation of branch lines"

System UC	S-UC 1
Title	Transport in rural areas (reactivation of branch lines)
Transport modes	Railway, Road
System actor(s)	Passengers, freight logistician, railway undertaking, TU rental company, carrier rental company, mobility management operator, service operator
Operational area(s)	Rural and semi-urban
Related UC	UC1 – UC8, UC 10 – UC 12, UC 16 – 19
Description mobility journey (Pod system)	
Person or freight logistics can register his transport request through a demand query in the corresponding mobile application, which is part of the MMP of the Pod System. The MMP on which the system is based allows the Carrier and TU to be dispatched as needed. The MMP coordinates the provision of the Carrier and TU according to needs and availability as well as the subsequent, timely transport from A to B. The passenger or freight logistics provider receives information about the journey and whereabouts at any time via the MMP. The Pod System allows the autonomous operation of Carriers with different TUs. For the system UC "Transport in rural areas", the use of the TUs according to the UCs UC1 – UC8, UC 10 – UC 12, UC 16 – 19 is conceivable depending on the respective requirements. Carriers designed to transport a TU can be used for deployment on branch lines. Due to the design of the TU and the maximum permissible loading capacity, the rail vehicles can be designed for an axle load of up to 12,5 t. The lightweight Carrier can be kept in use or ready for use in the sense of a moving infrastructure. Due to the autonomous operation of the Carrier, including the use of digital route data and communication with automated level crossing guards, they are driver-less in operation. In emergencies, manual emergency operation of the Carriers is possible. Depending on the route length, there are parking or storage options for the Carriers and TUs as well as charging facilities for recharging the Carriers batteries at intermediate stops or terminus stations. The dimensions of the passenger and/or freight TUs allows their transshipment onto road or rope-way carriers. This makes it possible to carry out transport to the desired final destination even after the end of a railway route. The change of the TU from one means of transport (rail Carrier) to another means of transport (e.g., road Carrier) is carried out using simple, autonomously operating reloading devices. The Pod System enables transport on existing, little-used branch lines and on railway lines that are to be reactivated with a feasible expansion for low axle loads. It connects rural areas and serves as a feeder for main routes, so the usual travel distance is 30-60 km. Basis of Flagship Project 6 FutuRe is up to 30 km (for separated lines), up to 80 km for lines with mixed traffic and 200 km for long distances (e.g., Sweden). A charging strategy includes fully charging on-depot overnight, and opportunity charging at every destination, considering that 30 minutes break are going to be available after 100 km operation. Alternatively, a battery-swapping strategy could be incorporated in the design, taking advantage of the single-car design.	

Key components
Pod system consisting of: • TUs, Carrier, Mobility management system, Handling system Additionally: • Automated level crossing protection and monitoring, Fast charging facility
Examples from current practice and development
Operation on mostly single-track branch lines in rural areas or around small and medium-sized towns is currently carried out in most cases with diesel multiple units. These vehicles often have more transport capacity than required. Freight transport in these regions is primarily handled by trucks. Alternatively, so-called tram-trains have become established in some European regions, which combine the operation of trams with that of regional railways. In most cases, operations are carried out using electric vehicles, which are largely equivalent to trams. Normally tram-trains are a type of light rail vehicle that both meets the standards of a light rail system, and national mainline standards. Beside these, different research activities are ongoing considering small, light automated vehicles. One example is the Flagship Project 6 FutuRe which aims at delivering innovative rail services to revitalise capillary lines and regional rail services.

The expected advantage over a conventional system is the use of the existing railway and road infrastructure, no longer requiring drivers and service personnel and the elimination of signalling technology for railways. For the user, the benefit of the system, in addition to transfer-less door-to-door transport, is constant availability, timely booking and billing and real-time information about the journey and whereabouts of the TU.

Considering the goal of achieving a seamless transport system, an additional feature that could be contemplated during design of the Pod system is the interoperability of Pods running on reactivated lines with neighbouring tram networks, thus connecting rural and semi-urban areas. The dimensions of the Pod system might allow for this interoperability, provided that the track gauge is compatible as well as the loading gauge.

7. Technical aspects of transport units and carriers

The use cases described above refer to the design options for the TUs, which can be flexibly transported in standardised basic dimensions on the also standardised carriers (vehicles). Based on the individual descriptions of the UC, basic technical parameters for the TUs as well as for the carriers can be derived. These are described below. Those parameters are not meant to be fixed requirements for the Pod system development. A final set of requirements will be developed for Task 3.2 (safety and security requirements), Task 4.4 (functional requirement specifications) and in subsequent work packages regarding the specific pod and carrier concept.

Based on the analyses of the possible UC and the basic idea of the pod system from the system description as well as possible future compatibility with existing swap body systems, initial estimations of dimensions for the TU were derived. The dimensions are shown in table 27.

Table 27. Basic dimensions for TU compared with standard container

Type	Length	Width	Height
10‘ Container	2,991 m	2,438 m	2,591 m
20‘ ISO Container	6,058 m	2,438 m	2,591 m
40‘ ISO Container	12,192 m	2,438 m	2,591 m
TU Type A	2,991 m	2,550 m	2,900 m
TU Type B	6,058 m	2,550 m	2,900 m
TU Type C	12,192 m	2,550 m	2,900 m

For the field of freight transport or combined transports, standardised cargo units like EPAL Euro palettes (e.g. for general freight transport), standardised roll-containers (e.g. for parcel, grocery and supermarket deliveries) or standardised package sizes (for package and parcel deliveries) are commonly used. The proposed standard dimensions of the Transport Units from Table 27 can integrate all those cargo units, as shown in the following list, and comply with the current global state of the art. Because of that they are suggested for the further TU development.

- EPAL Euro palettes: The most widely used exchange pallet in the world with a dimension of 1200 x 800 x 144 mm (length x width x height) [27]
- Deutsche Post/ DHL packages: Standardised package sizes from the market leader [28] for out of home logistics solutions with international operations. The maximum standardised package dimensions are 1200 x 600 x 600 mm (length x width x height) [29]

Keeping that in mind, there are also several use cases, where smaller TUs are needed to give higher flexibility with smaller volume demands. More specifically, for example a TU for 1-4 EPAL Euro palettes should be provided. They can either be used as a separate TU on a separate carrier, or they can also be placed inside a bigger TU (i.e., TU Type A-C) for combined transports. For example, for UC8 (PRM Application), UC11 (Transport Services), UC16 (Parcel delivery) or UC17 (Night Logistics) these are suggested options. A smaller TU can also increase the compatibility with rope-

way services. Related TU and carrier concepts can be found in D2.2 to deliver suitable TU dimensions (e.g. the U-Shift vehicle) or as stated in the use case descriptions above.

Basic possible requirements for the Carrier can also be derived from the different UCs that arise from the design variants of the TUs, as well as the underlying system idea. These are described in detail below to give suggestions for future pod system configuration.

Table 28. Rail carrier for one TU (branch lines or urban transport)

Rail carrier for one TU for branch lines or urban transport	
Gauge	1435 mm
Operational range	Between 100-300 km
Max. speed	< 80 km/h
Max. axle load	12,5 - 16,0 t
Train control systems	Developed for Autonomous Operation for GoA 4
Vehicle coupling	Virtual coupling Emergency coupling system based on hook coupling
Drive and brake technology	
Energy storage	Battery
Power supply	Sharing station and/or overhead contact line/3rd rail
Communication	FRMCS and/or xG LTE (4G, 5G, 6G, ...)
Noise	acc. to EN ISO 3095
Safety	High active safety system due to new approach of autonomous driving
Coupling between TU and carrier	Mechanical Electrical
Usable for TU Type	B, 2 x A

Table 29. Rail carrier for two TUs (branch lines or urban transport)

Rail carrier for two TUs for branch lines or urban transport	
Gauge	1435 mm
Operational range	Between 100-300 km
Max. speed	< 80 km/h
Max. axle load	16 - 25 t
Train control systems	Developed for Autonomous Operation for GoA 4
Vehicle coupling	Virtual coupling Emergency coupling system based on hook coupling
Drive and brake technology	
Energy storage	Battery
Power supply	Sharing station and/or overhead contact line/3rd rail
Communication	FRMCS and/or xG LTE (4G, 5G, 6G, ...)
Noise	acc. to EN ISO 3095
Safety	High active safety system due to new approach of autonomous driving

Coupling between TU and carrier	Mechanical Electrical

Table 30. Rail carrier for one TU (heavy freight transport)

Rail carrier for one TU for heavy freight transport	
Gauge	1435 mm
Operational range	Between 100-300 km
Max. speed	< 80 km/h
Max. axle load	16 - 25 t
Train control systems	Developed for Autonomous Operation for GoA 4
Vehicle coupling	Virtual coupling Emergency coupling system based on hook coupling
Drive and brake technology	
Energy storage	Battery
Power supply	Sharing station and/or overhead contact line/3rd rail
Communication	FRMCS and/or xG LTE (4G, 5G, 6G, ...)
Noise	acc. to EN ISO 3095
Safety	High active safety system due to new approach of autonomous driving
Coupling between TU and carrier	Mechanical Electrical

Table 31. Rail carrier for two TUs (mainline transport)

Rail carrier for two TUs mainline transport	
Gauge	1435 mm
Operational range	>= 1.000 km
Max. speed	< 80 km/h
Max. axle load	16 - 25 t
Train control systems	Developed for Autonomous Operation for GoA 4 Additional ETCS
Vehicle coupling	Virtual coupling Emergency coupling system based on hook coupling
Drive and brake technology	
Energy storage	Battery
Power supply	Sharing station and/or overhead contact line/3rd rail
Communication	FRMCS and/or xG LTE (4G, 5G, 6G, ...)
Noise	acc. to EN ISO 3095
Safety	High active safety system due to new approach of autonomous driving
Coupling between TU and carrier	Mechanical Electrical

Table 32. Tramway carrier (urban transport)

Tramway carrier for urban transport	
Gauge	1435 mm (or other)
Operational range	max. 100 km
Max. speed	< 60 km/h
Max. axle load	12,5 t
Train control systems	Developed for Autonomous Operation for GoA 4
Vehicle coupling	Virtual coupling Emergency coupling system based on hook coupling
Drive and brake technology	
Energy storage	Battery
Power supply	Sharing station and/or overhead contact line
Communication	
Noise	acc. to EN ISO 3095
Safety	High active safety system due to new approach of autonomous driving
Coupling between TU and carrier	Mechanical Electrical

Table 33. Road carrier (urban transport)

Road carrier for urban transport	
Operational range	Between 100-300 km
Max. speed	< 80 km/h
Max. axle load	11,5 t
Train control systems	Developed for SAE 5
Vehicle coupling	Virtual coupling
Drive and brake technology	
Energy storage	Battery or similar
Power supply	Sharing station
Communication	xG LTE (4G, 5G, ...)
Noise	
Safety	High active safety system due to new approach of autonomous driving
Coupling between TU and carrier	Mechanical Electrical

Other carrier and TU variants, for example the U-Shift or other concepts, in different transport modes are conceivable, e.g., for ropeway or road transport to maximise the benefits from the pod system flexibility.

To align with road transport standards, figure 3 and 4 show axle loads and dimensions for road vehicles, especially trucks. It shows that a maximum length of 12,0 m is allowed for 2-axle vehicles with a maximum height of 4,0 m and 2,55 m with. Longer vehicles up to a maximum length of 18,75 m are possible with additional axles. Figure 4 shows, that a maximum axle load of 11,5 t is allowed for a 2-axle vehicle.

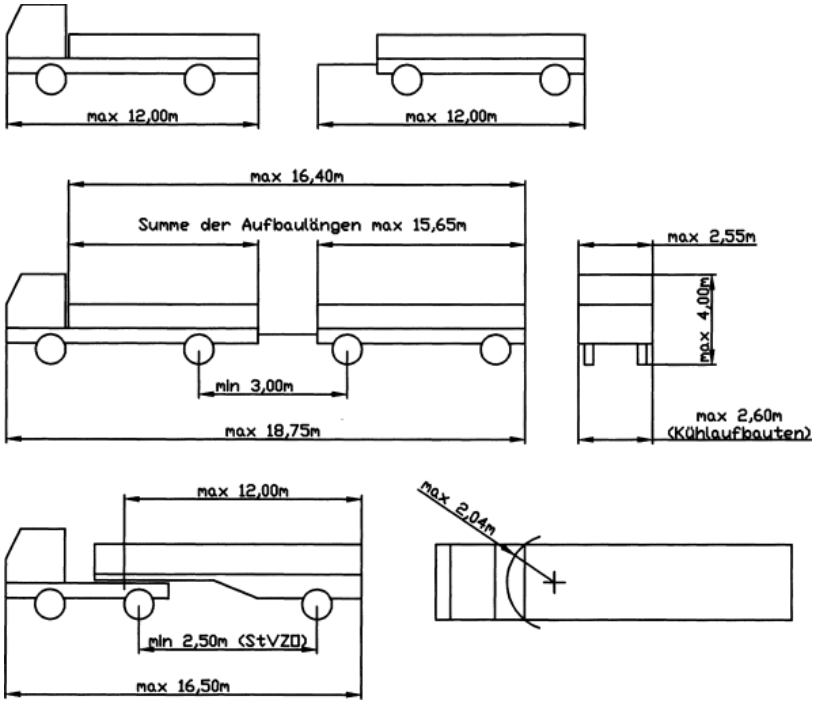

Figure 3. Description of road vehicle dimension requirements

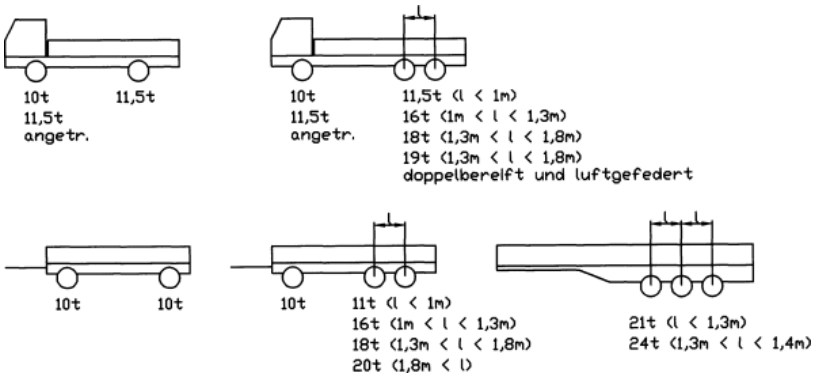

Figure 4. Description of road vehicle axle load requirements

Figure 5. shows standard dimensions of a lorry and Figure 6. specifies the axle load requirements of road vehicles [30]. To assume the required capacity for the Carrier (C), standard containers [31] represent a base size (valid for passenger and freight/ parcel services) for volume and mass (see Figure 5 [32]) to further technical aspects of the TU can be derived (see WP 7 and 8). High cube containers are not in scope of Pods4Rail.

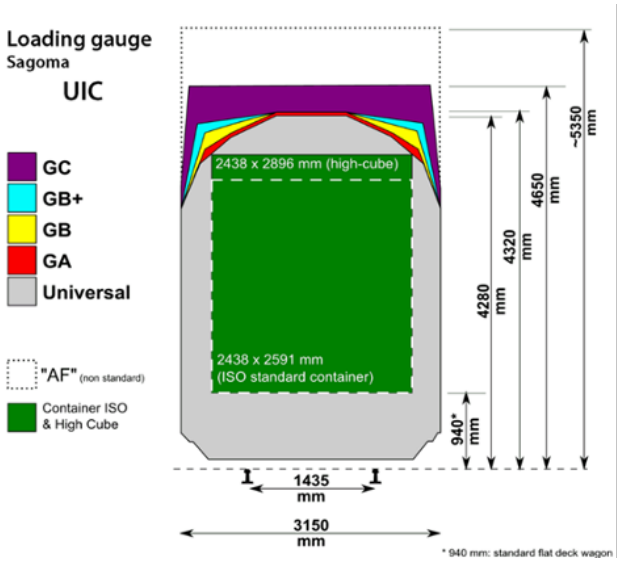

Figure 5. UIC loading gauge profile for freight containers

Technical sizing of payload

A carrier should be able to carry the following standard containers according to ISO 668 (see source [13]) as well as other TUs. Because those standard containers are important for train dimensions, they are presented more detailed in the following. The other possible TUs are not described more detailed but should be considered in following Tasks. There are two sizes of containers that are eligible for the Pod system:

- 10’ standard (tare weight: 1.300 kg, max. payload: 10.160 kg, dimension L/W/H in mm: 2989 x 2435 x 2591)
- 20’ standard (tare weight: 2.300 kg, max. payload: 21.700 kg, dimension L/W/H in mm: 6055 x 2435 x 2591)

Possible configuration are (see figure 6)

- 2 x 10’ container per 1 carrier unit (CU) or
- 1 x 20’ container per 1 CU

Figure 6. Principle sketch for possible configuration (TU type A and 20' containers) on rail carrier

Following, the possible configurations for specific UCs will be recommended in table 34 to 37.

Table 34. Possible configuration for passenger transport services for the example of 10’ and 20’ container

A – Passenger transport services		
ID	Name	Possible configurations
UC1	Basic passenger public transport	1x20’ container per 1 CU
UC2	Premium passenger public transport	2x10’ container per 1 CU
UC3	First class passenger public transport	2x10’ container per 1 CU
UC4	Mass passenger public transport	1x20’ container per 1 CU
UC5	Basic passenger private transport	2x10’ container per 1 CU
UC6	Premium passenger private transport	1x20’ container per 1 CU
UC7	Luxury passenger private transport	1x20’ container per 1 CU
UC8	PRM application	2x10’ container per 1 CU
UC9	Ambulance application	1x20’ container per 1 CU
UC10	Tourism application	1x20’ container per 1 CU

Table 35. Possible configurations for combined transport services

B – Combined transport services		
ID	Name	Possible configuration
UC11	Transport services	2x10’ container per 1 CU
UC12	Shopfloor	1x20’ container per 1 CU or 2x10’ container per 1 CU
UC13	Rescue application	2x10’ container per 1 CU
UC14	Housing application	1x20’ container per 1 CU
UC15	Event application	1x20’ container per 1 CU or 2x10’ container per 1 CU

Table 36. Possible configurations for freight transport services

C – Freight transport services		
ID	Name	Possible configuration

UC16	Parcel delivery	2x10’ container per 1 CU
UC17	Night logistics	2x10’ container per 1 CU
UC18	Container (10’/20’)	1x20’ container per 1 CU or 2x10’ container per 1 CU
UC19	Temperature-sensitive application	1x20’ container per 1 CU or 2x10’ container per 1 CU
UC20	Individual Pods dispatching (e.g., hazardous application)	1x20’ container per 1 CU or 2x10’ container per 1 CU

Table 37. Possible configurations for other transport services

D – Other transport services		
ID	Name	Possible configuration
UC21	Energy supply application	1x20’ container per 1 CU

8. Conclusions

The Task 4.1 “Description of use cases” is located in the framework of the Flagship Project 7 Pods4Rail as described in the EU-RAIL MAWP. Building on the technical Pod system overview of WP2, Task 4.1 aims to define and describe potential UC for intermodal Pod systems based on the findings of WP2.

The analysis of various research projects and (conceptual) systems for different TU in WP2 has shown that most of the Pod systems in development are still far away from full technical feasibility. Therefore, it is now important to derive relevant and promising UC which are highly usable for a wide range of passengers and freight as well as technically feasible for fast potential deployment with broad acceptance by the desired user groups. The major objective of Task 4.1 was the collection of a range of potential use cases with a user-centric perspective. This deliverable aims to describe each UC for further assessments within the following tasks of this project.

In order to determine the relevant UC, as a first step, morphological charts were created. Those charts can be used to explore the design space. It was shown that many individual solutions are possible for the use of intermodal, autonomous rail-based Pods. Based on the morphological charts and a thorough ideation process, a list of 21 relevant UC for the flexible, decentralised transport system were identified (see chapter 5.3). For those UC, mobility journeys were subsequently reported, and UC descriptions were written (see chapter 5.4). Lastly, a set of 147 parameters in terms of technological, economic, environmental and user and society-centred design and operation were evaluated according to their relevance and feasibility for each UC (see table A3-A6).

The description of the use cases shows that passenger transport, as well as freight transport, are relevant UC for Pod systems. In many situations, combined transport must be enabled with the employed TU. An important advantage of an intermodal Pod system is the flexibility of door-to-door transportation on-demand, which means that there is a wide variety of possible user groups and transported goods for a Pod system. In case of passenger transport, this means that, in addition to the existing standard public transport UC, particularly new services like seamless premium transport or transportation for PRM show great potential. Some of the most promising freight transport applications are combined services, which grant increased transport efficiency. For on-demand door-to-door mobility, special UC like ambulance or rescue services, as well as modular shop-floor or event containers, could be possible UC.

Within D4.1, some limitations have to be remarked. Firstly, a complete showcase of all possible use cases is out of scope and therefore not the aim of this task. For the full description of additional UC, further work has to be conducted. Secondly, this task uncovered a wide variety of parameters, including technical, ecological, economic and user or society aspects. These parameters should be considered in the following tasks and the development of the future Pod system. Each application scenario describes which TU can be used in operational practice and shows feasible technical parameters for the TU and carrier. The technical parameters are an initial orientation for the Pod design and the structure of the system infrastructure. Further research is required, however, in

order to complete the specification of the system, e.g., for the definition of business models. For the following Task 4.2 (SWOT analysis) this deliverable can serve as a pre-filter of relevant UC. Nevertheless, a selection of UC for further development will be conducted in the following tasks and work packages.

The contribution of D4.1 is of key importance for further work in Pods4Rail. With its results, D4.1 complies with the objectives of this task and also contributes to the Flagship Area 6 project FutuRe.

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10. Appendices

10.1. Additional Morphological Charts

The morphological chart in Table A1 describes how the TU is being used in each UC.

Table A 1. Description of general TU usage for the UC

Type of passenger transport	Type of freight transport	Trip distance	Usage of TU	TU size/ loads (for persons)	TU size/ loads (for freight)
private persons (single travellers)	General freight (standardized load carriers e.g., EURO-pallets)	Local (1-10km)	People (open access)	small (1-4 passengers)	small volumes (10' TU)
private users (group travellers)	Parcel deliveries (e.g., post, packages)	Regional (10-100km)	People (closed reservations)	medium (5-10 passengers)	large volume (20' TU)
business users (single/group travellers)	Time-sensitive goods (e.g., frozen, cooled)	Long-distance (>100km)	Freight (single client)	large (>10 passengers)	small volume (new designed TU)
Ambulance transport	High security goods (to be guarded)		Freight (mixed clients)		
Prisoner transport	Special freight transport (e.g., disaster/ sales equipment)				
Luxury TU					
Tiny House TU					

The morphological chart in Table A2 points out important technical details and gives information about possible business model descriptions of the UCs.

Table A 2. Technical details regarding the UC

Steering and control	Coupling automation (TU on carrier)	Power supply and energy storage	Interaction to other vehicles	Pod system integration	Carrier compatibility	Handling technology (stations)
Fully autonomous TU and carrier (=decides routes by itself)	Fully automatic coupling	Battery powered (power-train on-board)	Isolated operation with no interaction	TU, carrier and infrastructure fixed together	Suitable for existing rails	With a (limited) TU storage and waiting time
Fully automated TU and carrier (= on fixed routes)	Semi-automatic coupling	Hydrogen powered (power-train on-board)	Reserved line for Pod-Only traffic	TU and carrier fixed as one, infrastructure independent (out of scope)	Suitable for existing road	Without storage and waiting, unlimited
Central controlled TU and carrier	non-automatic coupling (Flexible)	Infrastructure powered (power-train on-board)	Mixed traffic with scarce interaction	TU independent, carrier and infrastructure fixed	Needs dedicated new infrastructure	Seamless synchronized transfer

Decentralized control		Infrastructure powered (no own engines)	Mixed traffic with frequent interaction	TU, carrier, and infrastructure independent	Flexible	Automatic transfer
Infrastructure controlled TU and carrier		Mixed				Flexible

10.2. Collections of identified Use Cases

Overview of all UCs compiled during the ideation process, including a brief explanation. The UC were divided into four groups:

1. UC for passenger transport services: see list 1
2. UC for freight transport services: see list 2
3. UC for combined transport services: see list 3
4. UC for other transport services: see list 4

List 1. Collection of use cases for passenger transport services

A – Passenger transport services
Elderly: Specific transport solution for elderly persons
PRM: people with reduced mobility (e.g., blind, handicapped etc.) Need to make allowances for getting on/off the TU, emergency button, wheelchairs, guide dogs etc.
Ambulance transport / hospital: A UC for transporting patients or medical staff-with specific needs and equipment
Urban mobility: public/ mass transport: Pod system for public mass transport Individual transport: Pod system for individual transport with small TU
Rural mobility: Sustainable rural mobility / connection of rural areas (reactivating branch lines, local operators, circle of declining rural regions, OECD) / service-to-people mobility solutions (service based on the needs of the region (tourism, healthcare services, school transportation, nightline, shift worker…)
Premium commuting: Specific solution with more comfort, from short to medium distance under consideration of the seating situations
Private “plug&play” TU: e.g., living space (time scarcity) / customization / changing interior trends / location specific needs / intelligent plug&play system to reconfigure the interior layout as well as the service offerings & elements that add to passenger comfort (enjoy the journey, “cool” interiors, entertainment) / rapid retrofitting / various ergonomic states /modular design / additive manufacturing / easy refurbishment / leasing
Low-cost mass TU: For high density situations / interior design and equipment with very basic comfort / only standing or leaning seats, handrails / robust materials / new “shell” materials
(Airport) shuttle: Transport solution with direct connection to airports / airport infrastructure focused on passengers with freight.
Children Transport: Specific Pod solution for children (e.g., seating, safety, HMI etc.)
People who do care-work and travel e.g., with kids: Specific solution for travellers with kids or other persons with special demands, similar to an “accessibility vessel”
Group travellers: Passenger transport for groups in specific (e.g., group of students that should/can stay together whole time)

Transfer-free “premium” service: Available solution for everyone without freight (i.e. anyone can book this optional service to get a transfer free ride to destination which could also be reached with conventional public transport on same route, but including transfers (focus on passenger capsules without freight)
VIP Passenger Transport: Transport solution specially for persons with high privacy or security demands (e.g., politicians, business travellers to not get disturbed etc.)

List 2. Collection of use cases for freight transport services

B – Freight transport services
Time-critical deliveries: e.g., direct delivery services to pharmacies, hospitals
Last-mile mobility: Transport with generally non-existent overhead lines at freight terminals (freight centres and ports)
Wagon-load freight/ shopfloor: supply transport / disposal transport (empty packaging) / automated storage and retrieval system / robotic solution / rack rail systems (grid/bins) / order and logistics management system / station
Freight is transported in a separate TU, dispatched individually: This may be applied to the freight types with special handling requirements such as refrigeration, Dangerous goods (DG), emergency goods. Other types of freight may also be considered for this type of TU depending on the availability of TUs and passenger demand patterns.
Transport of time critical goods: e.g., refrigerates, DG, Emergency goods, etc.
Transport of general freight: This UC defines cases where there is the need for a special TU such as those required by bulk freight. Here, Pod-sets can be formed between certain origins and demands. Here we may assume that traditional trains or Pod formations may be used.
Personalized door-to-door transport: Express-Deliveries and other personalized door-to-door transport (e.g., big packages, valuable goods etc.)
Freight exclusive uni/ multi-pod TUs: This UC concerns creating Pod formations which are dedicated to freight. For instance, for transporting freight where passenger demand is scarce.
Seamless freight transshipment synchronisation: e.g., at intermodal interfaces

List 3. Collection of use cases for combined transport services

C – Combined transport services
People with special requirements: e.g., groups; people who want to transport something on the TU, e.g., furniture; for elderly: walker, wheelchairs etc.
Transfer-free service for everyone with freight: i.e. Focus on passengers travelling with uncomfortable freight like bicycles/ luggage/ strollers/ wheelchair etc. Aim: To not set limitations for travellers e.g., “no bikes are allowed in city-trains during rush hour”
General Freight combined with passengers: Combined passenger and freight transportation in the same TU
Transport highway: dedicated line (rail or road lane), where Pods can run in platoon, combining passenger and freight Pods This UC concerns assigning empty capacity of passenger vessels for specific small sized freight, e.g., by provision of loading units inside the vessels.
Combined passenger and freight transport-exclusive freight TUs: This is where there is no capacity on passenger vessels or there is enough demand for freight transport/freight vessels need to be equipped with specific technology, such as freight status monitoring. This UC concerns combining vessels of freight and passengers into formations. The matching occurs based on freight type and origin-destination matching.
TU with freight space: Freight can be inserted into passenger vessels. In this scenario, there is a specific location considered for the freight inside the vessel. Additional considerations: Loading unit design; loading and unloading duration and order; compatibility (freight type, weight, etc.)

List 4. Collection of use cases for “Other transport services”

D – Other transport services
Service-Capsule: A vessel which is offering a service: i.e. for people who want to do something while traveling (e.g., hairdresser, library, kiosk, news (newspaper, TV), mini-restaurant, doctor ... Advantage: due to the intermodal vessel the time of using the vessel is longer and the travel can be more productive. The customer is saving time because she or he does not have to do it in the private free time)
Market service: A specific TU for selling different goods
Community/Communication vessel: A special vessel to be used for community activities
Business Capsules: i.e. tiny office with infrastructure for mobile working
Event-driven Pod deployment: A special TU for Events, Exhibitions, Entertainment / Immersive Experience
Emergency and disaster response: A vessel specially for supporting activities in emergency situations
Energy supply unit: e.g., feeder/charger for mobile uses
Hazard-related/critical UCs: A TU specially for critical goods or activities
Tourism application: A TU specifically for tourism activities, i.e. for transporting people and equipment but additionally to offer services like HMI systems or activities related to the current location/destination
Housing application: a TU that can offer room for individual purposes and for longer stays

10.3. Use case matrix

In task 2.2 several aspects were identified to characterise existing pod(-related) concepts. To describe the UCs and derive synergies technological, economic, ecological as well as user- and society-centred parameters were considered. The following tables (table A3, A4, A5 and A6) show the basic framework for characterising the UC. All parameters for characterisation are listed in the "Parameters" column. For easier tracking, each parameter has been assigned its own ID. The various parameters are summarised into a topic group in the "System elements" column. For example, five different operational areas are identified. However, some operational areas map different parameters due to similar requirements (the system element "Operational area I" contains the parameters "Main line", "Suburban line" and "Branch line"). The system elements are in turn assigned to a superordinate "System category" (e.g. Pod or railway infrastructure). Each parameter therefore refers directly to the corresponding subsystem. The parameter is assigned the value 0, 1 or 2 for each UC. The values were given together in groups of 3-4 experts based on their experience and understanding of each UC-scenario.

- 0 - Parameter is not relevant for the UC
- 1 - Parameter is nice to have
- 2 - Parameter is a must have for the UC

The assignment of values by the relevant experts means that the various UC can be compared with regard to the individual parameters. Furthermore, this method points out which parameters or system elements are of increased importance, and which are essential in the further processing of the project. Lastly, the evaluation of the technological, economic, ecological as well as user- and society-centred parameters can also be used to assess the feasibility of each UC. For example, if one UC is assessed with contradictory importances of parameters it might not be feasible. Meanwhile a UC which includes parameters that comply with the state of the art, it would be

considered as feasible. This is also how possible requirements for the carriers can be derived (see tables 28-33).

Table A 3. UC matrix including system elements and parameters: Technical

System categories		System elements	ID	Parameters
Railway network	Technical	Operational area I	1	Main line
			2	Suburban line
			3	Secondary / branch line (capillary lines and regional rail services)
Tramway networks		Operational area II	4	Urban transport systems
Metro systems		Operational area III	5	Metro systems
Road transport network		Operational area IV	6	Road transport vehicles
Cable Cars/ Funiculars		Operational area V	7	Cable cars
			8	Funiculars
Railway infrastructure		Train meets	9	low-frequency line
			10	high-frequency line
			11	separated line
Railway infrastructure		Existing electrical network	12	3rd rail
			13	Overhead lines (OL)
			14	independent filling/charging station
Operation system		Signalling systems	15	ETCS Level 3 (acc. TSI CCS)
			16	Tramway signalling system
			17	No train guard system
			18	New system (for autonomous driving)
Railway infrastructure		Gauge	19	Standard-gauge 1435 mm
			20	adaptable to other
Pod		Operational range	21	min. range > 100 (km)
			22	min. daily > 1.000 (km)
			23	max. range < 100 (km) per day
			24	no limit (km)
Pod		Operation mode	25	Autonomous operation and virtual coupling
			26	for emergency coupling system based on hook coupling
Pod		Grade of automation (GoA)	27	GoA3 (automatic door control – driver-less with train attendant)
			28	GoA4 (fully autonomous – no driver / no train attendant)
Pod		Max. speed	29	> 80 km / h
			30	< 80 km / h
			31	< 40 km / h
Pod		Design /	32	TU

	Architecture pod	33	Detach-ability
		34	Bi-directional
Pod	Configuration	35	Single car
		36	Two-car configuration
		37	2–4 car configuration
Pod	Payload / tare weight	38	Payload < 50 seating or < 100 stands (max. axle load 12,5 t / single axle vehicle) *
		39	Tare weight < 17(t) *Aachener Rail Shuttle
		40	other
Coupling system	Coupling technology (TU <–> carrier)	41	Electrical
		42	Mechanical
		43	Communication-based
Railway infrastructure	Tunnel / surface	44	tunnel operation
		45	surface operation
Pod	Propulsion (Engine)	46	Linear induction motors (kW)
		47	Asynchronous machines (kW)
		48	Permanent magnet machines (kW)
		49	other
Pod	Energy storage	50	Battery
		51	Contact Line
		52	other
Pod	Brake system	53	fully electric brakes
		54	for emergency mechanical brakes (2nd braking system)
Communication	Communication	55	FRMCS (Future railway mobile communication systems)
		56	xG – real-time
		57	PIS – incident management – active emergency case
		58	CCTV – safety & security active surveillance
Energy supplies & charging	Power supply	59	Charging station
		60	Fuelling station
		61	Electrification (Overhead line)
		62	Electrants
		63	Catenary island systems
		64	Fast charging stations
Station	Station infrastructure	65	existing Overhead lines (OL) in stations
		66	accessible platform height and length
Pod	Charging infrastructure	67	Catenary line
		68	Charging plug

Handling system		Handling infrastructure	69	Mobile cranes
			70	Industrial robot arm
			71	Coupling station
			72	Stacker
			73	other
Pod storage		Depots	74	TU storage
			75	Carrier storage
			76	Depots with charging infrastructure
Pod		Vehicle homologation	77	Approval for rail
			78	Approval for road
			79	Approval for rope-way

Table A 4. UC matrix including system elements and parameters: Economic

System categories		System elements	ID	Parameters
	Economic	Business relationship	80	Business-to-business (B2B)
			81	Business-to-consumer (B2C)
			82	Business-to-consumer (D2C)
Pod		Estimate demand	83	for new carrier per annum
			84	number of passenger TUs by type per annum
			85	number of freight TUs by type per annum
			86	other
Pod		LCC (operator)	87	Carrier operating life > 30 years
			88	Carrier operating life < 30 years
			89	TU operating life > 30 years
			90	TU operating life < 30 years
			91	Recharging infrastructure operating life > 30 years
			92	Handling system operating life > 30 years
			93	Storage system operating life > 30 years
Pod		Return on invest (ROI)	94	ROI expected < 3 years
			95	ROI expected < 10 years
		Business model	96	Dynamic pricing model
			97	Product-as-a-service model (subscription fee, pay-as-you-go/pay-per-kilometre/pay-per-capacity, flat rate pricing)
			98	Freemium model (all-inclusive/add-on)
			99	Leasing model (rent instead of buy)

			100	Experience selling
			101	Direct selling model (pay-per-unit, e-commerce)
			102	Mass customization
			103	Fractionated ownership (sharing)
			104	Revenue sharing (platform business, franchise, joint-ventures)
			105	Sale-leaseback model
			106	Data monetization
			107	Integrator

Table A 5. UC matrix including system elements and parameters: Environmental

System categories		System elements	ID	Parameters
Pod	Environmental	Emissions and air quality	108	emission-free (WTW, TTW)
			109	low emissions
			110	other
Pod		Energy efficiency	111	low energy consumption (WTW, TTW)
			112	recover energy
			113	other
Pod		Thermal comfort	114	HVAC
			115	other
Pod		Noise	116	low noise (aac. to EN ISO 3095)
			117	other
Pod		Vibrations	118	low vibration levels
			119	other
Railway infrastructure		Land use	120	uses the existing infrastructure
			121	minimal infrastructure adjustments (e.g. barrier-free stations)
			122	parking space reduction
Pod		Waste water	123	limitation of hazardous substances
			124	other
Pod		Eco-design	125	eco-design process
			126	limitation of hazardous substances
			127	other

Table A 6. UC matrix including system elements and parameters: User- and society-centred design

System categories		System elements	ID	Parameters
Pod	User- and society-centred design	Safety and Security	128	high active safety system (for autonomous driving)
			129	automatic door control
			130	acoustic and optic information
			131	emergency button
			132	other
Pod / Station		Accessibility	133	barrier-free
			134	only via steps
Pod coordination and mobility management		Travel time	135	short travel time from start to destination
			136	short travel time door-to-door
			137	travel time is not relevant (quality time is important e.g. to work)
Pod coordination and mobility management		Availability	138	demand-responsive transport
			139	reduction of delays
			140	no cancellations
			141	seamless integration with other transport modes
			142	other
Pod		Extended mobility needs	143	wheelchairs, walkers, strollers (acc. TSI PRM)
			144	(e-)bikes, (e-)scooter
			145	bulky baggage
			146	toilet
			147	other