Deliverable D 4.2
SWOT analysis

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1 Executive Summary

The aim of the Deliverable 4.2 “SWOT analysis” from the Pods4Rail project is to describe the performed qualitative assessment of the socio-economic factors using a SWOT analysis for Pod system applications. The analysis highlights strengths, weaknesses, opportunities, and threats of the autonomous Pod system for passenger and freight transport.

The SWOT analysis was accompanied by a survey. Questions were asked about two scenarios for Pod application in order to identify the preferences of different user groups. The survey distinguished between two target groups. The first is general public transport users and the second target group is users from the logistics sector. Both surveys are based on the use cases presented and analysed in Deliverable 4.1.

The results from our regular team meetings and user surveys provide insights into user acceptance and needs.

The SWOT analysis identified the potential benefits of the Pod system, such as energy efficiency and door-to-door service for passengers. The results of the passenger and freight transport surveys highlighted the importance of safety and flexibility in implementing the Pod system. The surveys indicated a preference for public Pods over private Pods, with a focus on the flexibility of the system and safety measures. Recommendations include further research on operational models to ensure the success of the Pod systems. The results of the surveys will be valuable in developing the business case in Work Package 5.

2 Abbreviations and acronyms

AGV	Automated guided vehicle
AMoD	Autonomous Mobility on Demand
AV	Autonomous Vehicles
EU-RAIL	Europe’s Rail
GA	Grant agreement
MAWP	Multi Annual Working Plan
MMS	Multimedia Messaging Service
Pod	Decentralized, detachable, fully-autonomous transport system
PRM	Persons with Reduced Mobility
SWOT	Strengths, Weaknesses, Opportunities and Threats
WP	Work Package

3 Background

The present document constitutes the Deliverable D4.2 “SWOT Analysis” in the framework of the Flagship Area 7, project Pods4Rail as described in the EU-RAIL MAWP.

Based on the description of the system to be developed in D2.1, the evaluation / benchmark of available and conceptual multi-modal mobility systems in D2.2, the consideration of the existing standards and legal regulations as well as the analysis of the safety requirement and identification of needs for standardisation on safety and security, which were presented in D3.1 and D3.2 as well as the description of possible use cases in D4.1, there is a need to determine the strengths and opportunities as well as the weaknesses and risks for the implementation of the system to be developed. The analysis is intended to help the project determine its position and to specify or focus on further action in the following work packages of the project. Socio-economic as well as technical aspects are included in the analysis.

4 Objective of the Document

For a qualitative assessment of socio-economic factors, an analysis with special regards on the strength, weakness, opportunities, and threats of the system is performed. Special focus is placed on a qualified comparison of different use cases. Based on the targeted different modes of transport, use cases for the transport units are defined and described in the document of D4.1. A definition of evaluation parameters (e.g., social, environmental, technical) was carried out to assess the potential use cases. The socio-economic evaluation also includes the evaluation of user acceptance of the selected use cases of a multi-modal mobility system including the assessment of user requirements, travel-related needs, and concerns.

The work is based on qualitative study, and it is closely linked with the works in WP2 on the general assessment of user acceptance needs and requirements. Different user segments for the use cases are considered. In addition, defining system design factors aiming at higher acceptability, implementability levels in complex design process from stakeholders' and technical perspectives were considered. The evaluation is based on in the WP2 developed system description.

5 SWOT Analysis

5.1 Introduction into the Methodology

A SWOT analysis is a strategic planning and strategic management technique used to help to identify Strengths, Weaknesses, Opportunities, and Threats related to business competition or project planning. [1] This technique is designed for use in the preliminary stages of decision-making processes and can be used as a tool for evaluation of the strategic position of an idea. It is intended to identify the internal and external factors that are favourable and unfavourable to achieving the objectives of the project. The primary objective of a SWOT analysis is to help the project Pods4Rail to develop a full awareness of all the factors to be considered in the development process.

The intention of the SWOT analysis is to highlight possible risks and weaknesses for the project, as well as strengths and opportunities that lie in the initial idea for the Pods4Rail project and are laid down in the "System Description" in D2.1. The focus is on considering the technical system approach and not on examining the business opportunities. This is only possible after a thorough examination of the technical framework conditions and the cost blocks that can be derived from them and will take place in a later section of the project.

5.2 Evaluation parameters

The focus of the SWOT analysis, as explained in 5.1, should primarily examine the idea of the system presented in the "System Description". Several subject areas are deliberately excluded because they cannot currently be assessed or do not need to be assessed. These include the complex of topics of autonomous driving, as well as common transport systems such as the railway.

As a result, the focus of the analysis is on the system approach, the question of constantly available door-to-door traffic, the possible use cases described in D4.1, the technical basis necessary for implementing the idea and the general acceptance of the system. So, the most interesting evaluation parameters are:

- social acceptance of the basic idea of a Pod system
- passenger transport requirements
- shared transport of people and goods
- requirements from the logistics sector
- technical feasibility and its boundary conditions

5.3 Unanalysed parameters

5.3.1 Social acceptance of existing modes of transport

The transport modes on which the system description is based, rail transport, road transport and cable cars, are technically sophisticated transport options that have been introduced for centuries and are subject to a high level of social acceptance. The first public railway was opened in 1825, and road transport has existed with different means of transport ever since there were roads. Cable cars / funicular in their current form also look back on 150 years of technical development.

Since all systems can rely on a mature state of the art, which is set out in standards, these transport modes as such are not the scope of the analysis. The social acceptance of these systems is largely determined by general use and the technical condition of the systems themselves as well as general legislation.

5.3.2 Social acceptance of autonomous driving

The social acceptance of such autonomous transport systems among users, such as the system on which Project Pods4Rail is based, plays a major role in assessing the risks and opportunities of a new means of transport that is intended to ensure autonomous operation. The departure from a familiar means of transport, which is characterised by the fact that professionally trained personnel always ensure operation, can create a feeling of insecurity for the user. From this point of view, the question of whether future users would accept such a new means of transport plays an important role. On the other hand, in public transport, means of transport that operate in automatic, unmanned operation have been introduced for several decades, especially in the metro area (e.g., Copenhagen, Nürnberg, Paris), and are used without restrictions. Similar operating methods also exist for monorail systems or cable cars. Automated, unmanned guided vehicles (AGV) have also been state of the art in container and freight logistics for several years.

Nevertheless, the paradigm shifts in public road transport, which, unlike in rail transport or freight logistics, does not take place in secure traffic areas, must be considered separately. Studies from recent years show that the acceptance of autonomous vehicles for public road transport is rather high. It should be noted that autonomous vehicles for road traffic are generally still in development and only semi-autonomous road vehicles are in test operation. In particular, the activities to introduce self-driving automobiles and minibuses are extensively accompanied by studies on user acceptance. [2] [3] [4]

Currently, statements about the social acceptance of autonomous means of transport, especially compared to the use of autonomous, self-driving automobiles (AV), are very different. There were differences in the results that resulted from the survey technique, the composition of the group of respondents and the questions. [10] [11] The statements about the social acceptance of AV vary between a) 56% of respondents aged > 65 would consider making trips using AV, compared to 62% and 61% for people aged between 18 and 34, and 35–64 and b) 40% of the 25–34 years old participants prefer AV, while only 12% for 65–74 years old consider making trips in AV. [13]

Several studies show that social acceptance of AV is currently rather low in the group of private individual transport with their own car, but on the other hand the same group of respondents has a much lower level of acceptance for autonomous minibuses, buses, and trams. At the same time, a reversed willingness to accept can be seen in the group of respondents from the area of public transport users, even though at a low level. However, the study showed that acceptance of new mobility services is not only determined by their automation concept, but that design and service concepts also play an important role here. [5]

A current study from Germany from 2022 indicates also a rather low acceptance of AV, for example "Robotaxis". Those surveyed saw time savings (27%) and safety (26%) as the advantages of an AV. Those surveyed saw further advantages in increased efficiency and environmental compatibility (19%), cheaper maintenance costs (19%) and a demand-oriented and short-term mobility offer (19% and 18%). The public still has some reservations about the introduction of autonomous means of transport. Around half of those surveyed (48%) doubted the basic safety of AV. In addition, the cyber security risk is seen as a problem (40%), as is concern about monitoring routes and passengers (21%). Another factor is the uncertainty in the event of a breakdown situation (19%). Only 5% said they had no concerns about using autonomous vehicles. [6] A recent Spanish study found similar results, with a high percentage of respondents expressing concerns about the use of autonomous vehicles (78%). [7] In contrast, a previous international survey showed that 46% of respondents say they feel good about the idea of using AV. The strongest affirmations come from respondents who are below 50 years of age (50%), live in China (72%) or in big cities (58%). [8]

Despite the highly persuasive state-of-the-art research findings, the true implications of the deployment of autonomous vehicles remain largely unknown in reality. [15]

A longitudinal study conducted on an autonomous bus service with a mileage of 70,000 km in Barkarby revealed that individuals were initially drawn to utilize the service when they perceived the information provided about it to be adequate. However, after trying the service, they were discouraged from continuing to use it if the comfort deteriorated, the frequency of the service was reduced or the journey time exceeded their expectations. [16]

Since most studies are aimed at surveying the public and private individuals who use their own cars, statements from the area of freight transport logistics are rather rare. Therefore, there are only a few statements that point to the general acceptance of AV in road freight transport. A study from Ireland from 2020 indicates that 51% of the truck drivers believe that AV might increase traffic safety and comfort. AV privacy and liability are the main sources of concern from fleet managers and truck drivers. [12]

There are significantly fewer statements regarding the use of AV within new mobility models. Among other things, the use of autonomous vehicles can facilitate the development of new mobility models such as Autonomous Mobility on Demand (AMoD). AMoD is a transformative mode of transportation in which self-driving robotic vehicles transport customers in a specific environment according to their mobility needs. This approach goes far beyond the use of autonomous Minibuses. Results of a study from 2018 shows that the AMoD experienced during this study was not perceived as sufficiently effective. As a result, both perceived benefits and performance expectations fell significantly. However, the study also showed that, in the eyes of those surveyed, AMoD can have positive effects and therefore represents a model that can be expanded. It is said: “Participants stated that AMoD could improve the autonomy of certain groups of the population, e.g. children and the elderly, persons with disabilities and persons who do not possess a car. The fact that an AMoD is able to respond to mobility needs in a flexible manner was considered valuable. These advantages are linked to a very high presumed autonomy of the autonomous shuttle (which would be able to pick them up at home and to support their accessibility needs if required).” The study also shows that waiting time and speed and pick-up at home were identified as important factors for a positive experience. How much the social acceptance of AMoD depends on existing use cases and model applications is also shown by the fact that the study indicates that the participants could imagine a wide variety of use cases in which AMoD could be useful (e.g., tourism, leisure, improving the autonomy of certain people populations), but they did not find it useful for their personal transportation habits. [14]

This very differentiated picture of the acceptance of autonomous mobility was one of the reasons for initiating the EU funded project “Building Acceptance and Trust in Autonomous Mobility” as part of the EU HORIZON 2020 program. [9]

6 Procedure and results of the SWOT analysis

6.1 General methods

For the SWOT analysis, relevant parameters as mentioned in 5.2 were developed in regular team meetings with experts from industry and science (see 6.2.1) and two surveys were conducted (see 6.3.3 and 6.3.4) to question specific aspects of the system from different user’s perspective.

6.2 Expert opinions from industry and science

6.2.1 SWOT matrix based on expert input.

The approach at our regular team meetings included an analysis of the system idea for Pods4Rail, which is presented in a matrix. The work was based on the use of facilitation techniques and the formation of group consensus. The aspects considered were grouped, structured, and weighted. The interdisciplinary composition and professional knowledge of the participants were essential to the result of the group work. Technical, social and economic aspects were taken into account and discussed.

The SWOT matrix in table 1 shows main findings from the strengths, weaknesses, opportunities, and threats for the intended system in general. A table containing all the collected strengths, weaknesses, opportunities, and threats of multimodal autonomous Pod systems can be found in appendix 3.

Table 1. SWOT matrix output from regular team meetings for Pods system in general

Strength	**Opportunity**
on-demand mobility	acceptance of system
individuality of Transport Units, e.g., special offer for comfortable travel	minimising faults due to staff
linking several types of mobility	sustainable mobility
utilisation of existing rail infrastructure	no new rail or road infrastructure need
potential staff savings	higher utilisation rate of transport vehicles
reducing individual vehicle ownership and thereby creating more living space, especially in cities	development of battery technology and higher capacity of new batteries
constant availability and usability	extremely lightweight construction of the transport units and carriers and thus a better cost basis due to conventional rail design
user acceptance increases due to the limited number of passengers	use of technical components from automobile construction and thereby improve the cost base due to conventional rail design
no change of transport modes necessary	branch lines will be better utilised with a higher frequency
modularity allows flexibility in consolidation for intermodal transport	smoother driving due to automation has positive environmental effect
increases the chances of individual customised applications	many positive effects due to door-to-door transport, e.g., for PRM
availability of standardised modular containers simplifies the loading and unloading process	increases the opportunity of modal shift to Rail
availability of real-time information simplifies further organisation of logistics processes	any advanced operational measure available for passengers will be available for freight
farther areas such as reactivated lines can be served	increase the express delivery opportunities
opportunities for modal shift and transport of goods via rail	reorganisation of logistic processes will provide a greener and more flexible and potentially faster service
if the information services are well designed, customer comfort	additional secondary benefits, such as increased environmental impact, energy savings
Weakness	**Threats**
technologies that do not yet exist, e.g., for autonomous driving, consistent introduction of contactless payment, charging	acceptance of system
handling of Transport Units	no automated and quick handling technology
additional storage infrastructure	currently no legal framework for autonomous operation

Weakness	Threats
limiting the number of passengers means a higher number of Pods required, therefore high acquisition costs	approval/homologation of the system
dependence of passenger planning, additional travel time may be imposed on goods	compatibility with cable cars, dependent on the availability of sufficient electrical energy
compatibility with cable cars / funiculars	cost of new system and its technologies
range of small vehicles with batteries	cyber security
in case of difficulties and emergency situations there is no staff on board	dependence on AI system
low capacity has a negative ecological effect, cannibalisation effects on existing public transport	availability of sufficient carriers in the system
availability of charging infrastructure for road applications	not existing test fields
synchronisation between transport modes in the MMS	if rail capacity utilisation increases, the infrastructure probably has to be expanded
additional complication related to integration of logistic processes	priority rules for passenger demand may hinder freight traffic plans

6.2.2 Results of the Main Findings

Through the automation of Pod systems, various advantages can be found. One of these advantages consists in the fact that autonomously driven vehicles are more accurate and smoother in their driving style compared to manually driven vehicle. Due to the smoother driving style of autonomous vehicles resulting from the minimisation of staff related faults, it is possible e.g.to prevent heavy acceleration and braking and thus save energy. Enhanced automation in terminals, ports, logistics centres, parking facilities, and border crossings will also lead to more efficient freight handling, fewer operational errors, and decreased costs. As such, this improved, more energy-efficient driving style will have a positive impact on the environment allowing the government to promote automation in order to achieve its climate targets. Additionally, a smoother driving style enhances the comfort experience on board for passengers. In this context, automation also offers the opportunity to increase on-board space for passengers as well as for equipment within the Pod, as there is no longer a need for a driver's cabin. Both of the mentioned points will result in an improved passenger experience and increased customer satisfaction.

Another strength of autonomous Pod system is the ability to offer door-to-door service. Door-to-door service plays a major role these days, as it enables passengers to use their journey time more efficiently. Also, there is no time needed for transfers, which results in further advantages in the efficient use of journey time. Door-to-door service also has a positive effect on passengers with reduced mobility, as not every transfer is barrier-free. Therefore, the change of transport mode needs to be carried out automatically. However, it is important to note that an automatic transfer of a Pod from one carrier to another transhipment (carrier swap) may also lead to potential concerns and anxieties among passengers, thus negatively impacting the travel experience.

Another aspect is the necessity to synchronize the development of automation between rail and road (and all other modes where the Pods shall be implemented). For implementing Pod systems, the existing infrastructure is fully suitable for both road and rail. Hence the strength is that there is no need to build new infrastructure. However, as the Pod systems are intended to be available at short notice, it may be necessary to check the timetable of trains already running on the tracks. If the frequency is increased by the Pods, there is a risk that conflicts may arise on the rails with other trains. As Pod systems are considered to be implemented on branch lines, which are often single-track, the infrastructure will probably have to be expanded so that trains can meet or overtake. In this case branch lines can be better utilized with a higher frequency. Hence, if the frequency is increased, this means that a timetable or a regulation for the Pods is required. The concept of virtual coupling might help to reduce this problem as it reduces the usage of track capacity. In addition, a higher frequency on the railway means that additional rail infrastructure must be built, which has a negative impact on the environment.

Automation of Pod systems come also with various risks as the market is not yet able to fully cover automation both on rail and road. This includes technological aspects as well as legislation, standards etc. In order for operators to cover their fleet with autonomous Pod systems it is necessary to have the vehicles as well as the infrastructure to be ready for automated or autonomous operations. In this regard the government must pay for the expansion of the infrastructure by means of subsidies. Another risk coming with that is the fact that operator need to purchase Pods for their fleet which in turn lead to major acquisition/investment cost. Further costs need to be considered also for the manufacturing of the Pods. Another disadvantage of complete automation is that there is no staff on board to assist in case of questions or problems. Only the passenger information system (PIS) is available for support. Besides, when it comes to full automation, the potential risk of cyberattacks must be considered seriously.

Furthermore, the consideration of freight use cases has the potential to reduce the delivery times, costs and negative externalities associated with road freight transportation. However, it also requires significant coordinated efforts to set up the system and to overcome operational challenges to plan and execute such multimodal and multi-actor system. In that regard, it is critical to understand the stakeholder views/motivations to assess better the basic design principles for the proposed system.

6.3 User survey

6.3.1 General procedure

To question essential parameters of the system idea in more depth, a survey of potential users was carried out. The focus here was on two target groups: a) general users of public transport, b) users from the logistics sector. The aim was to determine how certain aspects presented in the system description and the use cases (D2.1 and D4.1) are viewed by the different user groups.

With the help of everyone involved in the project, possible recipients from different countries were approached for the survey. This effort led to surveys being sent to nearly 200 respondents, with a response rate of 96 answers. People were contacted as general users of passenger transport and people from the logistics sector.
Due to the insufficient sample size of respondents with specific experience in the logistics sector, the survey results can only provide inaccurate findings.

6.3.2 User survey question

As two different target groups (general users of public transport and users from the logistics sector) were to be interviewed, two different surveys were created. All survey questions were specifically directed towards the intended target group for the survey. For the target group of general users of public transport, private individuals and passenger rail operators were asked. For the target group of users from the logistics sector, the freight rail operators, the industrial company, the public authority and international organization, the scientific organization and the non-governmental organization were surveyed.

Both surveys were divided into two parts describing two different scenarios: In the first part of the survey, questions were asked about a general scenario when using Pod systems and in the second part of the survey, specific questions were asked about a combined scenario, when Pod systems are used for passengers combined with the transportation of parcels. For a better understanding of the Pod systems, introductions regarding the general scenario when using Pod system were given in the first part of both surveys. As a third and last part of the surveys, socio- demographic data were collected.

The introduction intended for the target group "General users of public transport" was as follows. To read all questions from the "General users of public transport" survey, please see appendix 1.

"*Imagine this passenger transport scenario: A Pod system to travel for fulfilling their daily needs. For this example, we would like to introduce the person "A", a grandmother who is 68 years old and retired. The person lives in the city and has to go to the doctor. However, it is not the family doctor who is around the corner, but she needs a specialist who is on the other side of the town. In this scenario, the traveller will have to use the public transport because the person does not have a driving license or does not own a car. With the Pod system, the person will be collected from her front door at a preferred time (order by phone or by app) and will be driven to the doctor. Afterwards, the person can either order the pod to her home or carry out other errands (e.g. shopping). Imagine you are the Person A.*"

Similar to the survey aimed at "General users of public transport", the survey for the target group "Users from the logistics sector" consisted of three parts (General Usage of Pod system, Combined Usage of Pod systems, Social demographic data) and started with the following brief introduction:

"The Pod system will start from the distribution centre. Depending on the area/district, the parcels will be distributed to different pods. The data for each parcel will be transmitted electronically to the respective pods. Each pod then will travel to its assigned destination area or district where the parcels are to be delivered. Shortly before arriving at the destination address, the pod will determine a nearby parking spot or suitable place to stop (maximum distance of 100m from the house/apartment)."

The complete questionnaire of the "Users from the logistics sector" survey can be read in the appendix 2.
The following sections, the most important questions and answers as well as the highlighted and the most important results are summarized.

6.3.3 Results of the survey on freight transport

The results of the "Freight Transport survey" focus on three of the five groups surveyed, namely:

- Freight rail operator
- Industry company
- Public authority and international organization

The results are limited to these three groups as they seem crucial for the development of the system.

The first part of the survey is about a Pod system solely used for freight transport.

Due to the innovative nature of the Pod system, there existed a risk of the participants not comprehending this vehicle concept and its applications. When asked, “*Is the new transport system as called Pod-system understandable for you?*” over 80% of respondents answered that they understand the new system, which is a prerequisite for evaluating the results.

A first note to mention is that despite the increasing digitalisation and automation of transport and logistics, still around three-fifths of the respondents prefer to deliver goods and parcels with direct contact to the customers, what suggests that a fully autonomous delivery system might not address as big a market as desired (question no. 16). However, there should be the ability to track packages, which is important for over 90% of respondents (question no. 22).

Figure 1 shows the distribution of transport units currently used by the respondents (question no. 17).

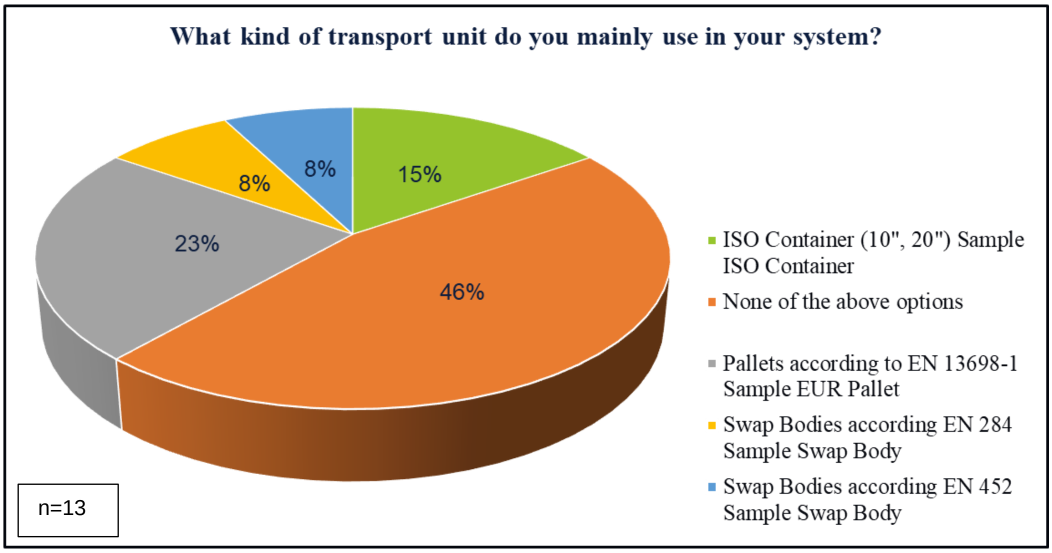

Figure 1. Answers to question no. 17 (transport units for parcels)

The Pod system aims to be compatible with standard freight transport and loading units. This survey reached stakeholders focused on logistics with euro-pallets in 23% of the cases, and swap-bodies and ISO-containers in 31% of the cases. Notably, 46% of the participants do not use standard loading units in their logistics, which indicates that the Pod system survey might have been answered by last mile parcel delivery stakeholders.

The next question reflects the answers, *"What type of goods do you mainly transport?".* Packages of different sizes and different types of goods are mainly transported, what concurs to the profile of the participants mentioned above. None of them mentioned roll containers and only a few stated that they transport pallets. The design of the pods could be adjusted in this direction and not necessarily be developed according to standard container or swap-body dimensions.

To question no. 20 regarding time-critical shipments almost 70% of respondents stated that it is very probable or likely that they would utilize a Pod system for sending time-critical shipments.
The following figure shows what factors would influence the decision to use a Pod system the most (question no. 21).

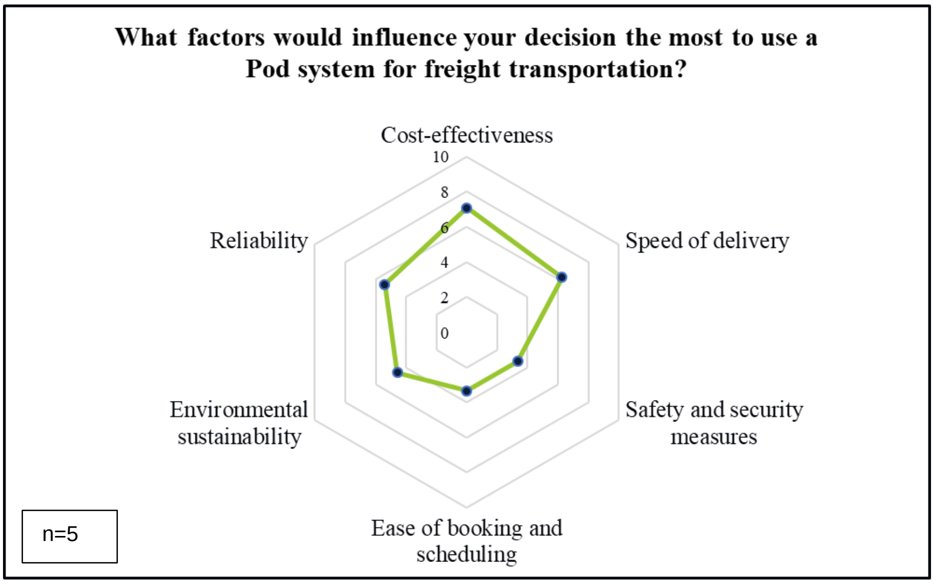

Figure 2. Answers to question no. 21 (influencing factors on using Pods for parcels)

The scale in the radar chart ranges from 10 to 0. 10 refers to the highest level of importance. Cost-effectiveness, speed of delivery and reliability are factors that would influence the decision the most to use a Pod system for freight transportation.
This might indicate that factors are sufficiently covered by the existing regulatory authorities, fulfil their requirements in terms of sustainability aspects and safety and also security and make them less interesting for logisticians.
Speed of delivery scores high as an influence factor, what concurs with the interest of 70% of the respondents to use the Pod system for time-critical deliveries. Upcoming Work Packages will address the design speed of the Pod system. Special attention should be drawn to time-consuming processes, such as the transhipment of the transport unit.

One note that was mentioned in the first part of the survey (question no. 23) is that it is unclear what business value this system will create. This should be further investigated and underlines the necessity to explore business models in WP5.

The second part of the survey was about the combined usage of the Pod system.
When asked the freight stakeholders whether they can imagine sharing pods where packages are transported along with passengers (question no. 24), just over three-fifths of the respondents answered that they would agree.
The respondents who declined were then asked if they would share a pod if it would reduce the transport costs (question no. 25). 60% of those surveyed still cannot imagine sharing the pod transporting parcels with passengers despite of a cost advantage.
It was interesting to find out how safe people would feel if parcels were transported along with present passengers in terms of possible damage to the goods (question no. 26). Approximately one third of respondents would feel safe if there was a secure storage location separate to prevent possible damage to the goods, and almost half would feel safe if there was a secure storage location

separated from the passenger area.

The next figure shows the graphic that refers to the question no. 29 about what challenges they can imagine that operators of passenger pods might face when integrating freight services.

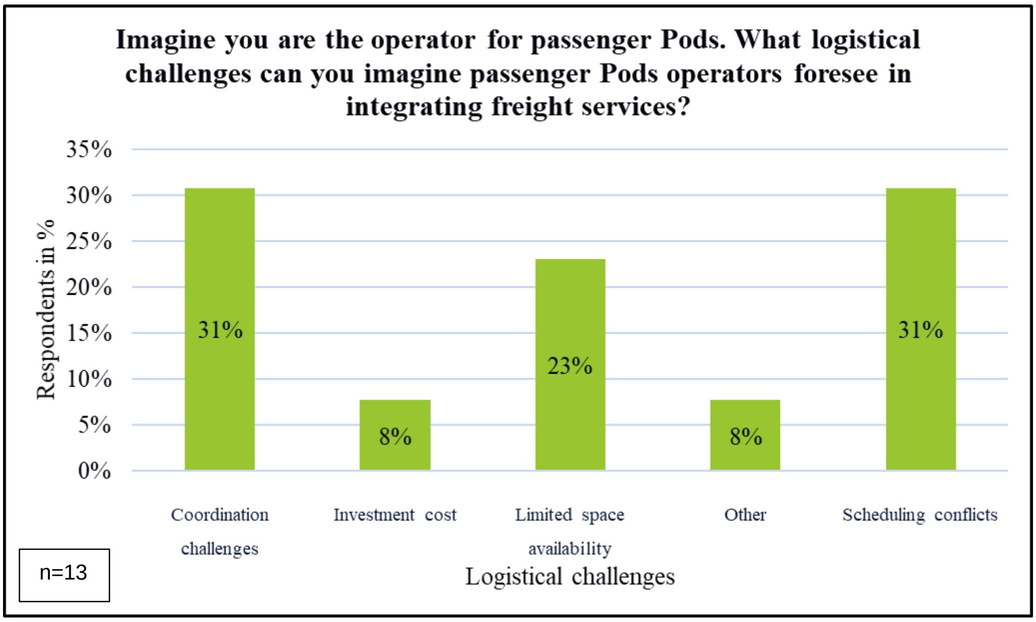

Figure 3. Answers to question no. 29 (logistical challenges)

The most selected logistical challenge passenger pods operators foresee in integrating freight services is with 31% the coordination as well as the scheduling conflicts with also 31%.
The answer may be related to the fact that many people cannot yet imagine a complete automation of the system.

When it comes to the types of goods people would use this system for (question no. 28), the majority of respondents voted for business-related goods, parcels, and perishable goods. This information is important for the design of the pods. They provide guidelines on how big the units should be and what requirements they must meet, such as maintaining the cold chain.

Additional notes were also made that could aid in the design of the pod (question no. 30). One participant mentioned that there has already been a similar solution attempted, but it was not successful. Therefore, it could be beneficial to conduct research and learn from their mistakes. An important comment was also that the system must not have any delays for the passenger due to loading and unloading.

6.3.4 Results of the survey on passenger transport

The second survey was the “Passenger Transport survey” with the focus on the two groups

- Passenger rail operator
- Private individuals.

An evaluation was conducted separately for each group. The response rate for, passenger rail operators was not very high, but trends can still be derived from the results.

The first part of this survey is the passenger only scenario. All rail operators surveyed can imagine the new type of transport (question no. 1). It is interesting to note that 80% prefer to use a public Pod over owning a Pod (question no. 3).

People were asked which distances they could imagine using this system for (question no. 4). At this point none of the respondents could imagine to use the Pod only for long trips. Perhaps this is because the distance for the journeys was not defined in detail. However, 60% of respondents could imagine using the system for short journeys and 40% for both options also for short and long trips combined.

Figure 4 shows how the respondents rated the 5 attributes mentioned and which attribute is most important to them in regard to the system (question no. 5).

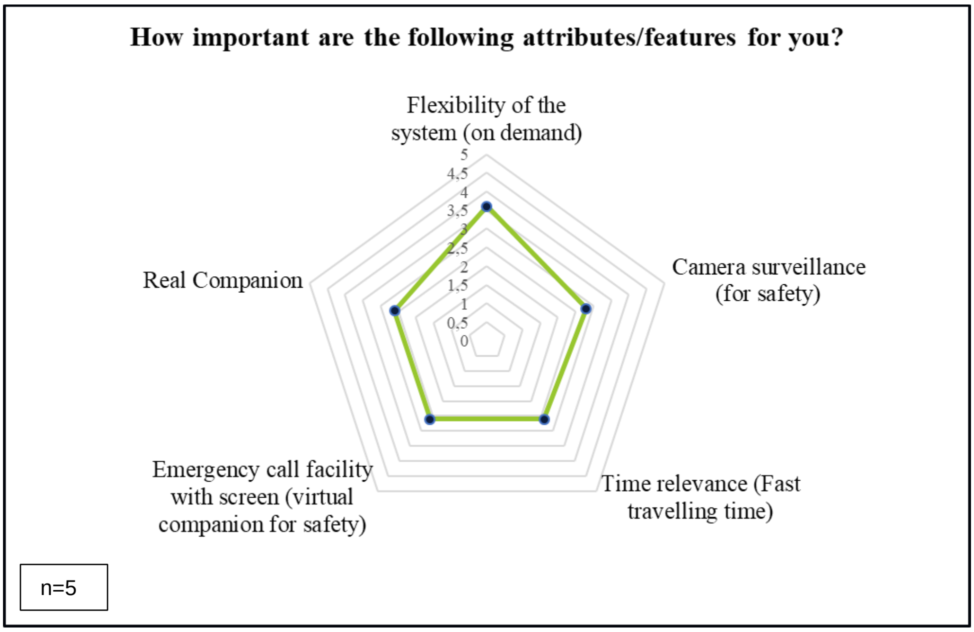

Figure 4. Answers to question no. 5 (important attributes for rail operators)

The flexibility of the system is the most important one among the 5 surveyed attributes. But on the other hand when asked whether they wanted to own their own Pod system or use a public pod, respondents favoured the public pod. However, this would offer less flexibility than owning your own pod.

The second part of this survey addresses the combined passenger Pod and parcel transport scenario. Of those surveyed, three fifths could imagine sharing the pod with parcels (question no. 7). The parcels should not block the passenger's way and the journey time should not be extended too much by loading and unloading the parcels (question no. 8). For 60% a delay or extension of the travel time due to the additional load is not acceptable (question no. 9).

The next figure shows the problems that arise for the respondents (Passenger rail operator) when passengers are transported together with parcels (question no. 11).

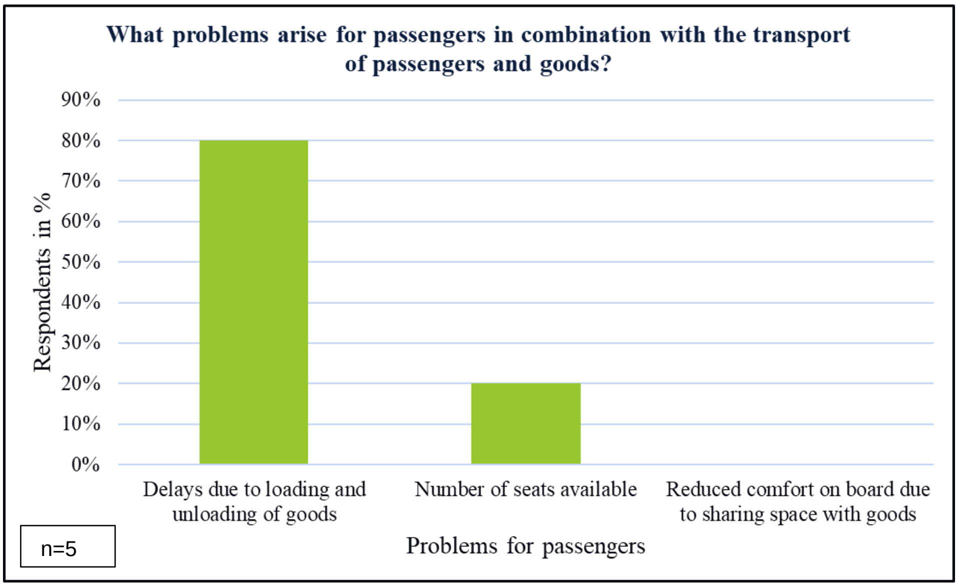

Figure 5. Answers to question no. 11 (problems for combined applications)

None of the respondents worries that comfort would be reduced due to combined transport. 80% of respondents think that delays arise due to loading and unloading of goods. The issue of delays was identified as important during the evaluation and should not be ignored when implementing the system.

The second evaluation relates to the responses of private individuals. The response rate was in this case higher.
Over 80% of the surveyed private individuals can imagine the first scenario that only refers to the transport of passengers in this new transport system (question no. 1). 77% would prefer a door-to-door transport without changing from one mode of transport to another (question no. 2). Comments to this answer are various and indicate that for someone it does not matter if they have to change modes of transport or that other factors are important like the costs, time sustainability or their own health status, suggesting that a seamless door-to-door mobility system like the Pod system would appeal to individuals with reduced mobility.

Like the passenger rail operators surveyed, private individuals also prefer to use a public Pod rather than own a private one with over 80% (question no. 3). This could also be related to the fact that no information was provided on costs.

Figure 6 shows the preference of individuals for a public or a private Pod, distinguished by the area they live in (question no. 3 and no. 13).

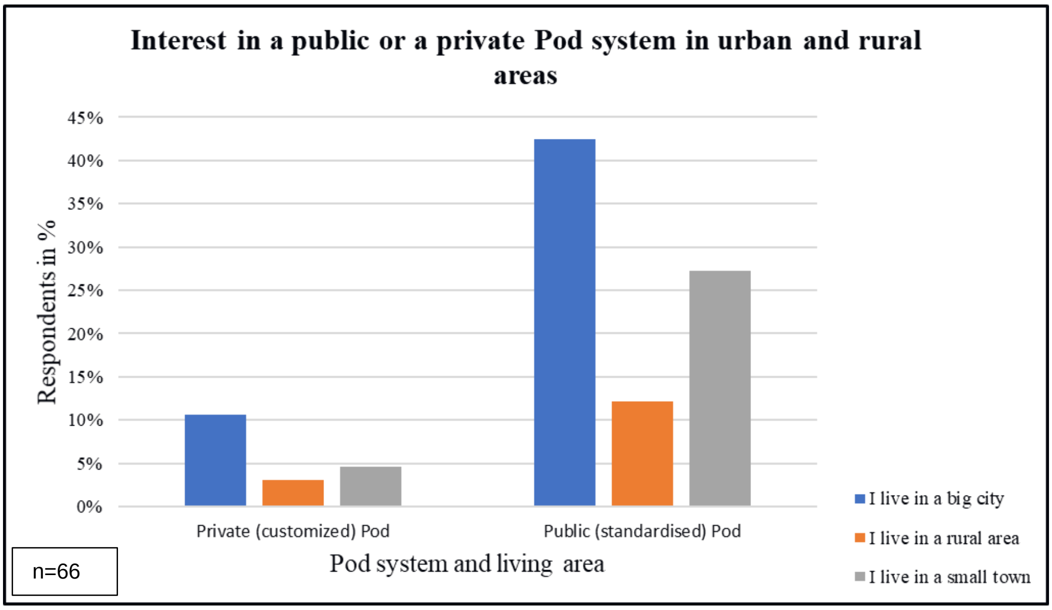

Figure 6. Answers to question no. 3 and no. 13 (public or private Pods depending on living area)

It is noticeable that people who live in the countryside generally show less interest in the Pod system, regardless of whether they want to buy a Pod or use a public one. This may have something to do with the fact that they probably own a car and were not asked anything related to cars in the survey. For example, if they had been asked if they had to travel instead of using a car, how would they travel? It would be interesting to see which options the result would then shift to. Would the interest in the Pod system then be higher and, above all, in owning one like the car? This should be investigated further.

Additionally, over 50% of respondents would use the system for long and short journeys (question no. 4). Just over a third of respondents would only use the system for short journeys and only a few per cent would use the system exclusively for long journeys.

The next figure shows where the people surveyed live and for which journeys they would use the system (question no. 4 and no. 13).

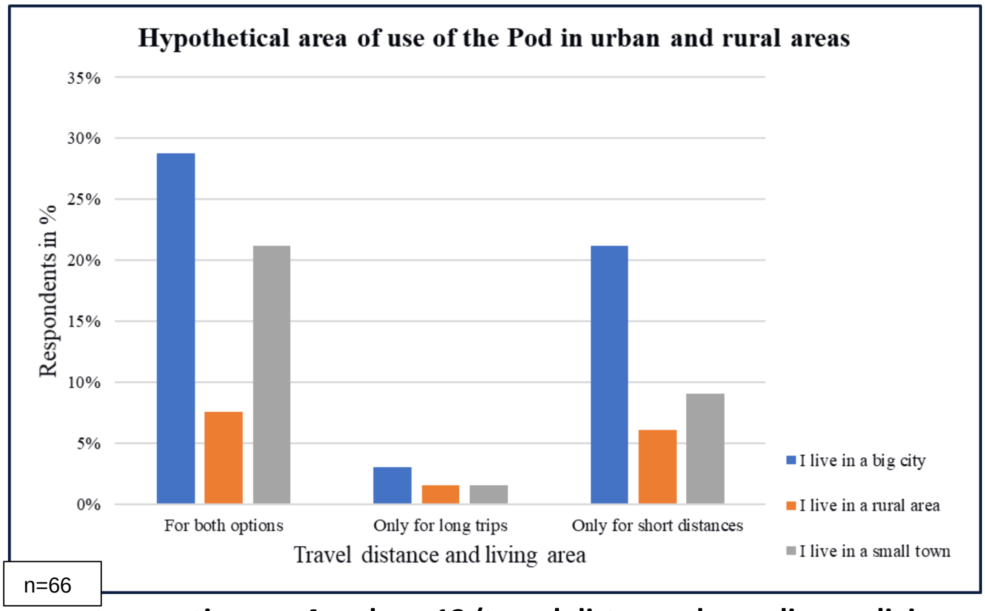

Figure 7. Answers to question no. 4 and no. 13 (travel distance depending on living area)

53% of the respondents in this survey for private individuals live in a in big cities, 15% in rural areas and 32% in small towns. The chart above shows a similar proportional distribution for individuals of big cities, small towns and rural areas when asked which distances would they operate with the Pod: around two-thirds of them estimate an operation in both short and long distances, while around one-third imagines its use only for short distances. The apparent size difference of their columns is due to the absolute amount of responses from each of these geographic areas.
A Pod operation in short distances can be, thus, imagined by over 90% of the respondents.
Operating the Pod system exclusively for long trips seem to be negligible for individuals living in any of the three areas.

The flexibility of the system is the most important attribute for the respondents that was asked in the survey (question no. 5). Here again, the statement might be in conflict with the preference that respondents want to use a public Pod rather than own one, since owning a Pod would presumably offer more flexibility.

As the response rate was highest in this group of people (private individuals), many comments were made as answer to the question *"Do you have any further comments?"*. In order to be able to draw conclusions from all comments, the comments were clustered according to similar topics and the following conclusions can be drawn from this:

- Pod systems can provide an efficient and flexible transportation solution, especially in small towns/rural areas and for last-mile. These can be both private Pods and public Pods.
- There have been comments that people do not believe in this way of travelling or that it is not possible on a large scale in the medium term.
- In general, Pod systems should be clean, comfortable, PRM (Persons with Reduced Mobility) friendly, and have specific interior features depending on the journey (e.g. toilets, reclining seats etc.). The booking app should not be complex. The interior design should be efficiently used and booking should be possible both in advance and last minute. Short waiting times, regular departure times should be offered, and in case of emergency, there should be the option to speak to a real person.
- Key criteria for evaluating Pod systems include cost for the system, system flexibility, Pod capacity, system reliability, and ticket price.
- Some questions on the questionnaire were not entirely clear for some respondents, especially due to the lack of an orientation regarding the cost of ownership or the ticket price of the Pod.

The second survey part relates to the combined scenario with parcels and passengers being transported simultaneously on a Pod.

Over 70% of respondents stated that they could imagine sharing the Pod with parcels or other goods (question no. 7).

A lot of comments were left on the question that deals with the wishes and thoughts regarding the shared Pod system (question no. 8). There was a significative agreement on the point that there should be a separate compartment for parcels and passengers. The second most frequently mentioned point was the importance of ensuring the safety of the passengers and avoid any risks arisen from transporting parcels simultaneously. It was also mentioned as important that the journey time should not be affected by loading and unloading.

Other comments mentioned the interior of the Pods, stating that passengers should have enough space and that the environment should be clean. Passengers also expressed the wish that there should be no additional noise and that passengers should generally not be disturbed.

The figure 8 shows the answers for the question what problems can arise for passenger when goods or parcels are transported at the same time (question no. 11).

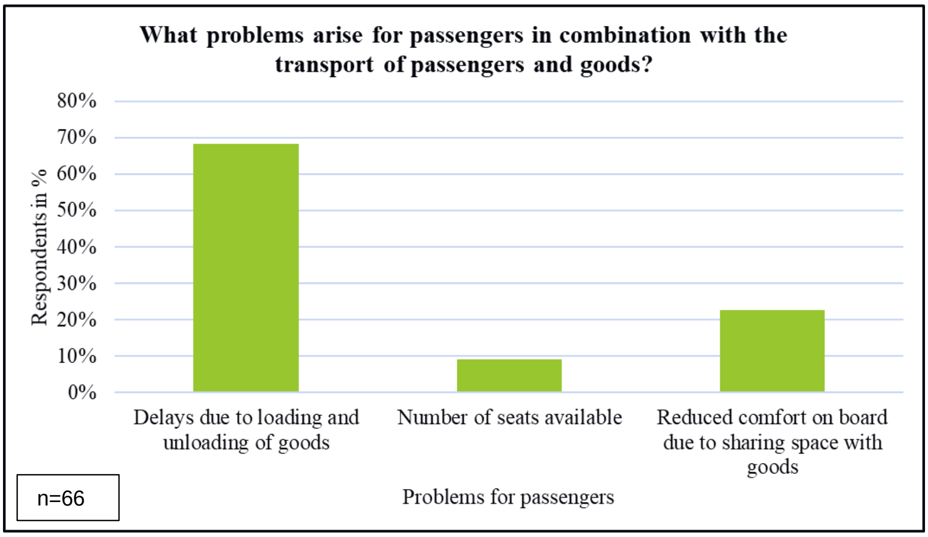

Figure 8. Answers to question no. 11 (possible problems with combined applications)

Out of the 3 suggested answer options, almost 70 % said that they think the biggest problem will be delays caused by loading and unloading parcels. When designing this Pod system, attention should be paid to the loading and unloading of parcels so that this does not take too much time and does not lead to delays.

There were also a lot of comments left for the question *"Do you have any further comments?"* in the combined scenario. Here, too, the comments were clustered according to similar topics, from which the following conclusions can be drawn:

- The pricing for a combined service seems to be a sensitive issue. There are concerns about longer travel times. Some statements indicate that a journey where packages are also transported should be offered at a lower price.
- Comfort must not be impaired by the carriage of parcels. A structural separation between the passenger and freight compartments is requested. It is also assumed that the loading and unloading of parcels causes imponderables for journey planning and punctuality.
- There are concerns that the safety of passengers will be impaired by the transportation of parcels, e.g. during abrupt driving manoeuvres. Thus, also for safety reasons, a separation of passenger and freight areas is required.
- There are also those who consider the system to be impractical or superfluous, as similar approaches already exist.

Overall, the system was viewed positively by the participants. When developing the business case in WP5, the respondents' statements should be taken into account in order to successfully implement and develop the system.

6.4 Discussion of analysis results

The SWOT analysis enabled content to be collected and important parameters for the Pod system to be identified. With the help of the surveys, trends on certain topics could be identified.

According to the European Rail Joint Undertaking's Master Plan, one of its main objectives is to transform the rail sector towards more resilient and sustainable mobility. Using electrically powered Pod systems, which are characterized by their autonomous operation, will contribute significantly to this objective. Such a contribution is also reflected in the Pod vehicle designs: Due to the lightweight Pod vehicles, Pod systems contribute to a lower noise impact on the environment. However, it must be taken into account that the modularity of the system is also associated with a lower capacity of the Pod vehicles. Depending on the capacity of the Pod vehicle, the carbon dioxide emissions per passenger kilometre (pkm) in particular can have a positive or negative impact on the environment compared to conventional vehicles.

Since Pod systems are based on autonomous driving, they offer all the advantages of automation mentioned in chapter 6.2.1, e.g. better utilization of existing infrastructure, a continuous travel chain without changing modes of transport (door-to-door) or an improved customer experience through improved comfort. In addition, Pod systems can offer more flexibility and punctuality for passengers and operators through small, on-demand Pod units that can be operated on multiple infrastructures and synchronize the use of different modes of transport. However, it is important to note that the technology must be advanced enough to be able to run autonomously on road and rail. There is currently a high risk because there is a lack of standards and communication on both road and rail, especially when combining the two modes of transport. Overall, with regard to high automation and autonomous driving on both road and rail, there are of course no standards established yet, no communication harmonization between all the components, etc. and there are a lot of activities and changes in progress, but they are far from complete and not integrated across all modes of transport. The issue of approval must therefore be viewed critically. Otherwise, the Pod systems cannot be introduced to the market. This also includes door-to-door service with driverless Pods, which requires a full automation concept.
From an economic perspective, Pod systems lead to energy savings through autonomous driving and improved route planning, thereby reducing operating costs for the entire fleet. In addition, the lighter Pod vehicles result in less wear and tear on the track infrastructure, reducing the need for maintenance and renewal, resulting in lower maintenance costs and less downtime. However, it should be noted that the purchase of new Pods to cover the entire fleet and the implementation of Pods in the current transport and mobility system on all modes of transport will involve very high investment costs.

Using the Pods system for transporting freight, requires an integrated approach and cooperation between passenger and freight transport sector, and all involved freight stakeholders. In addition, new business models, upgraded logistic operations, technological inclusion, etc. should come together to overcome the challenges and to offer affordable, efficient, reliable and environmentally friendly express small package transfers between any two points. Several regulatory, scientific, and practical challenges should be overcome to achieve the full potential of the system to reduce the delivery times, costs, and negative externalities associated with road freight transportation.

Finally, it is worth mentioning that Pod systems cover a wide range of technological innovations in the transport and mobility industry through their system technology, such as autonomous driving and virtual coupling technologies, including complex situations such as mixed traffic, virtual train building and complex logistical handling and storage processes. In this regard it should be highlighted that Pod systems could open a major chance for the European railway and automotive market. However, the acceptance of Pod systems and societal confidence in such new systems with interchangeable transport units for passengers and/or goods (Capsule) on a transport vehicle (Carrier), as well as autonomous driving facilitated by a multimodal system, is crucial for users and operators and therefore crucial for the success of Pod systems. In this context, it is important to note that there is currently little or no operational experience in the implementation of a multimodal autonomous transport system, both in freight and passenger transport. Therefore, further scientific research on operational models, capacity planning, logistics models, systems engineering, etc. is needed.

Key findings from the passenger survey indicate that both passenger rail operators and private individuals prefer a Pod system for public transport. An individual private purchase and the associated possibilities of integration into one's own living environment met with little response, probably because such a disruptive usage model is currently unimaginable and has not yet been sufficiently described. For them, the flexibility of the Pod operation and safety and surveillance systems are of significant importance. An exclusive long-distance application is currently out of consideration both for operators and passengers. At the combined scenario with parcels and passengers being transported simultaneously on a Pod, ensuring the safety of the passengers regarding risks from the parcels is of notable importance.

Due to the insufficient sample size of respondents with specific experience in the logistics sector, the results of the survey can only provide imprecise results. For this reason, special aspects of freight transport should be further analysed in the later work packages, in particular the type of transport and loading means used, in order to obtain essential boundary conditions for the dimensioning of the transport units. What should also be emphasized here is the high degree of possible acceptance for the proposed Pod system. The emphasis on speed delivery stands out as a significant determinant, especially for time-sensitive deliveries, therefore, the Pod development should focus particularly on optimizing operation processes that consume considerable time, such as the transhipment of transport units.

It should be emphasized that the results of the survey have shown that the idea underlying the system definition from D2.1 is definitely popular. This makes it all the more important to see this as an incentive to continue pursuing the basic idea of the Pod system in Project Pods4Rail. However, essential parameters must be taken into account when developing the system. Since no qualified statements can be made about the implementation of the system to be developed due to the early project stage, the different target groups should be surveyed again in a later project phase.

7 Summary and recommendations

We conducted an analysis of the strengths, weaknesses, opportunities and risks and applied this to the various scenarios. In particular, we looked at the scenarios relating to passenger, freight and combined. It was discussed together with experts from industry and science and many conclusions were drawn on this knowledge. The whole process was complemented by surveys to capture the tendencies of potential users and potential stakeholders. The results were interesting.

Based on the results of the SWOT analysis and from the results of the survey, it seems appropriate to continue the project on the basis of the conclusions from the deliverable.
The SWOT analysis reveals, among other aspects, the potential benefits of the Pod system, such as energy efficiency or the door-to-door service, which offers passengers comfort.
Recommendation include the need for further research on operational models, to ensure the success of the Pod systems. The document also discussed the key findings of the passenger transport survey and of the freight transport survey, emphasising the importance of safety and flexibility in the implementation of the Pod system.
The results of the survey can help to develop the business case that will be elaborated in Work Package 5.

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9 Appendices

Appendix 1: Questions from the "General users of public transport" survey

Part 1: Please answer the question from the user/operator perspective.

1. Can you generally imagine such a new type of transport system as was presented to you?
   a. Yes
   b. No
   c. Other:

2. Would you like to prefer a personal transport service from the doorstep to the desired destination (door-to-door) without having to change from one mode of transport to another?
   a. Yes
   b. No
   c. Other:

3. When you imagine the new Pod transport system as presented, would you like to own a private transport unit that you could customize according to your preferences, or would you prefer to use one that is designed for public transport?
   a. Private (customized) Pod
   b. Public (standardised) Pod

4. If you imagine the new Pod transport system as presented, would you use / operate it for short distances in your area (e.g. from home to the doctor, to go shopping, to visit the city) or also for long journeys?
   a. Only for short distances
   b. Only for long trips
   c. For both options

5. How important are the following attributes/features for you?
(rate the importance from 1 to 5, 1 = "not important" and 5 = "very important")
   a. Flexibility of the system (on demand)
   b. Camera surveillance (for safety)
   c. Time relevance (Fast travelling time)
   d. Emergency call facility with screen (virtual companion for safety)
   e. Real Companion

6. Do you have any additional comments?

Part 2: Imagine you share the pod not only with other passengers, but also with parcels.

7. Can you imagine sharing the Pod with parcels or other goods?
   a. Yes
   b. No
   c. Other:

8. If yes, what would be your wishes and thoughts if you travel in a shared Pod?

9. Is a delay or extension of the travel time acceptable for you? (Extension of travel time caused by collecting parcels)
   a. Yes
   b. No

10. Do you feel safe when parcels are being transported at the same time?
   a. Yes
   b. No

11. What problems arise for passengers in combination with the transport of passengers and goods?
   a. Number of seats available
   b. Delays due to loading and unloading of goods
   c. Reduced comfort on board due to sharing space with goods

12. Do you have any additional comments?

Part 3: Social demographic data

13. What environment do you live in?
   a. I live in a rural area
   b. I live in a big city
   c. I live in a small town

14. Are you replying as:
   a. Private individual
   b. Passenger rail operator

Appendix 2: Questions from the "Users from the logistics sector" survey

Part 1: Please answer the question from the stakeholder perspective.

15. Is the new transport system as called Pod-system understandable for you?
   a. Yes
   b. Not yet

16. How important is it for your company to have staff to deliver the parcel in direct contact to customers?
   a. Unimportant
   b. Important
   c. Very important
   d. Important in the future

17. What kind of transport unit do you mainly use in your system?
   a. ISO Container (10", 20") Sample ISO Container
   b. Swap Bodies according EN 284 Sample Swap Body

c. Swap Bodies according EN 452 Sample Swap Body
d. Roll container according to EN 12674 Sample Roll Container
e. Pallets according to EN 13698-1 Sample EUR Pallet
f. None of the above options

18. What type of goods do you mainly transport? (multiple selection is possible)
    a. Packages of different sizes
    b. Letters in standardised transport boxes
    c. Pallets (EN 13698-1)
    d. Roll Container (EN 12674)
    e. Different transport goods

19. Would you accept new standardised transport units for such a new transport system?
    a. Yes
    b. No

20. Considering the system description provided above, how likely are you to use such a Pod system for sending time-sensitive shipments?
    a. Very likely
    b. Likely
    c. Unlikely
    d. Very unlikely
    e. (Optional answer): Why is it likely for you to use such a system?

21. What factors would influence your decision the most to use a Pod system for freight transportation? Please select 3 answers
    a. Cost-effectiveness
    b. Speed of delivery
    c. Safety and security measures
    d. Ease of booking and scheduling
    e. Environmental sustainability
    f. Reliability

22. Is tracking the freight / load during transport important to you?
    a. Very important
    b. Important
    c. Not important

23. Do you have any additional comments?

Part 2: Imagine that you transport parcels in capsules that are also used to transport passengers.

24. Can you generally imagine such a new type of transport system as was presented to you?
    a. I can imagine sharing the pod with passengers
    b. I can´t imagine sharing the pod with passengers

25. If no, would you share the pod if this reduced the transport costs?

26. How do you feel about the protection of transporting parcels with passengers present regarding possible damage of the goods?
   a. I would feel safe if there was a safe storage location in the passenger room
   b. I would feel safe if there was a safe storage location outside of the passenger compartment
   c. I wouldn't feel safe

27. Considering the description provided, would you use such a system for sending time-sensitive shipments?
   a. Yes
   b. No

28. What types of goods or shipments do you envision using this system for? (Select all that apply)
   a. Personal belongings
   b. Fragile items
   c. Business-related goods
   d. Perishable goods
   e. Parcels
   f. Letters
   g. Other:

29. Imagine you are the operator for passenger pods. What logistical challenges can you imagine passenger pods operators foresee in integrating freight services?
   a. Scheduling conflicts
   b. Investment cost
   c. Limited space availability
   d. Coordination challenges
   e. Other:

30. Do you have any additional comments?

Part 3: Social demographic data

31. Are you replying as:
   a. An freight rail operator
   b. An organisation or a company (industry)
   c. An scientific organization
   d. Non-Governmental Organization (NGO)
   e. A public authority or an international organization

Appendix 3: Table containing all the collected strengths, weaknesses, opportunities, and threats of multimodal autonomous Pod systems in general

Strength	Opportunity
-Utilization of existing rail infrastructure -Potential staff savings -Minimising faults due to staff -Possibility of offering D2D, as the Pod systems can travel autonomously and with	-Possible shift from road to rail when passengers switch from travelling by car to public transport. -Sustainable mobility -Smoother driving due to automation has

small pods. D2D provides numerous benefits leading to an increase in customer satisfaction with public transport. -Integration of different infrastructure -Possibility to offer D2D when pods are intermodal -No more transfers necessary, which reduces journey times and can increase the customer's satisfaction. -Numerous benefits due to virtual coupling, e.g. increased capacity -Autonomous coupling saves time and staff -Increased efficiency through time savings at high range -Customer satisfaction: Passengers do not have to change trains, making the journey more comfortable. The UC in particular serves the purpose of travelling between villages or small towns. Passengers do not have to change trains while carrying groceries, buggies, etc. - Journey time is reduced as there is no need to change trains. -Quick handling possible due to the robot arm allowing the system to change smoothly and without friction. -The system fulfils safety requirements and can therefore be used -Existing infrastructure can be utilized: Suitable for road and rail -Energy savings -Cost savings: due to the already existing infrastructure -User acceptance is increasing: users benefit from a more private usage (lower capacity), improved working conditions in the vehicle -For the use case Premium Public Passenger Transport (PPPT), there is a restriction: 14-20 passengers. This number is attractive for passengers -> attractiveness increases -The lighter the vessels weigh (e.g. if the battery is lighter), the more equipment can be inserted into the pods. For PPPT, a premium equipment is an important factor for user acceptance -Assumption: Pods weigh less than trains and therefore generate less noise (sine wave of rail vehicles)	positive environmental effects. -No dependencies regarding strikes -Enhancing customer satisfaction for public transport -Politics encourages public transport -Intermodality enables to use alternative routes in order to avoid traffic jams etc. -Trains travelling at max. 80 km/h can be coupled with pods. -Pods can use existing railway lines that can be travelled at a maximum speed of 80 km/h. -Maximise the efficient use of free capacity -Policy funding for e-mobility possible? -No new infrastructure needs to be built. -If the vehicle is fully utilized, this will have a positive effect if Car-users switch to pod-systems and there will be fewer cars/taxis on the roads. -If more passenger shift from car-using to pod-using, the noise emission can be reduced- Also as 14-20 passengers can travel in one pod, it leads to postive environmental benefits. -Possible inclusion of people with limited mobility -This would have positive effects such as fewer parking spaces required, less congestion during rush hours, etc. -increases the opportunity of modal shift to Rail. -No additional measures are needed for transport of freight, any advanced measure available for passengers will be available for freight -Increases express delivery opportunities -As the use case covers different geographical applications, this can be considered in the planning phase, allowing full utilization of Pods system depends on trip length. Long range transport can be facilitated with en-route loading (overhead wire, 3rd rail, induction etc. -An enabler for increasing the share of railways -Increasing modal share of railway -Ready to be implemented as soon as passenger vessles are up and running -Available capacity if the vehicle is not fully

-Battery-powered carriers generate less noise than conventional vehicles (rail and road) -The group of people feels safer with the smaller capacity, as there can be no sensory overload from a large crowd. -Pods can be specifically adapted to people with limited mobility e.g. introduce low-floor (own use case) -As the UC is also intended for commuting to work, the benefits for business people are a strength. The D2D transportation makes it possible to work in the unit without changing trains and to use the time effectively without having to change trains. The equipment: Desk and other things make it easier to work there. The small number of people creates a comparatively quiet working environment. Contactless ticketing does not disrupt the workflow. -Benefits: special offer for comfortable travel -The maximum speed of 80km/h results in less noise (see above). Additionally, the driving experience is pleasant for PPPT as working in the pod is made easier (less shaking compared to a train). -Elimination of road to rail transshipment for freight -Modularity allows flexibity in consolidation for intermodal transport -Regional and urban deliveries are possible even with limited range -no transshipment for freight -reduced logistic provisions required -Flexibility of the use case in terms of consolidation -Same as passenger use cases, no specific additional measures required -Increases the chances of individual customer to business applications with the right business cases -Availability of standardized modular containers simplifies the loading and unloading process -Availability of real-time information simplifies further organization of logistics processes -Utilizing the existing railway infrastructure -Utilizing the unused capacity of passenger	loaded could still be deployed -In case the vehicle reaches its weight capacity, light parcels can still be transpoorted therein

Pods -Ability to integrate urban, regional and long-distance cases	
Weakness	**Threats**
-Possibility of cyberattacks -Older passengers or disabled passengers may be affected negatively as there is no staff available to assist in case of difficulties. (Support only available via Passenger Information System) -At night, some passengers may feel unsafe if there is no staff present in the pod. -High costs due to the acquisition of new vehicles -User acceptance may be restricted by passengers' concerns -Requirements for coordination among different transport operators -Carriers or infrastructure require the possibility of transhipment. -Virtual coupling currently not implemented. -Moving block not yet a standard. -Delay in travel time as pods need to wait for each other to be coupled. -Reduced efficiency in case of small range -Due to unpredictable route planning, more charging infrastructure must be available (solar?) -Powerful batteries are heavy so capacity decreases -Stationary infrastructure is inflexible -Carriers are heavy and expensive as a result of the robot arm -Battery replacement expensive -Use on branch lines railway: On single-track lines, a solution must be found for train encounters. Robot swaps the pods, crane lifts the carriers, etc. -Cable car probably needs to be adapted. -Height dimensions for bridges must be observed -If vehicles with the same destination are not fully utilized and several transport units are running on the rails, then the capacity of the infrastructure is being wasted. -Limiting the number of passengers means a higher number of pods required. Therefore, high acquisition costs.	-Competition to other mobility providers/mobility systems -Use of existing vehicles not possible as vehicles not (yet) capable of automated driving. Modification of vehicles expensive. -Purchase of new vehicles necessary. -In order to be able to offer D2D, road and rail must be suitable for autonomous vehicles. However, infrastructure is not (yet) ready. -Competition among mobility providers/mobility systems -More MIV on the roads: Road traffic involves negative environmental effects -Trains have priority: possible delays in journey times -Coupled pods travelling to the same destination instead of a train leads to inefficiency in the system -Coupling with high-speed trains not possible as system is limited to 80 km/h -More traffic is generated as pods run in addition to trains -Infrastructure needs to be improved -Vertical transfer can lead to anxiety among passengers, which in turn is reflected in customer satisfaction. -Battery replacement not environmentally friendly -Infrastructure would have to be expanded to cope with high capacity utilization. As the UC is used on branch lines, which are often only single-track, additional tracks would have to be built. (For train encounters) -Use on branch lines: On single-track lines, a solution must be found for train encounters. Robots swap the pods, cranes lift the carriers, etc. " -A higher frequency means that additional rail infrastructure has to be built, which has a negative impact on the environment. -Cannibalization effects on existing public transport -In general, climate protection is currently important. Therefore, low capacities are

-The quantitative criterion is the CO2 emissions per passenger kilometer; depending on the capacity of the pods, this is positive/negative for the environment. -The smaller the pod, the relatively more expensive the ticket price. -The more the containers weigh, the fewer people or equipment can enter the pods. -The more a pod weighs, the more energy is required -> more costs -Increased risk of accidents if the vehicle is too quiet (at junctions) -PIS must be available and adapted to the groups of people -> Depending on the restrictions, assistance functions can be adapted (multichannel) -Older people are unsure about technology and would not use Premium Public Transport. -Contactless ticketing is not available for all groups of people -Multi-purpose areas for e.g. rollators/pushchairs/assistance dogs must be provided -Time losses possible due to technical features such as: Speed, virtual coupling, ... -Additional complication related to integration of logistic processes -Additional stops may be needed to load/unload freight -Having full truckloads of parcels requires (multi-actor) consolidation -Planning the platooning (sequence and number) and also control may be complicated. -Highly sensitive to real-time communication cuts " -Limits delivery of parcels having strict deadlines if range is limited -Limits the reach to farther areas" -Limits the weight of packages that can be transported in each vessel -Passenger flow (either real-time or predicted) is needed for planning -Available capacity is highly dynamic requiring real-time re-routing" -Energy concumption by heavier vehicles may impact the energy consumption	comparatively unfavorable from an ecological point of view and could be considered critically (quantitative criterion is the CO2 emissions per pkm, depending on the capacity of the pods this is positive/negative for the environment (compared to the existing system)). -The more a pod weighs, the more energy is required --> Not environmentally friendly -There are maximum weight allowances on the rail. -Complete automation can have a negative impact on older people or people with a disability, as there is no staff on site to assist with problems. Only via the PIS. -Possible cannibalization effects compared to standard public transport -If logistic processes are hard to integrate then implementation is difficult -Variation in the freight weight may make autonomous operation of Pods difficult -On time availability of moving infrastructure at transshipment point -Unpredicted events or disruptions on the road -Freight weight may limit the charging range also for passenger pods -Difference in the weight of the cargo -Legislative and technical/safety issues -Limited weight that can be carried by the weight limit of the infrastructure and the passengers