D4.5 Impact assessment and city-specific policy response

Padua pilot

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Table of Contents

Executive summary

The Padua pilot project introduced cutting edge-technology for urban transport, the NEXT system, a mixed freight/passenger transport mean composed of electric pods. Their relevant feature is modularity and flexibility, which leads to resource optimization. The pods are capable to join and detach while running.

The pilot project included three-month trials in Longhin Street, located in a directional/commercial area of the city (small-scale pilot test). This area was selected because it could create a reserved lane where the innovative pods could run after the necessary works to adapt to the existing road's viability.

Trials were carried out according to the current regulation, and data from the pod was collected to test the innovative futures, assess the vehicle technical performance and measure its sustainability impacts. Key Performance Indicators were verified to ensure the achievement of specified goals (reduction in traditional fuel consumption, reduction in CO2 emissions, improvement of environmental quality). The evaluation concluded with the financial, socio-economic and environmental impact assessment, based on the results of the trials and additional information. During this process, the manufacturer validated the data collection and results.

The impact assessment was complemented with the simulation of scenarios according to the methodologies in the SPROUT evaluation framework. The simulation considered a wider urban area stretching from Longhin Street and the bus/railway station, where the innovative mobility service could be introduced and integrated with the other transport systems (for both freight and passenger).i30t oers(u)132876 rg0.30t(h)13(e)0(I)-4(a 0.9[(i41do)4(l)5(o)13om)9 sseng10(in(t)-

1 Introduction

1.1 Aim of the deliverable

The deliverable aims to explain the work and results of testing and assessing the pilot's mobility solutions, identify a list of alternative policy responses according to the stakeholders' objectives and users' needs, and define the final city-specific policy response. The work consists of three steps. The first step was the implementation and assessment of the mobility solution. The barriers and problems found together with the sustainability assessment were the basis for the sequential steps and the definition of the city-led policy. By the time the second step started, the city of Padua was able to find only one problem for the use case implemented. Based on the Stakeholders Based Impact Scoring (SIS) methodology, the pilot identified the veto stakeholders, found their objects and showed the trade-offs all stakeholders have to make. In the last step, Padua identified a list of alternative policy responses to enhance the mobility solution adoption, scalability and transferability. Finally, the pilot assessed the alternative policy responses implementation and user acceptance and defined the policy measures that harness the implementation of Padua innovative mobility solutions.

1.2 How this deliverable relates to other deliverables

The development of the task considered previous SPROUT work. More specifically, the pilot followed the steps and methods reported in D4.4 COVID-19- disruptions and other challenges encountered during the pilot implementation forced to adjust the initial set-up as explained in this document. The list of alternative policies identified in D3.3 was essential for identifying alternative policy responses and defining the city-specific policy response. This deliverable and the rest of the pilots' reports (D4.3, D4.7, D4.9 and D4.11) will be the foundation for defining the policy implementation messages in D4.14 and the urban policy system dynamics model in D5.2.

1.3 Task participants and sharing of contribution

The T4.3 participants were the pilot leader (Venice International University, VIU) and the pilot partner (Padua Municipality). Padua Municipality supplied with the deployment of the infrastructure, performed the physical test and the technical assessment. The pilot leader supported the pilot implementation and provided/supervised simulation and the overall evaluation. ZLC supported the entire process for developing the specific task and the overall deliverable.

VUB was the T4.4 task leader. It set up the guidelines and general methodology for modified MAMCA, and the surveys analysed the results and conclusions. VIU and Padua Municipality cooperated during the implementation. Padua municipality helped with the stakeholders' identification, the formulation of stakeholders' criteria and the survey distribution. The pilot leader (VIU), as a scientific supervisor, evaluated the alternative in terms of their stakeholders' criteria. VUB supported the pilot during the whole process for developing the specific task.

ZLC, as T4.5 task leader, defined the overall task methodology to be adopted and the criteria to be considered for the evaluation, set up the surveys and gave second level feedback. Supported by the pilot leader (VIU), Padua Municipality defined the set of policy responses involved the stakeholder in their assessment of feasibility and user acceptance and provided with the second-level feedback. ZLC supported the pilot during the whole process for developing the specific task.

CERTH was the overall deliverable technical coordinator and reviewer.

1.4 Structure of the deliverable

The deliverable is structured as follows:

- Chapter 2: Pilot activity description
- Chapter 3: T4.3 sustainability assessment
- Chapter 4: T4.4 Formulation and prioritization of alternative policy responses
- Chapter 5: T4.5 City-specific policies for harnessing the impact of new mobility solutions
- Chapter 6: Summary and Outlook

2 Pilot activity description

The Padua city aims to optimize passengers and freight transport (cargo-hitching). The SPROUT pilot, based on testing new disruptive mobility business models at the urban level through the implementation of innovative technologies, helped to materialize this goal.

The disruptive tested technology was the "NEXT system[1]", an advanced transport model based on advanced, modular, electric, pods (Figure 1). The transport system is also potentially self-driving.

The activities described in the deliverable are those previously described in D4.4. - Setup Report - Padua pilot (Masetto 2020), focused on the application of innovative mobility solution (the "NEXT" system, see also (Masetto 2020), par. 2.1), based on trials at the urban level of innovative vehicles and business models based on cutting-edge technologies carrying both passengers and freight (cargo-hitching).

As described in D4.4, the main feature is the possibility, for each module, to join and detach with other modules on standard city roads. When joined, a bus-like vehicle is created by modules. Each module can move autonomously on regular roads, join themselves and detach, even in motion.

This allows to dynamically adapt the supply to demand: modules carrying passengers and goods are combined on the basis of estimated flows, which are calculated in real-time by algorithms considering different final destinations for users and freight. The "NEXT" system can provide significant benefits in terms of dramatic reductions in traffic levels, travel times and emissions by dynamically consolidating urban traffic flows (both passengers and freight), thus optimizing urban transport capacity.

Therefore, the main objectives of the trials follow Sustainable Urban Mobility Plan (SUMP) main goals and can be summarized as follows:

1. Promoting the use of more sustainable and environmental-friendly transport modes, developing e-mobility to reduce emissions, fossil fuel consumption and mitigating climate change;
2. Detecting and testing new mobility solutions to overcome the actual barriers and limitations of traditional transport systems, currently operating in the city of Padua (see also (Masetto 2020), chapter 2.2. where a brief description of the current organization is given), allowing to reduce traffic levels and travel times, and therefore improving efficiency and effectiveness of urban mobility. About passenger transport, in fact, one of the current needs is the rising need to dynamically follow the transport demand. From the perspective of freight transport, it is desirable to optimize vehicles movements, especially inside the urban perimeter.

[1] For more details: https://www.next-future-mobility.com/

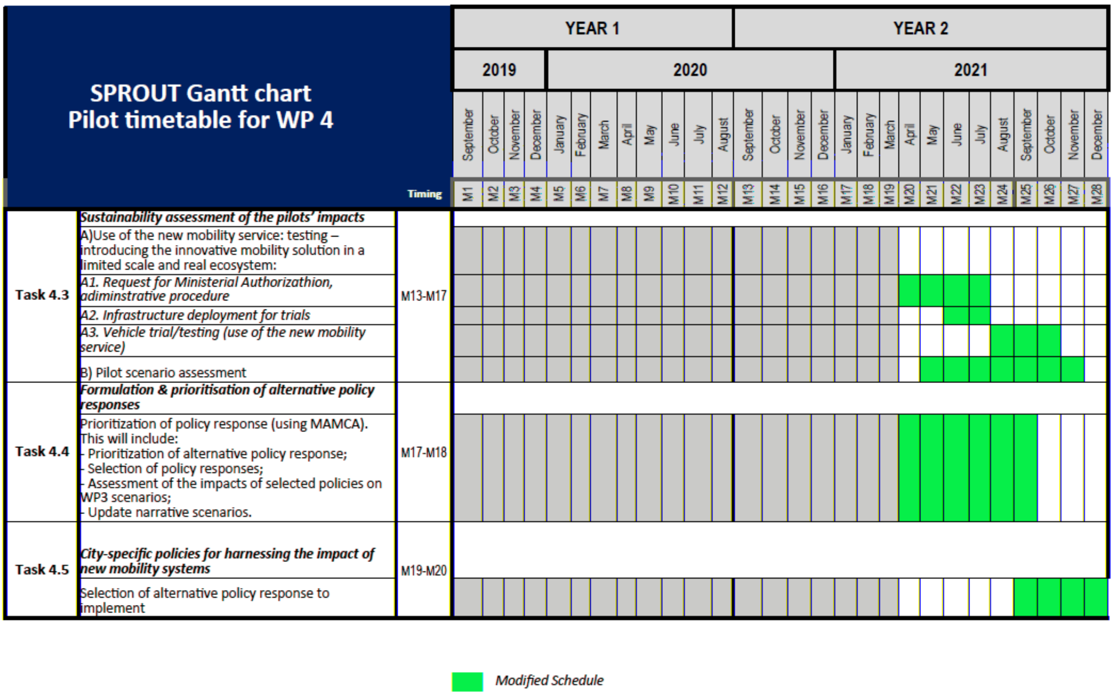
Figure 1.

During the last year, the pilot in Padua focused on implementing the WP4 tasks further detailed in this deliverable. Despite some time-deviations due to some challenges, briefly described COVID-19 below, Padua completed all the foreseen activities and found meaningful insights and learnings from the outcomes and the process to consider when adopting this mobility solution.

Table 1 shows the updated Gantt for WP4. A short resume of three major tasks is the following:

- T4.3 started in M20 and finished in M27 (this also included time for administrative procedure);
- T4.4 started in M20 and finished in M25;
- T4.5 started in M26 and concluded the Padua WP4 activities in M28, leading to the Padua city policy response.

Table 1. Updated Gantt diagram for Padua pilot WP4 activities.



In the next section, a short description about time deviations, content deviations and how COVID-19-19 affected the progress of activities is given.

2.1 Time deviations

Since the submission of D4.4, there were some time deviations from the original time plan: The pilot in Padua is an ambitious and disruptive project, which required a further commitment from the Municipality for its realization.

For Padua Municipality, one of the learnings from trial implementation was to successfully face some issues not initially foreseen in the original timeline, due to the complexity of the necessary administrative and financial procedure for trials execution (public tender); the completion of this procedure was a requirement to start T4.3 activities Sustainability assessment of the pilots' impacts.

The administrative procedure for the public tender and procurement was concluded in July. Subsequently, also Task 4.4 and Task 4.5, were affected by these delays and postponed. In the following table a brief description of different tasks regarding WP4 activities is reported.

Table 2. Short description about time deviations for WP4 tasks.

Task	Sub-task	Actual time of realization	Reasons for postponements
T 4.3 Sustainability assessment of the pilots' impacts	*A1. Infrastructure deployment for trials*	Time deviations from original timetable reflected the completion of the administrative/financial procedure. See also Gantt diagram. Deployment of infrastructure completed in the second half of July, 2021	The completion of infrastructure deployment in via G.A. Longhin was a requirement to start the trail activities (Figure 3) The time and the resources needed to realize the infrastructure was relatively low, but could not be performed before completion of the administrative procedure, since involved the removal of some paid parking lots.
	A2. Request for Ministerial Authorization/ *A3. Vehicle trial/testing (use of the new mobility service)*	The beginning of trials originally foreseen was postponed: road test of pods vehicle started at the end of July, and lasted until the end of October 2021. Some running sessions were also recovered in November. Request for ministerial Authorization (test plate) did not face any problem.	Completion of the administrative and financial procedure.
	B. Pilot Scenario assessment	As regarding data test analysis for the calculation of essential KPIs to demonstrate the achievements), there were no time deviations as regarding trials themselves. However, the begin of trials was postponed for the aforementioned reasons. The final scenario assessment followed the trial timeline.	
T4.4 *Formulation & prioritisation of alternative policy responses*	*Prioritization of policy response (using MAMCA). This will include:* *- Prioritization of alternative policy response;* *- Selection of policy responses;* *- Assessment of the impacts of selected policies on WP3 scenarios;* *- Update narrative scenarios.*	See Gantt Diagram.	The timeline for task completion was not affected, but VUB had to modify the adopted methodology to ensure the task completion, implementing SI methodology (see section 4). Minor slight delays were recorded, mainly due to difficulties in receiving quick answers or feedback from different stakeholders. However, it did not affect the task timeline.

Task	Sub-task	Actual time of realization	Reasons for postponements
T4.5 City-specific policies for harnessing the impact of new mobility systems	*Definition of the city-led policy response.*	Task was completed between October and December, 2021.	The activity also suffered delays due to the postponement of Task 4.3 and the methodological adaptation of T4.4. Collection data from trials, even if not definitive, and outcomes from wider area simulation, were a requirement for a meaningful evaluation by the stakeholders. For the methodology, see section 5 addressing T4.5.

2.2 Content deviations

Referring to the contents and all the descriptions given in the set-up document (D4.4), there are no significant deviations on contents originally identified or designed.
The modifications are:

- Regarding one of the mandatory KPIS originally foreseen about mobility charging points (that was removed as explained later in the document.);
- T4.4 methodological adaptations (see section 4);
- T4.5 additional activities to find the list of alternative responses.

2.3 How COVID-19 affected the pilot in Padua

During WP4 activities, COVID-19 was not directly a limiting factor but has generally affected and slowed down the operational activity of the Municipality since the need to manage unexpected quarantine periods and subsequently the temporary lack of personnel. The Municipality of Padua tackled the issue by adopting new health and operational protocols and making smart working compulsory for employees (at least a few days a week).

3 T4.3 Sustainability assessment of the pilots impacts

3.1 The “NEXT system” business model

As explained in the previous chapters and in the D4.4, the NEXT system (Figure 1) is an electric and modular mobility system based on vehicles capable of coupling and uncoupling, even on the move, to modulate the transport capacity in relation to the real-time demand.

The Padua Pilot aims to demonstrate the efficiency and effectiveness of the NEXT system as urban transport for people, goods and in a mixed solution of so-called Cargo hitching. The term refers to the management of people and freight mixed flows: cargo that hitches a ride on a vehicle transporting persons or persons hitching a ride on a vehicle transporting cargo. This creates attractive business opportunities because the same transportation needs can be met with fewer vehicles and drivers[2].

Starting from this definition, the NEXT system fits into this concept of business model, allowing vehicles to be used for mixed transport, significantly lowering traffic levels and travel times during the day

NEXT system can have a better impact aspect that reduces the traffic, and therefore the urban pollution than other existing solutions. Below some examples of papers and scientific publications regarding the NEXT system from international universities/institutions:

- NYU (New York - USA):
  - "On the design of an optimal flexible bus dispatching system with modular bus units: Using the three-dimensional macroscopic fundamental diagram" (Dakic 2021);
  - "Day-to-day market evaluation of modular autonomous vehicle fleet operations with en-route transfers" (Caros, 2021);
- UM (Michigan - USA): "Modular transit: Using autonomy and modularity to improve performance in public transportation"(Zhang, 2020);
- USF (South Florida - USA) -:
  - "Operational design for shuttle systems with modular vehicles under oversaturated traffic: Continuous modelling method"(Chen, 2019);
  - "Vehicle dispatching in modular transit networks: A mixed-integer non-linear programming model" (Pei, 2021);
- QUT (Queensland - AUS) - Publication "Modular dynamic ride-sharing transport systems" (Gecchelin, 2019)
- CTH (Chalmers - Göteborg - Sweden): - "A modular, adaptive, and autonomous transit system (MAATS): A in-motion transfer strategy and performance evaluation in urban grid transit networks" (Wu, 2021);

The main innovative features of the NEXT system are the following:

1) **Electrification**: Reduction of pollution and increased efficiency due to the electrification of public transport, compared to internal combustion vehicles and electric buses and fleets of taxis;

2) **Modularity**: Reduction of traffic thanks to the fleet management system, which adapts in real-time to the request and can combine, in a door-to-door service and without mandatory routes, several passengers sharing the same destination;

[2] https://cargohitching.wordpress.com/

It is noteworthy to underline that modularity allows to significantly help to improve the electrification feature, allowing lower electric consumption.

Another significant feature of the pods is the technical possibility for the implementation of self-driving; however, since this feature is not the main innovation of the project and the legislation for autonomous driving is not currently allowed, autonomous driving has not been tested. The current European and Italian regulation should evolve into an adequate framework to allow autonomous driving on public roads. However, these trials can be seen as a first step in the implementation towards the implementation of autonomous vehicles.

3.2 Policy framework

The Municipality of Padua is developing an innovative policy framework within the adopted

3.3 Pilot description

The city of Padua tested the NEXT system in a real urban ecosystem. More specifically, the pilot focused on selected areas of the city, consisting of the Longhin St. along with the stretch routes comprising Stanga district, the Fair and the railway station and divided the assessment into two stages as described below and in the setup report (D4.4-Masetto, 2020) and showed in the following Figure 2:

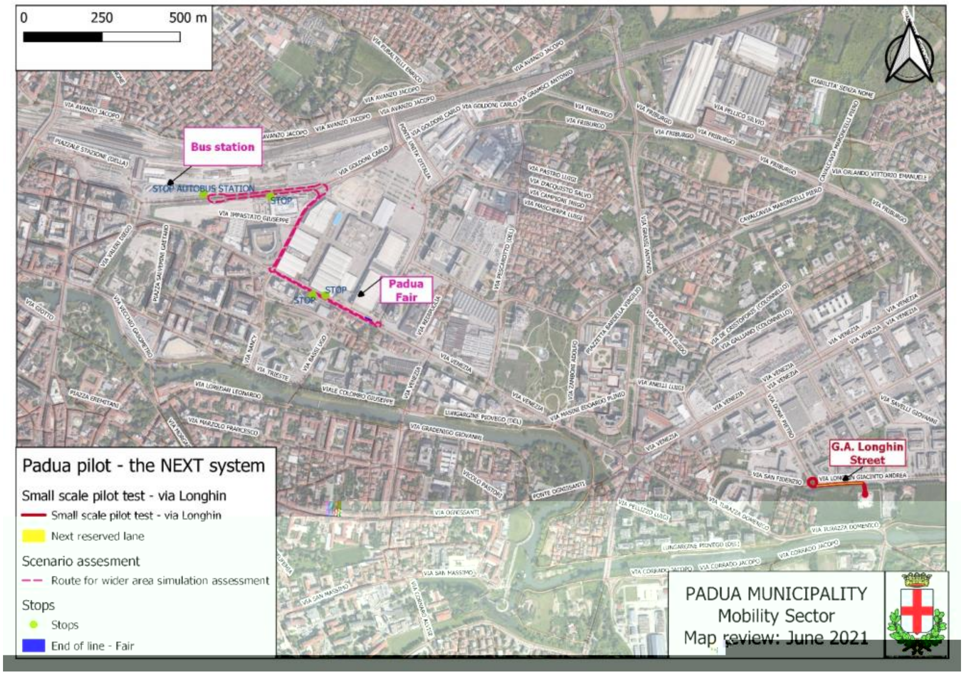


Figure 2. Small scale pilot test (G.A. Longhin) and route for wider area simulation assessment.

a) Real-life -testing (trials): the technical performance assessment of the transport system was performed in a selected urban area (Longhin Street);

b) Simulation assessment in a wider urban area: a “light” financial and cost-benefit analysis is conducted to show the financial and socio-economic feasibility where the proposed transport option is supposed to be implemented (Fair/Autobus station route).

Firstly, to choose the correct context to perform the trials, it was necessary to identify the ideal roads for running the NEXT system. The selected area, Longhin Street (Figure 3), is inserted in the context of the city’s directional/commercial area, closed to the Padua industrial area (see D4.4).

The reasons for selecting this area were the following:

- it is closed to the industrial area;
- it allows the realization of a dedicated lane for trials;
- it implies low impacts on local traffic and sustainable infrastructure costs;
- it is closed to large park areas which can encourage the NEXT services adoption.

More specifically, the width of the selected road allows creating a reserved lane to perform mostly technical tests/trials in accordance with the provisions of the Italian traffic rules and was obtained without any viability changes to the local vehicular traffic and assess the technical performance of the system. The lane was obtained by temporarily removing some parking slots aside the testing area and slightly modifying the cycle-pedestrian traffic. It allowed eliminating the potential risks of interference. For the creation of the reserved lane it was necessary to issue a specific municipal ordinance in agreement with the Local Police. Subsequently, the works for the modification of the horizontal and vertical signs were carried out, as shown in Figure 3.

Besides the horizontal signage, the separation was completed positioning jersey barriers[3] to create a physical separation.

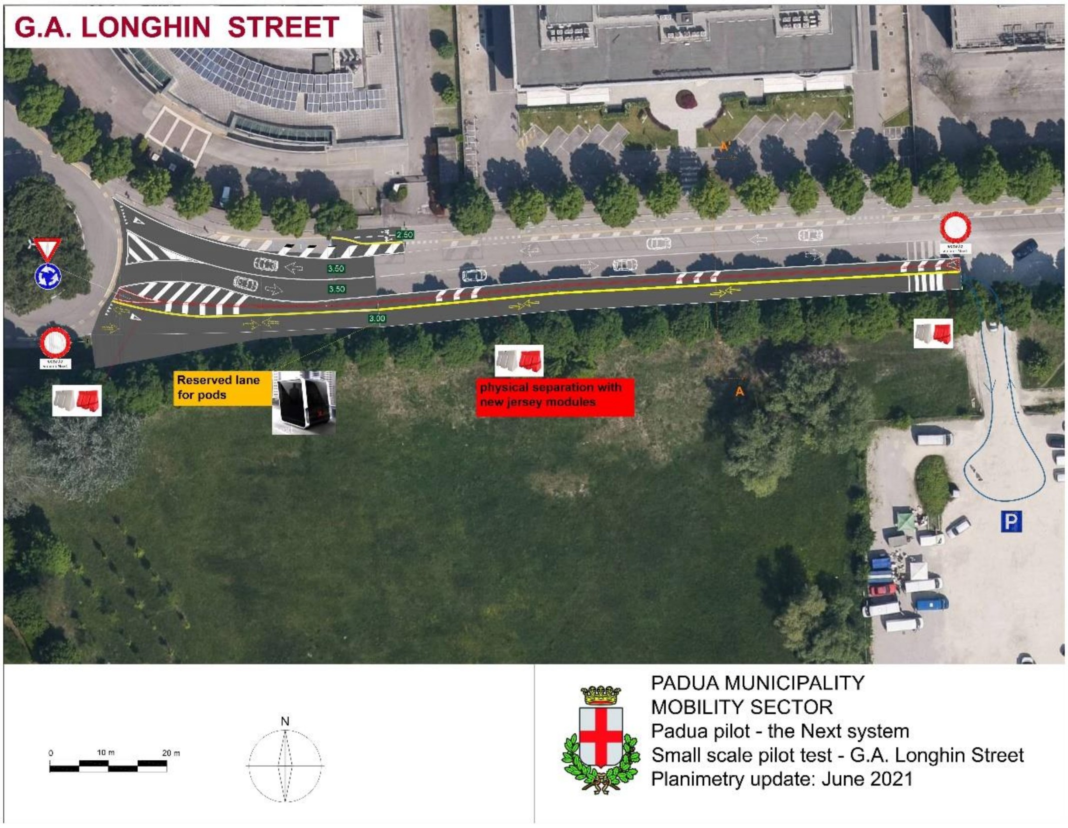


Figure 3. Actual realization of reserved lane for pods trials in Longhin Street.

Based on the testing activities' results in Longhin St., the brand-new innovative business model was simulated and assessed in a wider urban context – see Figure 2 – as proposed by the SPROUT EF (European Framework - D4.1). In particular, the extended deployment of the NEXT service will include some strategic urban areas – the Fair and the bus/railway station –

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[3] A *Jersey barrier*, *Jersey wall*, or *Jersey bump* is a modular concrete or plastic barrier employed to separate lanes of traffic. It is designed to minimize vehicle damage in cases of incidental contact while still preventing vehicle crossovers resulting in a likely head-on collision (https://en.wikipedia.org/wiki/Jersey_barrier)

which would benefit from a regular urban mobility service for both passenger and freight. In particular, for freight transport mostly related to e-commerce deliveries (small parcels), the role of the Fair as a potential urban logistics "micro-hub" is envisaged. It may consist of a relevant policy response leading to the reconfiguration of the existing urban logistics network. In this framework, the location of an urban fulfilment centre may require signing an agreement between the Municipality and the Fair. In this route, there is a large supermarket closed to the Fair. Prospectively, if a dedicated stop would be realized in the surroundings, customers could benefit from the innovative urban mobility solution as well. With an overlook to the future, the NEXT system will be integrated into the existing local public transport network (in particular reaching the bus/railway station), thus, giving rise to a further policy response providing integrated and sustainable transport services to the users, which is again something definitely in line with the main strategic goals of the forthcoming SUMP.

The city-led policy response required for scaling the mobility solution to the extended area was identified according to the methodologies and activities described in the SPROUT EF (D4.1) and detailed in Chapters **4** and **5**.

3.4 Involved stakeholders

The pilot in Padua assumed that the project stakeholders are the individuals or entities that are partners of the SPROUT project but affected, either positively or negatively, by the deployment of the mobility solution. The list of project stakeholders and roles is the following:

- Padua Municipality (Mobility Councillor, Mobility Sector, Public Works Sector, Environment Sector) and Local Police provided the pilot testing and assessment activities with the necessary technical assistance as detailed below;
    - Mobility Councillor: ensured political support to the whole project;
    - Mobility Sector: ensured the implementation of the project activities through necessary administrative, regulatory and technical steps and collected data for the assessment;
    - Public Works: provided relevant information for the data collection and technical support for deploying the Longhin Str. infrastructure;
    - Environment Sector: provided relevant information for the data collection;
    - Local Police: provided technical support concerning regulatory and safety issues.
- The group of companies that designed and produced the NEXT system (Getplus s.r.l.[4] and Paradigma s.r.l.[5]) played the key role in performing the trials under the supervision of the Padua Municipality (Mobility Sector) and facilitating the activity data for the assessment;
- Nowadays, two stakeholders play a crucial role in mobility in Padua for facilitating the major transport services in the area: BIV (BusItalia Veneto) for passengers' transport and CityPorto for freight transport and logistics:

[4] https://www.next-future-mobility.com/copy-of-about

[5] https://www.paradigma.city/

- Busitalia Veneto Ltd[6] is the company operating in Veneto Region that provides the metropolitan area of Padua with the urban and suburban services. The company has 930 employees, 650 buses and 18 trams. In the urban context, there are 24 ordinary bus and tram lines, for a total bus network of 232 km of buses, and 10 km of trams. Its involvement in the pilot was about provide relevant information for pilot data collection.
- Cityporto[7] is a service of goods delivery in the urban area carried out with a fleet of Compressed natural gas (CNG) vehicles which consolidate the deliveries of different transport operators, meanwhile reducing the traffic of freight transport vehicles. The key-words for Cityporto are: sustainable transport, intermodality, reduction and moderation of traffic. Its involvement t was about providing the data collection with relevant information.

- APS Holding S.p.A. and Radio Taxi Association. These companies were indirectly affected during the trials execution as the reserved lane required temporarily removing some paid parking slots (39) and taxi places (4).

3.5 Pilot Impact assessment framework and target KPIs

The objective of the implementation of the NEXT system was to assess and demonstrate the positive impacts of the innovative transport system, in terms of environment and sustainability, on reducing the negative externalities of the urban mobility and achieving the following targets:

- 3% reduction of traditional fuel consumption (I405);
- 4% reduction of CO_2 emissions (I406);
- 9% improvement of the environmental quality (air pollution) (I407)

During the trials, data were collected from field tests in order to verify the aforementioned measurable goals obtained by the introduction of the NEXT transport system, and to assess the technical performance.

The introduction of 10 mobility charging points was initially planned (I415). The development of some infrastructures for electric mobility, including 10 charging points within the SPROUT project framework, should have been carried out by the Municipality. Subsequently, it was clear that the implementation of such infrastructures needed to have an overall management for the whole city. Therefore, the definition of a specific implementation plan for these infrastructures and their realization was assigned to the municipalized company APS, making its implementation independent of the aims of the SPROUT project.

3.5.1 Testing and data collection activities

After the infrastructure deployment, field operational tests (trials) started in Longhin Street (see previous chapter) at the end of July, the 29th and lasted three months, until the end of October. Additional sessions in November allowed recovering the ones not performed in October.

[6] https://www.fsbusitalia.it/content/fsbusitalia/it/veneto.html

[7] https://www.interportopd.it/cityporto/

Prior to start the trials, it was necessary to obtain a specific authorization from the Transport Minister (and corresponding test plate), needed to use experimental vehicles on public roads; no problems were encountered at this stage.

The route was flat and consisted mainly of a reserved lane (Figure 4, a roundabout open to traffic and a parking lot where the vehicle reverses the direction of travel; in this way, a ring tack somehow was created (the lengths of the circuit was approximately 300 m long – see Figure 2 and Figure 3).

Figure 4. Infrastructure deployment for reserved lane

Before starting the trials, the following activities were performed:

- The definition of a procedure to guarantee safety during trials (manoeuvre directives, escort vehicles that accompanied the pods from headquarters to the test site). In addition, the NEXT system manufacturers provided the Mobility department with the Operational Safety Plan for trials. For the unconditional transportation of people (volunteers), a specific disclaimer was prepared;
- The definition of data collection and daily reports to be filled for each day of tests;
- Running-in test with a single vehicle and in two-pods configuration[8];
- Technical manufacturer assessment of steering, braking, traction, wheel-suspensions, speed, and handling performance;
- Batteries test, stress test, discharge curve analysis;
- The measure of the running parameters and telemetry (travel times, distances, speed and verification of electrical consumptions based on different speed and acceleration patterns, vibrational analysis of the vehicle, verification of internal noise comfort;
- Consumption tests under different use conditions and variable loads;
- First trials with joint system;
- IT Assessment on hardware/software components.

[8] Two pods were used at the same time in some running session for technical needs (especially to test the coupling system).

After the preliminary activities, the pods, already equipped with a test plate and specific insurance had the possibility to travel in normal roads and transport employees of the company and goods. During the trials, the pods were tested most of the time as a single pod, but in some sessions also in paired mode (Figure 5).

Figure 5. Run session trial with two paired pods

The trials were conducted by the NEXT system manufacturers, under the supervision of Mobility and Department and Local Police (for safety issues). In order to minimize risks and interferences with other vehicles (roundabout was open to traffic), the trials were conducted avoiding peak traffic hours, therefore, in the morning between 9:00 and 12:00, or between 14:30 and 17:00.

Some sessions trials were carried out with on-board passengers (authorized employees of the NEXT manufacturers). Every journey was recorded with a GPS recorder that generated the corresponding *.gpx* and *.kml* files (Figure 8). It is important to outline that the data collected referred only to the effective runs, therefore, it is not considering the transfer trip from the headquarters to the site of the trials in Longhin Street.

Some other pictures taken during run sessions are shown in Figure 9 and Figure 10.

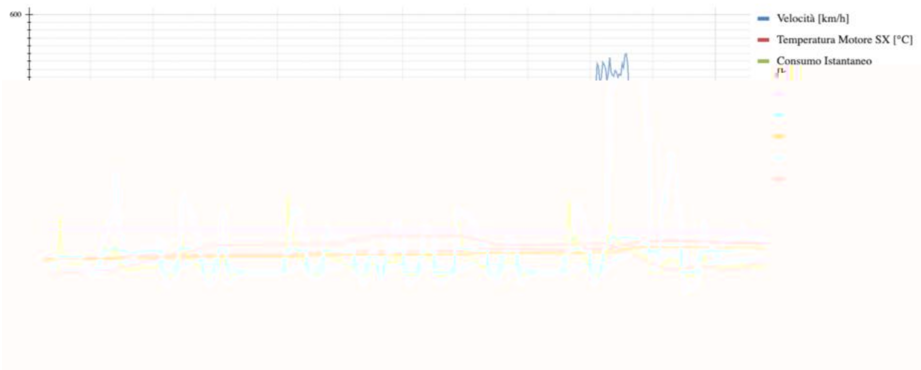

Figure 6. Example of recorded telemetry for pods

Figure 7. Running sessions for single pod in reserved lane

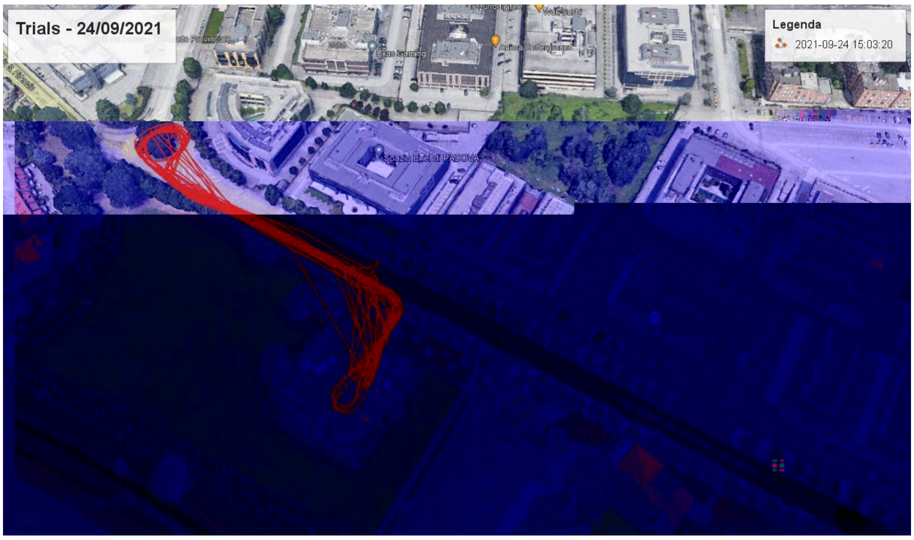

Figure 8. Geo-referenced .kml file produced for run session (24/09/2021)

Figure 9. First vehicle used in Longhin street trials (uncovered wheel configuration).

Figure 10. Picture of the pod (faired configuration) at the end of reserved lane.

3.5.2 Pilot objectives assessment description

The calculations of the targets described above (3% fuel consumption reduction, 4% CO_2 reduction, 9% environmental quality improvement) were performed using data collected during trials.

A fundamental parameter obtained from the trials was the electricity consumed by the pods. The NEXT manufacturer measured this electricity consumption and other parameters associated to the trials (load, speed, temperature, weather conditions, distance, simulated stops, other functional parameters) during each running session

The total distance covered by pods during the trials was nearly 300 km (the total amount is higher, but just the effective distance where the parameters were monitored is considered).

a) *Reduction of traditional fuels energy consumption*

To verify the traditional fossil-fuel consumption reduction, the measured data were compared with the current standard passengers and freight transports and assumptions were needed.

Assuming that electric means of transport have an undoubtedly higher efficiency than with an internal combustion engine, it was necessary to find a reasonable way to compare different energy sources. Energy equivalence in energy terms is based on a chemical property, the calorific value, already useful today to compare traditional fuels (petrol and diesel, liquid fuels) with LPG and methane (gaseous at atmospheric pressure); from literature data, the available consumption data (in l/100*km, or kg/100*km) from traditional transport means have been then converted into kWh/100*km equivalent and compared with measured pods electric consumption[9].

Knowing the electrical consumption data at a given speed and the distance travelled by the pod, it was possible to obtain a traction energy cost, expressed in terms of €/km. Using then the national average cost for energy (€/kWh), the total equivalent amount was obtained.

For passengers' transport, the comparison has been made respectively with other standard means of transport operating in Padua: buses with the internal combustion engine (Diesel, Methane), as well as with cars with the internal combustion engine (Diesel, Methane). In addition, a comparison with electric buses and electric cars was also made, in order to compare pods' consumption data with means of transport where the same type of energy source is used.

For freight, the comparison was made between NEXT and the alternatives currently in use for freight transport: vans with internal combustion engine (Diesel and Methane). About the electric motor, this is not a widespread standard for logistics yet. Therefore, the lack of literature did not allow comparing the pod with an equivalent electric vehicle for freight.

Firstly, the pilot compared the NEXT system with the public transport system (buses). The starting hypothesis for the calculation was to consider the minimum number of buses required to ensure the same transport service offered by pods used during trials.

In reality, the demand for transport undergoes natural fluctuations during the day; if the daily transport demand fluctuation is known, it would be possible to estimate the overall consumption saving over the day. Then, in order to have a more realistic comparison, starting from real data on the average daily trend of demand for Padua bus lines, the consumption of a bus was compared with the average daily number of pods needed to satisfy such demand; from internal estimates, the necessary average number of pods is equal to 3. A bus with full

[9] *Source:* http://osservaprezzi.mise.gov.it/index.php?option=com_content&view=article&id=81:confrontare-i-prezzi-dei-carburanti&catid=16:osservaprezzi-carburanti&Itemid=293

passenger capacity would correspond to n. 5 connected pods. In this configuration, the advantage over traditional fossil-fuels would in any case be considerable too.

The Table 3 presents the comparison between NEXT system and public transport system currently in use in Padua.

Table 3. Energy consumption comparison between NEXT system and public transport system currently in use in Padua (trials).

Data description	BUS 12m (Diesel)	BUS 12m (Hybrid-Diesel)	BUS 12m (CNG)	BUS 12m (Electric, BYD K9UB)	Pods(2 pods)
Source →	Literature data, WHTC cycle[10]	Literature data, WHTC cycle[11]	Literature data, WHTC cycle[12]	Literature data, WHTC cycle[13]	Recorded data. Number of equivalent passengers for pods: [(5 +1)*2]
Total consumption [l/100 km], [kg/100 km]	36.75	27.75	33.20	---	---
Total consumption [kWh/100 km]	---	---	---	104	55.2
Conversion factor for traditional fuels[14][kWh/l], [kW/kg]	10.0	10.0	12.3	--	--
Energy consumed in 1 hr[15][kWh]	72.40	58.31	85.29	20.49	11.00
Traction Energy cost (€/km)	0.70	0.56	0.82	0.20	0.11
Equivalent v*km ratio (trials)	0.5	0.5	0.5	0.5	1

[10] Source: https://www.trentinotrasporti.it/azienda/trentino-trasporti/autobus-e-treni/400-emissioni-e-consumi-degli-autobus
[11] Source: https://www.trentinotrasporti.it/azienda/trentino-trasporti/autobus-e-treni/400-emissioni-e-consumi-degli-autobus
[12] Source: https://www.trentinotrasporti.it/azienda/trentino-trasporti/autobus-e-treni/400-emissioni-e-consumi-degli-autobus
[13] Source: https://www.autobusweb.com/wp-content/uploads/2021/04/SLIDE-ZANINI-GTT-Bus-elettrici-MZ-aprile-2021.pdf
[14] Source: http://osservaprezzi.mise.gov.it/index.php?option=com_content&view=article&id=81:confrontare-i-prezzi-dei-carburanti&catid=16:osservaprezzi-carburanti&Itemid=293
[15] Average speed recorded: 19,7 km/h

Data description	BUS 12m (Diesel)	BUS 12m (Hybrid-Diesel)	BUS 12m (CNG)	BUS 12m (Electric, BYD K9UB)	Pods(2 pods)
Energy consumption reduction with the use of pods (trials) (%)	84.82	81.15	87.11	46.35	--
Energy consumption reduction with the use of pods (average daily demand)[16] (%)	77.22	71.72	80.67	19.52	--

As expected, the advantage offered by the NEXT system to transport passengers in terms of energy savings, compared to traditional fuel buses, is undeniable, being above 70% with the fossil fuels and close to 20% with the electric alternative (average daily demand).

Then, the NEXT system was compared with traditional fuels and electric cars. To make a realistic description, the number of vehicles on the road with an occupancy rate of 1.2 passengers/car was chosen, that is reasonably the current average occupancy rate for cars (Table 4).

Table 4. Energy consumption comparison between NEXT system and private cars (trials).

Data description	Private Cars (Diesel)	Private Cars (Electric)	Pod(1 pod)
Source →	Literature data (Average specific consumption of new cars, Italy[17])	Literature data (standard car, WLTP cycle[18])	Recorded data. Number of equivalent passengers: (5 +1)
Total consumption [l/100 km]	4.9	---	---
Total consumption [kWh/100 km]	---	17.1	27.6

[16] From internal estimates of the Municipality, the typical daily average transport demand would need 3 pods.
[17] Source: https://www.odyssee-mure.eu/publications/efficiency-by-sector/transport/specific-consumption-new-cars-country.html
[18] Declared data from manufacturer (Nissan Leaf, best case). Source: https://www.nissan.it/veicoli/veicoli-nuovi/leaf/autonomia-ricarica.html

Data description	Private Cars (Diesel)	Private Cars (Electric)	Pod(1 pod)
Conversion factor for traditional fuels[19] [kWh/l], [kW/kg]	10.0	--	--
Energy consumed in 1 hr[20][kWh]	9.65	3.37	5.50
Traction Energy cost (€/km)	0.09	0.03.	0.05
Occupancy rate	1.2 passengers/car	1.2 passengers/car	5 passengers/pod
Equivalent v*km ratio	3.42	3.42	.1
Energy consumption reduction with the use of pods (%)	**83.36**	**52.33**	--

As expected, the analysis demonstrates the excellent performance of NEXT compared to traditional combustion cars, but surprisingly its competitiveness even compared to the most efficient electric cars on the market, if we consider the modularity characteristics.

For freight transport, the comparison between Light Commercial Vehicles (LCV) and the NEXT System highlights also the advantages of the pod compared to vehicles with traditional fuel in

Table 5. Energy consumption comparison between NEXT system (2 pods) and LCVs (trials).

Data description	LCV (Diesel)	LCV (CNG)	Pods(2 pods, total load: 950 kg)
Source →	Literature data[21]	Literature data[22]	Recorded data. Total reference load: 950 kg
Total consumption [l/100 km] [kg/100 km]	10.1	8.8	---
Total consumption [kWh/100 km]	---	---	55.2
Conversion factor for traditional fuels[23] [kWh/l], [kW/kg]	10.0	12.3	--
Energy consumed in 1 hr[24][kWh]	19.90	21.32	10.99
Traction Energy cost (€/km)	0.19	0.21	0.11
Equivalent v*km ratio	.0.5	.0.5	.1
Energy consumption reduction with the use of pods (%)	**44.75**	**48.45**	--

[21] *Fiat Ducato 2.3 M-Jet Source: https://www.macrofocus.com/iaul/iAUL.html?dataset=Ecomobiliste%2520ATE%2520utilitaires%25202021-12-09*

[22] *Fiat Ducato 3.0 NP Source: https://www.macrofocus.com/iaul/iAUL.html?dataset=Ecomobiliste%2520ATE%2520utilitaires%25202021-12-09*

[23] *Source: http://osservaprezzi.mise.gov.it/index.php?option=com_content&view=article&id=81:confrontare-i-prezzi-dei-carburanti&catid=16:osservaprezzi-carburanti&Itemid=293*

[24] *Average speed recorded: 19.7 km/h*

Table 6. Energy consumption comparison between NEXT system (1 pod) and LCVs.

Data description	LCV (Diesel)	LCV (CNG)	Pods (1, total load: 475 kg)
Source →	Literature data[25]	Literature data[26]	Recorded data. Total reference load: 475 kg
Total consumption [l/100 km] [kg/100 km]	10.1	8.8	---
Total consumption [kWh/100 km]	---	---	27.6
Conversion factor for traditional fuels[27] [kWh/l], [kW/kg]	10.0	12.3	--
Energy consumed in 1 hr[28][kWh]	19.90	21.32	5.50
Traction Energy cost (€/km)	0.19	0.21	0.05
Equivalent v*km ratio	1	1	1
Energy consumption reduction with the use of pods (%)	**72.38**	**74.22**	---

In both cases, the energy savings compared to traditional fuels are evident simply by analysing the route travelled during the trials. An increase of efficiency is expected also in terms of time reduction and reduction in travels.

After comparing the recorded consumptions of the pods with the equivalent alternative means of transport for the current state of mobility, it was seen that in all the cases, the target of traditional fossil fuels consumptions reduction has been largely reached. For passengers' transport, the fossil fuels savings indicated above 70% for buses and above 80% for cars for realistic conditions. Even if compared with electric means, the consumption recorded data showed remarkable outcomes, ensuring nearly 20% energy savings for buses and 55% for private cars. For freight, it showed relevant results too (where the savings vary from 44 to 74% for LCVs).

[25] *Fiat Ducato 2.3 M-Jet* *https://www.macrofocus.com/iaul/iAUL.html?dataset=Ecomobiliste%2520ATE%2520utilitaires%25202021-12-09*
[26] *Fiat Ducato 3.0 NP Source:* *https://www.macrofocus.com/iaul/iAUL.html?dataset=Ecomobiliste%2520ATE%2520utilitaires%25202021-12-09*
[27] *Source: http://osservaprezzi.mise.gov.it/index.php?option=com_content&view=article&id=81:confrontare-i-prezzi-dei-carburanti&catid=16:osservaprezzi-carburanti&Itemid=293*
[28] Average speed recorded: 19,7 km/h

Therefore, it has been demonstrated that the goal to reduce by 3% the energy consumption from traditional fuels has been fully achieved.

b) *Reduction of Carbon dioxide (CO_2) emissions*

Data from trails have been used to calculate the CO_2 emissions saving by pods, with a comparison with equivalent traditional means of transport with an internal combustion engine, and therefore, capable of generating climate-change pollutants emissions.

The overall methodology described in the SPROUT EF (D4.1) was adopted, using the European External Transport Cost Handbook [10] for reference calculations. Since the Handbook does not provide external cost factors for new forms of mobility – pods included – the guidelines described in D4.1 have been followed to compute CO_2 emissions.

In the aforementioned reference guide, the items where the CO_2 emissions can be computed in terms of costs are 2: climate change cost and well-to-tank cost.

Costs have been calculated with the "SPROUT Environmental Impact Assessment Tool". After the data collection from trials, the number of equivalent vehicles was defined for the types of vehicles considered (cars, LCVs and buses). For cars, the occupancy coefficient of 1.2 was used to find the number of corresponding equivalent vehicles. For buses and LCVs, each run of a single pod is corresponding to an equivalent bus or LCV run (in other words, the same value for the v*km[29] parameter was used). To determine the t*km[30] parameter used for the LCV, the load values were set-up considering the difference between the load defined for each run of the pod and the dry weight of the vehicle.

The results are reported in Table 7, showing the pods allow reaching a CO_2 emissions reduction by 100% compared to transport means with traditional fuel engines. The used cost factors are shown in Table 8.

Table 7. Climate change pollutants emissions reduction (CO_2 included) – comparison between pods and other fossil-fuel vehicles (trials).

Cost item	Cars	LCV	Bus	Pods
Equivalent climate change cost [€/tkm Σtkm]	---	2.47	---	0.00

[29] V*km: Abbreviation of vehicle-kilometre, which is the movement of one vehicle the distance of one kilometre. Source: https://www.bts.gov/content/us-vehicle-kilometers-0

[30] T*km: Abbreviation of tonne-kilometre. It is a unit of measure of freight which represents the transport of one tonne over a distance of one kilometre. Source: : https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Tonne-kilometre_(tkm)

Cost item	Cars	LCV	Bus	Pods
Equivalent climate change cost [€/pkm Σpkm]	12.15	---	4.84	0.00
Equivalent climate change cost [€/vkm Σvkm]	18.72	7.92	25.42	0.00
Total Equivalent climate change cost [€]	30.87	7.92	30.26	0.00
Well to tank cost [€/tkm Σtkm]	---	0.71	---	0.00
Well to tank cost [€/pkm Σpkm]	3.91	---	1.75	0.00
Well to tank cost [€/vkm Σvkm]	6.11	2.27	8.98	0.00
Total equivalent Well to tank cost [€]	10.02	2.99	10.73	0.00
Total reduction of CO_2 emissions with the use of pods (%)	100%	100%	100%	--

Table 8. Transport climate change and well-to-tank cost factors (SPROUT EF - D4.1, 2020)

Unit cost item	Car	LCV	Bus	Pod
Climate change cost (€-cent/vkm)	1.9	2.75	8.83	0
Climate change cost (€-cent/pkm)	1.18	---	0.47	0
Climate change cost (€-cent/tkm)	---	3.98	---	0
Well-to-tank cost (€-cent/vkm)	0.62	0.79	3.12	n/a
Well-to-tank cost (€-cent/pkm)	0.38	---	0.17	n/a
Well-to-tank cost (€-cent/tkm)	---	1.15	---	n/a

c) *Environmental quality improvement*

About the last KPI, the overall methodology described in the SPROUT EF was adopted too, using the European External Transport Cost Handbook for reference calculations.

The improvement of environmental quality refers to the gaseous emissions saved in terms of other pollutants, whose genesis is to be found mainly in the thermal combustion processes of traditional engines. The relevant pollutants reported in Handbook on the external costs of transport includes substance as NO_x, PM_{10}, $PM_{2.5}$, CO, NH_3, SO_2, NMVOC.

For self-driving pods, there are few literature data or similar applications: as for climate change emissions, D4.1 assumes the external costs for air pollution equal to 0 for self-driving pods; this means that it is already possible to identify a 100% improvement compared to vehicles with internal combustion engine.

The results are reported in Table 9, while in Table 10 the air pollution costs are shown.

Table 9. Environmental quality improvement between pods and other vehicles (trials).

Cost item	Cars	LCV	Bus	Pods
Equivalent air pollution cost [€/tkm Σtkm]	---	2.90	---	0.00
Equivalent air pollution cost [€/pkm Σpkm]	7.31	---	7.83	0.00
Equivalent air pollution [€/vkm Σvkm]	11.23	9.33	40.85	0.00
Total equivalent air pollution cost [€]	18.55	12.23	48.68	0.00

Cost item	Cars	LCV	Bus	Pods
Total environmental quality improvement with the use of pods (%)	100%	100%	100%	--

Table 10. Air pollution cost factors (SPROUT EF - D4.1, 2020)

Unit cost item	Car	LCV	Bus	Pod
Air pollution cost (€-cent/vkm)	1.9	2.75	8.83	0
Air pollution cost (€-cent/pkm)	1.18	---	0.47	0
Air pollution cost (€-cent/tkm)	---	3.98	---	0

3.5.3 Financial sustainability description

Following the SPROUT EF (D4.1), a "light" financial and cost-benefit analysis was conducted to show the financial and socio-economic feasibility of the proposed transport option in Padua. Following the field tests, the NEXT system is expected to be operated in the urban area encompassing the Fair and the rail/bus station.

The impact assessment was performed based on some preliminary assumptions, including the scenario for which the NEXT system is supposed to absorb around 50% of the current private cars and 100% of the freight transport in the very-last-mile urban network[31].

The financial sustainability of the NEXT system is under the viewpoint of the operator and consists of the following elements:

a) Investment costs;
b) Operational costs;
c) Revenues.

A time horizon of 20 years was considered for the financial return. Eventually, the FNPV (Financial Net Present Value) indicator was used to assess the *overall financial viability.*

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[31] *Since NEXT consists of an Uber/taxi-like urban mobility service for passengers, the assumption seems to be definitely reasonable, or prudent indeed (it implies that half of current passenger traffic still uses private cars). As for freight and logistics, NEXT represents the very-final leg of the urban logistics network, which would operate the total traffic in the selected area.*

a) Investment costs

Investment costs include the expenses to get the necessary fleet of pods as well as well some additional equipment (e.g., the IT platform managing the mobility app).

First, the number of pods necessary to operate the service in the area is calculated. Since the NEXT system represents a mixed passenger-freight urban mobility system, the number of pods must be determined to accommodate both passenger and freight flows. As for passenger flows, we consider the overall ADT (average daily traffic) in the selected area and then the proportion related to passenger flows.

As for the freight transport, we estimated that it absorbs some 6% of overall ADT in the area, according to official data. It is assumed that the NEXT system is going to operate all the freight traffic in the area. In fact, the pod will be implemented within an overall redesign of the (very) last-mile urban logistics network.

The sum of the number of pods necessary to accommodate both passengers and freight flows provided the overall fleet of pods that the operator needs to manage the urban service. On the basis of the financial cost of each pod, we got the overall investment by the operator. Then, from a financial point of view, a constant depreciation charge (or an annual lease) over the time horizon was determined.

Some other investment costs by the operator include the provision of the IT platform integrating various functionalities and apps, and its integration into the existing IT systems of the Municipality. The related costs are estimated and included in the analysis over the time horizon.

b) Operational costs

It was assumed a perspective scenario in which the NEXT system will be self-driving (no need for drivers). Operational costs were then computed by considering the most relevant cost items, e.g., fuel consumption[32].

Additionally, thanks to the operational model and according to some estimations from the literature, it is shown that NEXT (being a modular/on-demand/more extensive system) covers some 60% less distance with respect to a non-modular/ traditional systems on a given O-D (Caros, 2018). The distance parameter employed in the analysis was then adjusted accordingly.

c) Revenues

Revenues from passenger transport were computed by considering that the NEXT system will partially substitute private cars and taxies by being less expensive with respect to the car-ownership business model. A corresponding rate (€-km) was then employed in the analysis[33].

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[32] *maintenance, insurance, etc. items are here considered negligible.*

[33] *In the Fair-railway station urban area no public transport service operates. Thus, main effects from the deployment of NEXT will come from the reduction of private cars and taxies, while urban public transport will not*

The overall revenues were obtained by multiplying the number of passengers using NEXT by such a rate.

As for freight transport, revenues will come by considering an average standard rate to perform the (very) last-mile deliveries of cardboard boxes/parcels. By and large, "price lists" in this field are complicated and depend on a variety of parameters. We considered an official rate (€/parcel) which is applied at national level for standard parcels on local distribution. Such a rate was then multiplied by the number of parcels operated in the area.

Overall financial viability

Aggregate financial results are elaborated considering annual values over a time horizon of 20 years. Operating financial results were computed for each year consisting of the difference between revenues and overall costs (including investments and operational costs). Each annual financial result was then discounted (using a 2% social discounting rate). The aggregate sum of annual discounted financial results provided the Financial Net Present Value (Table 11).

Table 11. Results summary of financial viability analysis.

	Base case	Sensitivity case (+10% total cash outflow)
Total investment cost (IC)	278.756.371 €	306.632.008 €
Total operating cost (OC)	584.650 €	643.115 €
Total cash outflow (A=IC+OC)	279.341.021 €	307.275.123 €
Total cash inflow (revenues) (B)	5.166.739.872 €	5.166.739.872 €
Total net cash inflow (NCI=B-A)	4.887.398.851 €	4.859.464.749 €
Financial Net Present Value	3.995.798.827 €	3.972.960.697 €

Notes:

- Values shown in table are given for a 20-year assessment period.
- For a robust FNPV estimate, two cases were considered, namely a base case and a sensitivity case whereby the total combined investment and operating cost was factored up to 10%.
- A discount rate of 2% was assumed in the calculation of FNPV

be affected negatively. The overall relationship between NEXT and existing public transport, which is a sensitive one, will be discussed when addressing policy-response issues.

3.5.4 Socio-economic sustainability description

In this section, the sustainability of the NEXT system in the selected urban area was assessed from a societal point of view. Cost-benefit analysis methods, principles and techniques were employed. The goal was to assess whether the deployment of the innovative system would ultimately result in net savings rather than losses for the society with respect to the current situation. According to the literature, from the societal viewpoint the relevant elements are:

a) Investment costs[34];
b) Operational costs;
c) Travel time costs.

In a cost-benefit analysis framework, the proposed innovative system must be compared with the existing business as usual scenario (BAU). Differential values then show the overall benefits the society as a whole would enjoy. Technically, we employed a methodology in which the overall socio-economic costs are computed both for the BAU and the "NEXT" scenarios. Annual values were calculated for each scenario and they were subsequently discounted to the baseline year. Finally, aggregated discounted values for each scenario were compared to get the overall benefit of the proposed system.

The baseline scenario (BAU)

a) <u>Investment costs</u>

In the "as is" or BAU scenario no additional investment costs were expected.

b) <u>Operational costs</u>

Operational costs both for private cars and freight traffic were computed with reference to the existing urban mobility scenario. As for private cars, we estimated the (average) v-km traffic values on the selected area and multiplied them with a standard official rate of unit operational cost for cars. The overall annual value was then calculated. Seemingly, the total annual operational costs for freight were computed by considering a standard official rate for vans. Then, overall annual costs for both private cars and freight transport were computed.

c) <u>Travel time costs</u>

Travel time usually represents one of the most important components expressing the "social" benefit of a transport alternative. However, according to the literature, it is relevant for passenger transport only[35]. We computed overall travel time values at annual level.

[34] To be largely seen as overall consumption of resources.
[35] Going through the literature on the role of travel time for freight transport in a cost-benefit analysis, it is generally suggested not to take it into account.

NEXT

a) *Investment costs*

In the NEXT scenario investment costs consisted of both, the costs incurred to operate the NEXT fleet and the costs for the Municipality to deploy suitable infrastructures (both physical and IT) in the urban area to operate the NEXT system.

b) *Operational costs*

Operational costs were first computed for the passenger traffic of private cars still operating in the area; that is, the “remaining” private cars traffic which is supposed not to shift towards the new service. Values were then represented at the annual level.

Subsequently, operational costs for the NEXT vehicles were calculated. According to the operational model and the literature (Caros, 2018) the NEXT system - may cover around 60% less distance concerning a non-modular/individual transport on a same origin-destination. Finally, annual values were estimated.

Overall operational costs, both for private cars and the NEXT system, were computed and referred to the time horizon.

c) *Travel time costs*

Travel time costs were first computed for the passenger traffic of private cars in the area. Overall passenger traffic was multiplied by the (average) travel time in the area and a standard travel time unit value[36]. Next, the overall annual value was estimated.

The same method was then employed for passengers using the NEXT system. In this case, travel time was computed according to shorter distances travelled by a modular/on-demand/extensive system. The overall annual value was then calculated.

Overall travel time costs for both passengers still using private cars and those riding the NEXT system were estimated at annual level and referred to the time horizon.

The cost-benefit aggregate assessment

An aggregate assessment was then elaborated which considered the annual values over a time horizon of 20 years. A “total cost” result was computed for each year and each alternative (baseline and NEXT scenarios). Annual figures were then discounted to the base year (using a 2% social discounting rate). Finally, the discounted total cost figures were summed up to get a single “total cost” or the Economic Net Present Value for each alternative. Then, both ENPVs were compared. The difference represents the aggregate benefits or costs from a societal point of view.

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[36] *From the literature*

Results of socio-economic sustainability analysis (base case and sensitivity case with a 10% increase in the cash outflow are shown in Table 12 and Table 13, respectively.

Table 12. Results summary of socio-economic sustainability analysis. Base case with no increase in the cash outflow

	BAU scenario	NEXT scenario
Total investment cost (IC)	0	278.908.395 €
Total operating cost (OC)	92.786.155 €	34.913.978 €
Total travel time cost (TTC)	696.526.207 €	471.494.663 €
Total cash outflow (A=IC+OC+TTC)	789.312.361 €	785.317.036 €
Total cash inflow (revenues) (B)	0	0
Total net cash inflow (NCI=B-A)	-789.312.361 €	-785.317.036 €
Economic Net Present Value	-645.319.423 €	-642.052.959 €

Notes:

- Values shown in table are given for a 20-year assessment period.
- A discount rate of 2% was assumed in the calculation of ENPV

Table 13. Results summary of socio-economic sustainability analysis. Sensitivity case with a 10% increase in the cash outflow.

	BAU scenario	NEXT scenario
Total investment cost (IC)	-	306.799.235 €
Total operating cost (OC)	102.064.771 €	38.405.376 €
Total travel time cost (TTC)	766.178.828 €	518.644.129 €
Total cash outflow (A=IC+OC+TTC)	868.243.597 €	863.848.740 €
Total cash inflow (revenues) (B)	0	0
Total net cash inflow (NCI=B-A)	-868.243.597 €	-863.848.740 €
Economic Net Present Value	-709.851.366 €	-706.258.254 €

Notes:

- Values shown in table are given for a 20-year assessment period.
- A discount rate of 2% was assumed in the calculation of ENPV

Additional impact assessment benefits

Since the NEXT system represents a modular system allowing a dynamic optimization of available urban capacity, its deployment results in less congestion at the urban level concerning the current urban mobility pattern (Figure 11). In particular, in terms of circulating vehicles, results show that congestion would be some 40% lower.

Figure 11. Street occupation rate: BAU scenario vs NEXT scenario (Source: NEXT)

Some other additional benefits from the deployment of the NEXT system come from improved comfort, including less stress while driving (in a less congested environment) and parking.

The NEXT system also implies a significant improvement of overall urban transport capacity utilization performance. From our simulation one estimates some 50% less capacity – with respect to the current situation - which is necessary to manage the same levels of urban flows.

3.5.5 Environmental impact assessment description

In this section, selected environmental indicators reflecting the external costs are computed according to the SPROUT EF which includes the external transport categories as presented below. The cost factors used for the calculation are presented in Table 14.

Padua compared the current urban mobility pattern with the deployment of the NEXT system in the selected area. Daily values were considered. Table 16 summarizes results from the assessment.

Table 14. Transport environmental cost factors (D4.1, 2020)

Unit cost item	Car

Unit cost item	Car	LCV	Pod
Air pollution cost (€-cent/vkm)	1.14	3.24	0
Noise cost (€-cent/vkm)	0.9	1.1	n/a
Accident cost (€-cent/vkm)	7.2	4.1	n/a
Congestion cost[37] (€-cent/vkm)	6.7	11.6	n/a

3.5.6 Operational feasibility description

According to the SPROUT EF, the NEXT system has relevant technological components, the operational feasibility was assessed by the manufacturer itself following the 'Product Quality Model' and the 'Quality in Use Model' of ISO/IEC 25010. For the operational feasibility assessment three different stakeholders were identified (driver, manufacturer, service operator), setting-up their specific requirements.

Stakeholders requirements

- Driver: The main requirements of the driver are related to the User Interface (UI) optimization to read clearly data important for the driving experience: speed, range, location, camera feed;
- Manufacturer: On the manufacturer side, all the telemetric and the underlying data need to be accessible not only for the vehicle, but especially remotely to make diagnostics and intervene quickly to solve eventual issues;
- Service Operator: For the service operator, having remote access in real time to the position of each unit in the road network, and their remaining battery level/range are the main requirements.

IT system requirements Characteristics of the Product Quality Model

Most of the NEXT system IT requirements are the general ones present in the ISO/IEC 25010 Quality in Use Model:

- functional fitness: the software has been developed internally for the purposes cited before;
- performance or efficiency: as of the trials result the software runs very smoothly on a low consumption embedded windows tablet pc hardware integrated in the vehicles cockpit;
- compatibility: the data files generated by the system can be easily broadcasted and shared in multiple formats to be accessible from many different platforms and integrate APIs;
- usability: the usability, even if tested only by a limited number of target subjects seems to be good, and easily adaptable to specific uses;
- reliability: as of now the data generated by the system, compared, where possible, with externally audited data are giving a good data reliability;

[37] Congestion costs have already been assessed in the previous paragraph. Although guidelines in D 4.1 show that cost factors for self-driving pods are not available, we consider that modular/on-demand services reduce overall travel times.

- safety: this part of the software is not “mission critical” therefore this aspect is not a main concern of this section. The data reliability, eg.: the battery level monitor and motor temperature monitor have been carefully adjusted due to initial unreliability, reaching a very safe and reliable situation. In terms of security and data protection, the system communicates only via encrypted channels through the internet and the data uploaded on the cloud servers can be accessed only from authorized personnel;
- maintainability: the software embedded in each vehicle computer can be easily accessed remotely to be updated OTA, audited, or fixed if necessary;
- portability: the software, as said, is implemented in the vehicles embedded tablet, and the data can be shown remotely in real time.

IT system requirements Characteristics of the Quality in Use Model

- Effectiveness: accuracy and completeness with which users achieve specified goals - the software developed and deployed in this testing phase achieve the goals of being accurate and complete in showcasing the information needed in a clear readable manner for the driver and for the trials information gathering;
- Efficiency: resources expended concerning the accuracy and completeness with which users achieve goals - the accessibility to the information is immediate while in the vehicle, while the information log in cloud can be organized more efficiently. We are working on a comprehensive dashboard and cloud managing system to reduce the effort for non-trained people to access and easily interpret the information;
- Satisfaction: the degree to which user needs are satisfied when a product or system is used in a specific context of the use - within this limited number of drivers and technicians who used the software, the satisfaction is very high. Some level of customization and aesthetical refinements shall be implemented to be more adapt to many different types of drivers.
- Freedom from risk: the degree to which a product or system mitigates the potential risk to economic status, human life, health, or the environment - this software is designed to be clearly readable but not creating distractions to the drivers, therefore limiting the risks associated with it.

Characteristics prioritization

Given the pilot nature of testing consumptions, reliability and adaptability to different uses: passengers and cargo especially, the sensors used in the vehicles have been augmented by additional data to check the parameters guaranteeing these requirements. In particular vibrations, accelerations and noise sensors have been added to check the following parameters:

- Passengers comfort: low noise (on average 76 dB), low vibration and bumps induced accelerations (less than 0,2G on average);

- Cargo stability: low vibrations and limited pitch and roll during braking and cornering to keep the cargo stable (less than 5 degrees pitch and roll in all the tested cornering and braking situations);

The pods, in fact, are equipped with a wide series of complementary sensors in order to reach the requirements described above:

- Speed sensors, temperature sensors, current and voltage sensors in each wheel-motor to monitor consumption and stress status;
- Battery status sensors to monitor discharge curve and efficiency;
- Steering position/angle sensors: to track the driveability;
- GPS: to track the speed independently and to check the route path;
- Acceleration/Vibration sensors to check the internal comfort and stability.

Apps for the users - Travel booking and end-route transfer instructions

Given the low number of the NEXT system units existing at the moment, this app has been developed in a prototype phase, mostly concentrating on the User Interface and User Experience (UI/UX) and less in the backend fleet management system.

The UI/UX has been developed through a demo app that can be used by the passengers/co-tester to get feedback from them about the ease of booking a trip and accessing the vehicle with the QR code ticket.

On the other hand, the main feature of the NEXT system, the end-route transfer from pod to pod while in motion, is the aspect mostly seen as a potential difficulty for passengers/users. For this reason, we have done a virtual reality simulation has been done and tested by a significant number of people (24 people).

Using only a 6 DOF (Degree of Freedom) interactive Virtual Reality headset[38] and two chairs, simulating the vehicles joint situation, we've therefore limited the risks and bureaucratic hurdles associated with testing the pods transfer in motion with many passengers in the real-life prototype. In the VR simulation we had the chance to simulate a totally driverless scenario (Figure 12).

Figure 12. Interactive Virtual Reality simulation.

The VR test showed a typical experience of a passenger in one vehicle, watching a pod that was docking in motion in the front, and app notifications and instructions to move to the unit just docked. The passenger needs to understand the notification and instructions to relocate, physically stand up, walk and sit in the other pod. Within this part of the trials it was gradually tailored the type of notifications and the app UI and general UX to showcase the instructions to transfer to the other pod.

[38] HTC Vive and Asus Windows Mixed reality - https://it.wikipedia.org/wiki/HTC_Vive / https://www.microsoft.com/it-it/p/asus-windows-mixed-reality-headset/9n0plkmm3sc3#activetab=pivot:overviewtab

The final result is that the UX is very understandable even for the older people, for whom we had to add internal audio announcements, seat vibration and internal big monitors showcasing the instructions and destinations of the pods.

App for drivers and pro-users

Within these trials, collaborating with Padua municipality and the mobility operator revealed the requirement of additional app features that we have analysed. They will be implemented in the following months, hopefully having the chance to test them in other contexts:

a) *App for drivers*

It is profoundly different from the app for the user and the operators managing software. This app should provide driver identification, preferences when driving and routing indications, as the majority of the regular existing driver apps.
While most of the info is already embedded in the board computer, the main additional aspect is managing in advance the number of pods to run at a specific time, or in a particular day to fine tune the capacity of the bus and personally managing the role of the pods when detached from the main NEXT-bus-assembly.

b) App for pro-users

This app is the result of the interpretation of a rising critical point and the need of many operators, that is the lack of bus drivers. This pain point viewed in the perspective of having a modular bus, such as NEXT, poses some concept solutions that can be summarized as follows:

- a single NEXT system unit is considered and M1 vehicle[39] when all the passengers are seated and less than 9 + 1 driver in total;
- therefore, when some pods are not in use for the main “NEXT-bus-service” each pod can be available for car-sharing, used by anyone with a B driving licence. Aside from personal use, the bus-like nature of the pod is highly adapted for pooling, therefore a secondary bus service that could be managed semi-automatically via app and pro-users with B licence instead of professional bus-drivers;
- the same thing is very useful when the “NEXT-bus” has to serve a vast area and therefore it is supposed to split to reach many destinations in a shorter time. While this scenario is not an issue for NEXT when level 5 self-driving will be legal, nowadays, it has to be solved in terms of drivers.

Therefore, the pro-user working as driver for the last mile can be a solution for this scenario, driving the single pod in up to a local destination, generally carrying up to 9 passengers (maximum) with B licence. The pod can be parked at the pro-user house so the same pod can

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[39] *According to UNECE (United Nations Economic Commission for Europe) standards, M1 refers to vehicles used for carriage of passengers, comprising not more than eight seats in addition to the driver's = 9.(Larger Than Standard Car e.g.: London Cab / E7 Type Vehicle 8 seat + Driver.)*

be using the following morning to pick up some local passengers and reach the rendezvous point where it attaches to the main NEXT-bus composed of several joined pods.

Although the software parts are still under development, the results are encouraging while of course more fine tuning and customization are in the development pipeline to create a seamless experience from the driver to the passengers and the fleet management operators. Within these trials, it has been highlighted the requirement of having also additional app features.

3.6 Outcomes

Some remarkable, noteworthy considerations can be done both from real tests and scenario simulation assessment.

Real test was really important to test the performance of the vehicle in a real, traffic environment. First part of trails was dedicated to set-up of the vehicles and performance evaluation of steering, braking, traction, speed and handling.

Alongside the standard operating parameters and vehicle set-up, special attention was paid in verifying the system's electrical consumption. Consumption was measured under different load conditions, as well as under different temperature conditions.

For a single pod with different load conditions, most of the consumption data recorded varies from 20,0 to 35,0 kWh/100 km.

The recorded data showed values slightly higher than the theoretical ones.

It was also verified that two vehicles combined consume less than traveling separately, confirming the theoretical predictions. Technically, the fact can be associated with the reduction of turbulence and the better aerodynamic profile of two vehicles joined together compared to a single one. Furthermore, for short distances the head pod can also act as a tow for the other pod, compensating for any problems of the latter.

In terms of modularity, the trials were fundamental to test the coupling and detachment system during the race. The result was successful also during the movement.

Besides these technical considerations, some strategic “macro-outcomes” can be rather clearly envisaged from scenario simulation assessment.

3.6.1 Pilot objectives assessment results

The trials made it possible to obtain the data necessary to verify the achievement of the objectives defined by the target values of the Key Performance Indicators for sustainability assessment of the pilots’ impact (see section 3.5.2).

The assessment of the proposed solution is largely positive, highlighting relevant results in terms of sustainability and efficiency. About reduction of traditional fuels consumption, the electric pods demonstrated its efficiency compared to means of passengers’/freight transport with traditional fuel (private cars, LCV, buses), but showed its competitiveness also with electric ones (private cars, bus). In the following table, the main results are resumed.

In terms of CO_2 emissions and improvement of environment quality, the initial assumptions were confirmed, guaranteeing the possibility of saving 100% CO_2 emissions linked to the use of vehicles alone and production of gaseous pollutants.

Table 15. Key Performance indicators in scope of sustainability assessment of the pilots' impacts.

Key Performance Indicator	Target	Camparison and value	Comments	Outcome
Reduction of traditional fuel consumption using pods	-3%	Bus – Diesel: 84.82 % Bus – Hybrid/Diesel: 81.15 % Bus – CNG: 87.11 % Bus – Electric: 46.35 %	Comparison between 2 pods and 1 bus (trials)	Target fully achieved
		Bus – Diesel: 77.22% Bus – Hybrid/Diesel: 71.72% Bus – CNG: 80.67 % Bus – Electric: 19.52%	Comparison between 3 pods and 1 bus (average daily estimated demand)	Target fully achieved
		Private cars – Diesel: 83.36% Private cars - Electric: 52.33%	Considered occupancy rate: 1.2	Target fully achieved
		LCV – Diesel: 44.75% LCV – CNG: 48.45%	Worst case: comparison between NEXT system (2 pods) and LCVs (trials)	Target fully achieved
Reduction of CO_2 emissions using pods	-4%	Bus – Diesel/CNG: 100%	Comparison between 1 pod and 1 bus	Target fully achieved
		Private cars – Diesel: 100%	Considered occupancy rate: 1.2	Target fully achieved
Environmental quality improvement (air pollution)	9%	Bus – Diesel/CNG: 100%		Target fully achieved
		Private cars – Diesel: 100%		Target fully achieved
		LCV – Diesel/CNG: 100%		Target fully achieved

3.6.2 Financial assessment results

First, revenues from freight definitely represent the largest proportion of overall financial outcomes.

Indeed, the compensation between financial results from passengers and those from freight eventually ensures an overall robust financial sustainability of the NEXT system. Remarkably, such a compensation made it possible by the innovation deployed by the NEXT system, both in terms of vehicle design and overall system. In the analysis, this clearly emerged even if one assumes the pod operates a limited share of the freight market in the area.

3.6.3 Socio-economic assessment results

From a cost-benefit assessment, the NEXT system realizes very significant savings in terms of travel times and operational costs, which counterbalance the costs of initial asset investments. The net social outcomes turn out be relatively positive.

3.6.4 Environmental impact assessment

From an environmental point of view, the NEXT sytem realizes very significant overall improvements, especially if compared to the current scenario. Results from trial and KPIs analysis are confirming the main outcomes from simulation scenario assessment, making it clear how the application of the scenario thus described allows to significantly improve the environmental performance of current transport model businesses systems. Results from environmental impact assessment are summarized here (Table 16).

Table 16. Environmental impact assessment for wider area (comparison between BAU and NEXT scenario).

Cost item	BAU scenario			NEXT scenario			% change
	Cars	LCV	Total	Cars	Pods	Total	
Climate change cost (€/year)	734	71	805	367	0	367	-54%
Well-to-tank cost (€/year)	239	20	260	120	0	120	-54%
Air pollution cost (€/year)	440	83	524	220	0	220	-58%
Noise cost (€/year)	348	28	376	174	0	174	-54%

Cost item	BAU scenario			NEXT scenario			% change
	Cars	LCV	Total	Cars	Pods	Total	
Accident cost[40] (€/year)	2,781	106	2,887	1,391	83	1,474	-49%
Congestion cost (€/year)	2,588	299	2,887	1,294	0	1,294	-55%

3.6.5 Operational feasibility

For operational feasibility, refers to section 3.5.6 (Testing and data collection activities – operational feasibility description).

3.7 Process evaluation

3.7.1 Barriers and drivers

A factor that has contributed significantly in postponing the implementation of the processes was the completion of the administrative procedure. Given the experimental nature of the action, it was necessary to find coordination with the administrative offices. However, this aspect made it possible to provide the opportunity to develop a specific know-how internally within the Sector, in the field of administrative procedures for the assignment of non-conventional services, such as testing an experimental vehicle.

A potential barrier that in the initial predictions could be more complex to overcome was the time relating to obtaining the test plate for an experimental vehicle. However, it turned out to be a not so demanding hurdle, and there were no particular problems in obtaining the document from the Ministry of Transport, since the manufacturer already obtained a pre-technical assessment for the pods.

The realization of the trials in Longhin street required a further indirect economic effort from the Municipality, as it was necessary to give up some paid parking spaces during the test phase.

Concerning the regulatory aspect of the autonomous driving, the circulation on the road of vehicles without a driver is currently not permitted. At the moment it is not possible to hypothesize when a change of regulation will take place. It was therefore not possible to experiment the driverless guide during the trials, however a total driverless scenario was simulated through Virtual Reality experience.

[40] According to the literature, it is assumed that autonomous vehicles result 50% safer than non-AVs at the early market penetration.

The possibility of dynamically combining the transport of passengers and goods in the very-last mile logistic would allow a substantial increase in mutual efficiency, in environmental terms, in reducing traffic and transport times, and then reduced travel costs.

An obstacle in this sense is to be found in the substantial difference of stakeholders needs and the different regulatory framework between passengers' transport and freight.

The system does not require any infrastructure, so it can be easily implemented in similar urban contexts. Due to the peculiarity of the coupling mechanism, the precautions to pay attention to is that the system should be used on smooth and well-maintained roads, and in a road network with regular elevation profiles.

Nevertheless, the implementation of this transport model gives the opportunity to generate positive social outcomes and improves users' accessibility and city's liveability.

3.7.2 Learnings and findings

Trials and simulations confirmed how the real strength of the tested system is not only the potential autonomous driving (which, however, is currently not allowed by law, as explained in the previous chapter), but the modularity and flexibility of the transport system compared to traditional means of transport. The possibility to overcome the static nature of the traditional transport allowing to dynamically adapt it to the real-time demand, create the conditions to generate high transport efficiency; these benefits are evident especially in an urban environment.

One great innovation is the possibility of eliminating the traffic congestion that traditional transport systems generate by their nature (the current average occupancy rate for private car is about 1.2); this means that if the innovative transport system can improve efficiency and replace empty or half-empty traveling vehicles, it results in traffic congestion reduction, literally freeing-up public space on the street.

Undoubtedly, additional benefits can derive from if freight and passenger transport integration, even if, on the other hand, it is necessary to find a balance between different needs. In order to make more feasible this process, new public-private partnership schemes should be sought for the inclusion of new business schemes.

Nonetheless, the experimentation highlighted how it is necessary, a high competence and know-how, both technical and administrative including the public Body in charge of the management and coordination, in order to implement such innovative technological solutions.

From a technical point of view, electricity consumption of the pods proved to be interesting, even if, compared to theory, it was slightly higher than expected. An aspect to be investigated in the future is also the variation in consumption in relation to the number of vehicles connected in series, which from a preliminary analysis, also on a theoretical base, allows to further improve electric consumptions efficiency.

During the tests the usability of the software part of the NEXT transport system was also tested with the support of VR simulation, even if it is still under development; it was highlighted how the user experience is particularly simply and understandable even for the older people.

3.8 Conclusion

To summarize overall results, preliminary assumptions were that potential innovation comes at a cost: rather expensive asset should be deployed by public and private stakeholders to ultimately get important social and environmental benefits. In other words, a trade-off scenario would be in place initially. Instead, the impact assessment analysis has shown that this is not necessarily true, in so far as the NEXT system:

- consists of a financially viable business model, where additional asset investments are counterbalanced by less operational costs and significant revenues, especially from freight logistics.
- generates positive social outcomes and terrific environmental benefits.
- As for the socio-economic assessment, the following conclusions can be drawn although the NEXT system requires ad-hoc investment costs, it allows significant savings in the operational costs and travel times with respect to the current urban mobility scenario;
- the annual socio-economic results turn out to be better in the NEXT scenario with respect to the current urban mobility pattern. Meaning that although additional resources (in terms of fixed costs) are needed to deploy the innovative system, significant operational savings are obtained offsetting investment costs over the time horizon: as a result, the aggregate resource consumption in the NEXT scenario is lower with respect to the current mobility scenario. Eventually, the Economic Net Present Value for the NEXT system turns out to be relatively higher than for the BAU scenario.
- autonomous, driverless driving is still far from to be realized; however, since the coupling system was tested during trials, and a totally driverless scenario has been tested with VR simulation, these trials can be considered as a preliminary step towards the envisioned autonomous urban mobility;
- as regarding the passenger transport, from the simulations carried out, the system appears to be very promising in terms of user experience, even for elder people.

In conclusion, these outputs from trials suggested some development policies for harnessing the impact of mobility solution, taking in account the needs of the SUMP, and in other considering the current context of the city of Padua. The identified policy response concerns the integration of the Next system with the public transport system (PM 1) favouring the modal shift, and the development of innovative solutions to support logistics (PM 2).
For the implementation and management of these innovative but complex policies, complementary actions have been identified as facilitators: PM3 (New function / office dedicated to the development and management of freight logistics and Local Public Transport) and PM4 (Set-up of specific procurement procedures for innovative mobility solution. All of these have been deeply analysed in T4.5 (see Chapter **5**).

4 T4.4 Formulation and priotitisation of alternative policy responses

4.1 Introduction

The third stage of the SPROUT project is the setup and implementation of the pilots in each of the pilot cities. The aim of Task 4.4 is to develop, based on the outcomes of the pilots and the operational assessment (Task 4.3), a list of alternative policy responses for each of the 5 pilot cities. The alternative policy responses will then be prioritized for each pilot city with the help of Multi-Actor, Multi-Criteria Analysis (MAMCA) [11]. This will allow the identification of synergies and conflicts between different stakeholder groups, to show the (lack of) consensus for the proposed policy alternatives.

Because of the COVID-19-pandemic and the various lockdowns in the Fall of 2020, the implementation of the tasks preceding Task 4.4, and most importantly the implementation of the pilots, was delayed. A traditional MAMCA departs from a problem identified, and formulates alternative solutions to a problem. These alternative solutions are then evaluated by different stakeholder groups to show which alternative has the highest consensus among stakeholders. So as the first step of a MAMCA is a problem identification phase, it was difficult for the pilot cities to come to a problem identification with regards to the pilot due to it not yet being (fully) implemented. This made it difficult to distinguish several potential alternative policy responses. If more than shows the trade-offs all stakeholders have to make. The results of the MAMCA can then start a discussion among stakeholders to find a consensus.

4.2.2 Stakeholder-Based Impact Scoring

Stakeholder-Based Impact Scoring (SIS) is a modified MAMCA that provides a weighted impact evaluation of policy options (te Boveldt, 2019). This impact evaluation considers the objectives of stakeholders that impact, or are impacted by, the problem described, thereby quantifying the benefits and burdens of project alternatives. It was developed for problems that cannot be addressed through the ranking algorithms of other MCA methods. The SIS method contains two fundamental aspects:

- *Non-compensability*: the principle of non-compensability entails that positive and negative impacts are accounted for separately, and do not cancel each other out.
- *Non-relativity*: if there are multiple alternatives, these alternatives are not compared to each other, but to a baseline scenario.

SIS steps

The application of SIS involves seven different steps:

1. Formulation of the problem and identification of alternative solutions. In order to perform a SIS, there should minimally be one baseline, and one alternative to the baseline.
2. Stakeholder identification. The stakeholders that impact, or are impacted by the project need to be identified.
3. Formulation of stakeholder criteria. These criteria represent the objectives of the stakeholder with regards to the problem and the identified alternative solutions.
4. The effects of the alternative in terms of each criterion when compared to the baseline scenario are assessed through a performance score ranging from +1 (very positive) to -1 (very negative).
5. Attribution of weights to their criteria by the stakeholders, to evaluate the relative importance of each of the criteria.
6. Impact score calculation of each alternative for each criterion, for each stakeholder. This is done by multiplying the weight of a criterion, as attributed in step 5, with the impact, as assessed in step 4. This impact score will be either positive or negative, and will fall between +1 and -1.
7. Calculation of the aggregate positive impacts and of the aggregate negative impacts.

4.3 Application of SIS within SPROUT

The application of SIS within the SPROUT project followed the steps described in the previous section. It was applied to one use case per pilot city. The following section describes steps 1-5 more in detail. These steps make up the preliminary work of SIS, i.e. the gathering of all necessary input for the analysis. Section 5 (Results) describes steps 6 and 7, i.e. the results of the analysis, for each pilot city.

4.3.1 Formulation of problem and identification of alternatives

The first step in the SIS is the identification of the problem and the alternative solutions. To do this, a template was sent out to all pilot cities containing questions with regards to issues they had identified with their pilots. This was filled out and sent back to VUB. The goal was for the proposed policy alternatives to be very specific. The sections below give an overview of the identified problems and proposed policy solutions for Padua.

Table 17. T4.3: Padua identified problems and proposed solutions.

Problem encountered	Interferences between pods and other vehicles
	The deployment of the NEXT system as "regular" mobility service in the wider urban area
	The possibility that the so-defined mobility service does not match the transport demand
	The integration of the NEXT system with the existing urban public transport network
Possible Solutions	Creating reserved lanes for pods. Reviewing the current traffic decrees that define reserved lanes in the urban areas
	Designing, developing and deploying NEXT as regular mobility service (including timetable, tickets, etc)
	See previous point. The planning of the future service should include a careful analysis of the evolving demand. Defining routes, timetable and fares based on peak demand at the future launch of the service. Effective communication campaign.
	Integrating NEXT into the urban public transport network

4.3.2 Stakeholder identification

In order to come to a weighted evaluation that reflects the preferences of stakeholders, it was necessary to identify the stakeholders to involve in the SIS. The stakeholders to involve are the ones that are impacted, or can impact, the pilot project of the city of Padua. To do this, the pilot partners were asked to contact stakeholders that had been previously involved in the scenario building workshops of WP3. The participating stakeholders in WP3, in turn, were the result of the stakeholder identification done in Task 2.3, 'Urban Mobility Transition Drivers'. After asking the cities to contact some more stakeholders than the ones present for the WP3 workshop, the full overview of participating stakeholders per city is described in the following paragraph:

- APS Holding S.p.A. (city parking, car sharing, and shared mobility services provider);
- BIV S.p.A. (Public transport operator);
- Padua municipality- Environmental department;
- Padua local police;
- Padua Fair;
- Padua municipality- mobility department;

- Cityporto (Logistics operator).

4.3.3 Formulation of stakeholder criteria

The third step in SIS is the identification of the criteria for each stakeholder group. The key question for the formulation of criteria is the following: *what distinguishes a good project alternative from a bad one?* Stakeholders therefore reflect on what their objectives are with the implementation of a project. These criteria can be both positive and negative, and examples include traffic safety, cost, or accessibility. Within SPROUT, the alternatives that stakeholders were asked to reflect upon were the pilot situation without policy changes, as well as the pilot situation with the proposed policy alternatives.

In order to collect stakeholder criteria, an email template was set up for all pilot cities. This email, that can be found in Annex 1, contains a short description of the pilot without policy changes, and a short description of the pilot including the policy alternatives. The stakeholders were asked to come up with two to six criteria that would make the implementation of the pilot situation with policy changes successful, in their eyes. This step required a lot of exchanges with the city, as it was not always clear from the beginning what was understood by 'criteria'. After two or three rounds however, a consolidated list of criteria for each stakeholder group was obtained.

An overview of the criteria per stakeholder group for Padua can be found below.

- APS Holding S.p.A. (city parking, car sharing, and shared mobility services provider);
    - Reduction of urban air pollution
    - Service integration/connectivity
    - Accessibility
- BIV S.p.A. (Public transport operator);
    - Financial feasibility
    - Impacts on the other transport systems
    - Integration with public transport
    - Traffic reduction
    - Reduction of urban air pollution
    - Reduction of greenhouse gas emissions
- Padua municipality- Environmental department;
    - Reduction in private vehicle use
    - Reduction of urban air pollution
    - Reduction of greenhouse gas emissions
- Padua local police;
    - Increased public transport network offering
    - Integration with other transport systems
- Padua Fair;
    - Service integration/connectivity
    - Accessibility
- Padua municipality- mobility department;
    - Reduction of urban air pollution
    - Traffic reduction
    - Accessibility

- Cityporto (Logistics operator).
    - Very-last-mile accessibility for freight
    - Traffic reduction

4.3.4 Expert evaluation

After the identification of stakeholder criteria, the next step of the SIS is an evaluation of policy intervention on the impact of the policy interventions on these criteria by experts. In this step, the effects of the pilot with policy implementation are compared to the pilot without policy changes for each of the criteria. The alternative is given a performance score on a 7-point scale, ranging from ‘Very negative’ to ‘Very positive’. The key question to answer in this step is the following: in terms of each criterion, *what are the impacts if the alternative pilot with policy changes were implemented?*

The scientific partners in each of the pilot cities were asked to evaluate the alternative in terms of their stakeholders’ criteria. Annex 1 contains the email with explanation that was sent out to the scientific partners. If the experts had any additional information or justification for their evaluation, they were asked to add this to the evaluation form as well. The expert evaluations were done between February 22 and April 28, 2021. Below, the results of each expert evaluation are shown.

Table 18 T4.4 Experts evaluation.

Criteria	Scenario 1: current situation	Scenario 2: pilot compared to current situation	Performance score of the pilot compared to current situation	Justification for the chosen evaluation
Reduction of urban air pollution	Deployment of the NEXT modular transport system that combines freight and personal mobility.	Integration of the NEXT modular transport system as a regular freight / passenger transport service, extended to a large part of the urban area, with timetables, ticketing and fare structure.	positive	With the integrated service a larger share of passenger and freight volume – compared to Scenario 1 – is expected to use the system, hence an improvement of air quality will result from road congestion mitigation (e.g., reduction of travel times). Also, NEXT system is deployed through electric pods and takes up less road space to operate compared to conventional transport systems.
Integration of services/connectivity			very positive	A capillary service paves the way to a better integration among transport services and a more connected network, thus resulting in a seamless door to door travel for end users.
Accessibility			very positive	A much larger impact on urban-level accessibility – from a purely territorial/geographical viewpoint – is expected for Scenario 2, that is an enhanced ability for all types of travellers to reach destinations within the urban area in an easier and more convenient way.
Financial feasibility			negative	Higher financial impact in terms of investment and operating costs to operate an integrated and larger scale service.

Criteria	Scenario 1: current situation	Scenario 2: pilot compared to current situation	Performance score of the pilot compared to current situation	Justification for the chosen evaluation
Impacts on other transport systems			positive	See comments concerning reduction of vehicle use and PT
Integration with public transport			very positive	See second last comment
Traffic reduction			positive	See first comment – mitigation of road-based traffic congestion (i.e., reduction of travel times).
Reduction in greenhouse gas emissions			positive	With the integrated service a larger share of passenger and freight volume – compared to Scenario 1 – is expected to use the system, hence mitigation of global warming effects from transport activity will result from congestion mitigation.
Reduction in private vehicle use			positive	A greater share of private car-borne traffic is expected to shift towards NEXT service to meet their everyday travel needs compared to Scenario 1.
Increased public transport network offering			very positive	A more connected and integrated service (within PT network) delivers a wider PT offering for travellers thanks to the synchronisation among

Criteria	Scenario 1: current situation	Scenario 2: pilot compared to current situation	Performance score of the pilot compared to current situation	Justification for the chosen evaluation
				local transport services, integrated ticketing and coordinated fare structure.
Integration with other transport systems			very positive	Greater potential in Scenario 2 for integration given the extended reach of the service, resulting from a higher degree of connectivity of the overall transport network

4.4 Criteria weighting by stakeholders

The next step in a SIS evaluation is the attribution of weights by the stakeholders to their criteria. This shows the relative importance that the stakeholders attach to each criterion. To evaluate this, a survey was set up to be distributed to all stakeholders within each of the pilot cities. The survey was set up by VUB, and can be found in Annex 1. To facilitate the process for the stakeholders, it was decided to translate the surveys in the local language. This was done by each pilot city. The translation of the surveys was done between April 30 and May 18, 2021, and the surveys were launched on May 19, 2021. The survey for Padua was launched later, on May 27, as the city asked to include an additional stakeholder group that was not included at the beginning of the SIS analysis. To include the new stakeholder group (Cityporto), steps 3 and 4 of the analysis had to be redone, delaying the launch of the survey. All surveys were closed by July 8, 2021.

4.5 Results

This section provides the result of the SIS analysis for all pilot cities (steps 6 and 7).

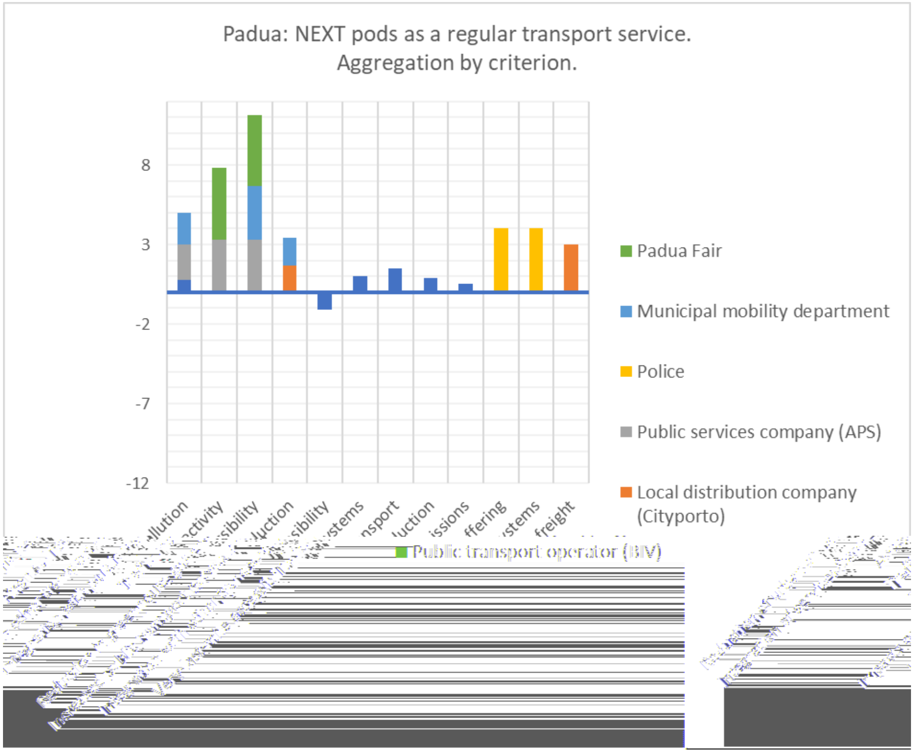

Figure 13. Regulations for NEXT pods. Aggregation by criterion.

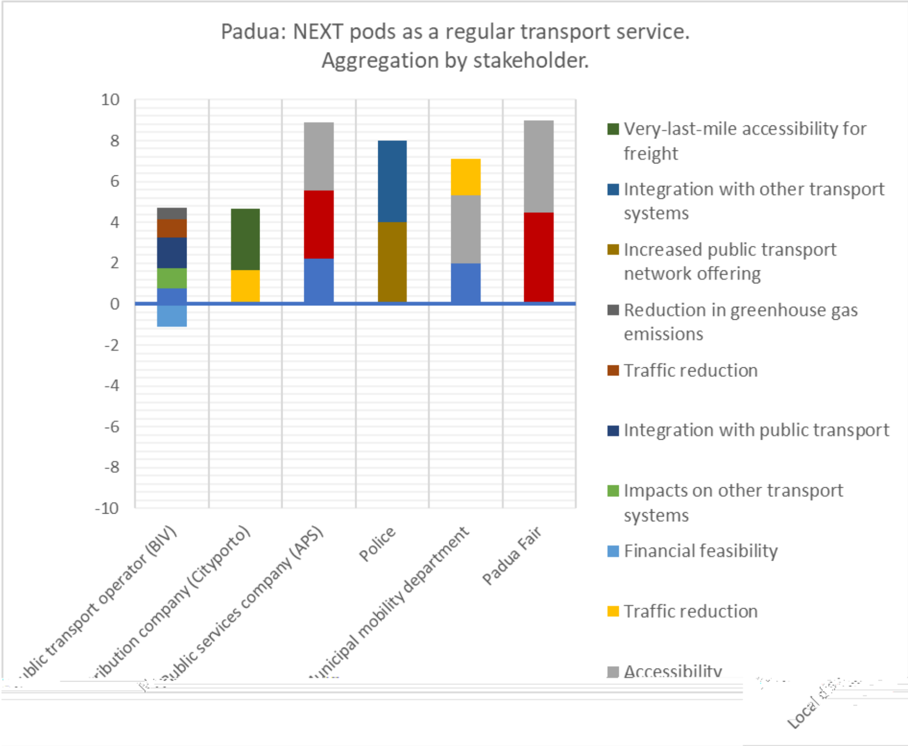

Figure 14. Regulations for NEXT pods. Aggregation by stakeholder.

Figure 13 and Figure 14 show the expected negative and positive impacts of the Padua pilot as compared to the current situation. While the current situation (deployment of the NEXT modular transport system that combines freight and personal mobility) is taken as a baseline, the pilot involves the integration of the NEXT modular transport system as a regular freight / passenger transport service, extended to a large part of the urban area, with timetables, ticketing and fare structure.

As can be seen in Figure 13, ‘accessibility’ and ‘integration of services/connectivity’ are expected to be the most important positive impacts, followed by the reduction in air pollution, increased public transport network offer, integration with other systems and the very last-mile accessibility of freight. The only minor negative impact is ‘financial feasibility’.

Figure 14 shows the distribution of positive and negative impacts over the different stakeholders. Here we see that for all stakeholders the expected impacts are largely positive, in particular for APS and Padua Fair. The only negative impact, financial feasibility, is on account of the public transport operator (BIV).

4.6 Conclusion

Compared to the pilot as it is, the integration of the NEXT modular pods as a regular passenger and freight transport system is expected to have mainly positive impact. This expected positive impact can be seen across all criteria and is especially strong for APS and for Padua Fair. Only financial feasibility is expected to have a negative impact, for BIV. The strongest positive impact is expected for the criteria of ‘accessibility’ and ‘integration of services/connectivity’.

5 T4.5 City-specific policies for harnessing the impact of new mobility solutions

5.1 Introduction

The objective of this task is to compile the information to assess the feasibility and user acceptance of introducing the predefined set of policy responses on a limited scale (city-specific). This task uses some information from the previous tasks 4.4, more specifically the set of stakeholders and preferred set of policy responses. About the latter, by the time the T4.4 was implemented the pilots were not able to distinguish several potential alternative policy responses that were mutually exclusive (see section 4), therefore prior this exercise additional policy responses were identified by the methodological partners (VUB, CERTH, ZLC) and shared with the pilots. Then they validated and fine-tuned to better address pilots' characteristics. The result of this task is the combination of champion city-specific policy responses or city-led policy response.

5.2 Methodology

Implementation of effective policy responses that will harness the benefits of the emerging mobility solutions represents a challenging process which can be viewed as a knowledge quest and creation process within an urban stakeholder's network requiring the reduction of uncertainty. Uncertainty is particularly high for those measures that include new science, technology, markets, regulatory frameworks. The types of uncertainties can be categorized as being concerned with technological feasibility, organizational capability and social acceptability.

In order to minimize the uncertainty in implementation of a policy measure and at the same time to maximize its effectiveness, the Task 4.5 will address three main research questions per each pilot:

1. How to assess the policies implementation feasibility?
2. How to assess the policies user acceptance?
3. How to determine threshold user acceptance and feasibility values for selecting policy responses?

5.2.1 Implementation feasibility

About the first question, the policy implementation feasibility will be addressed by the following steps:

1. Selection of the relevant feasibility criteria;
2. Ranking the relevant feasibility criteria by the stakeholders and determining the most critical criteria;
3. Detailed analysis of the most critical feasibility criteria in order to identify potential infeasibilities;
4. Determining a set of actions to avoid the risk of infeasibility during the implementation of a policy measure.

The set of feasibility criteria will include the following dimensions:

1. Technical feasibility;
2. Financial feasibility;
3. Political feasibility;
4. Administrative feasibility

Detailed explanation of the feasibility criteria included within each of these dimensions are explained below.

1. ***Technical feasibility*** dimension includes following feasibility criteria:
   - Effectiveness: the extent to which the alternative policy measure will reach the goals set in the project statement;
   - Feasibility of implementation: Under this category will be assessed whether technology exists or is readily available to implement an alternative policy measure.
2. ***Financial dimens*** [illegible]

feasibility criteria based on a 5-tier scale (from 'very low' to 'very high'). Those measures with a low feasibility rating (*less than 2.5 on a 1-5 scale*) against the specific feasibility criteria will be the subject of additional analysis in order to reveal eventual risks of implementation as well as mitigation strategies.

5.2.2 User acceptance

User acceptance includes different indications based on attitudes, believes and norms of individuals that are directly or indirectly affected by a proposed policy measure. More precisely, the user acceptance (social feasibility) relates to the question how will potential users act and react if a certain policy response is implemented. Following main indicators of user acceptance will be used for analysis (this list may be extended depending on the specific policy measure):

1. Personal and social aims;
2. Problem perception;
3. Information and knowledge about;
4. Perceived efficiency;
5. Satisfaction;
6. Usefulness;
7. Affordability.

Detailed explanation of the user acceptance criteria is given below.

1. ***Personal and social aims***. In general, a higher valuation of common social or personal aims will be positively related to acceptability. Users of the service who perceive a proposed policy measure as compliant to their own preferences will express a higher acceptability and acceptance rate.
2. ***Problem perception***. The extent to which a problem corresponding to a specific policy measure is a necessary indication in defining of user acceptance. In general, the high problem awareness will lead to an increased willingness to accept proposed policy measures for the perceived problems. More precisely, in order to assess the user acceptance from the perspective of "problem perception", the respondents will be asked to rank the importance of different factors (perceived as a consequence of non-applying a specific policy measure). It can be assumed that the higher a specific factor is ranked; the more users will perceive that factor as a problem in society and therefore the higher weight will be given to a corresponding policy measure.
3. ***Information and knowledge about***. The level of acceptance can depend on how well informed the potential users are about a specific urban mobility problem (corresponding to a specific policy measure) and about the new policy measure that can be introduced to reduce/eliminate the consequences of the problem. The better the people are informed the higher acceptance will be. During the questionnaire design, from the perspective of this dimension, the distinction will be made between whether a person feels well or poorly informed or whether he/she is actually well or badly informed. In other words, the difference between objective knowledge and the subjective assessment of the own knowledge must be made.
4. ***The perceived efficiency*** indicates the possible benefits potential users expect from a concrete policy measure as compared to other measures. More precisely, respondents will need to evaluate how they perceive different policy measures and how they evaluate a

specific policy measure as compared to other alternative measures. The recognition of corresponding problem and the information potential users have will influence the rate of efficiency. If the users note a specific policy measure as more efficient a higher support to that measure can be possible.

5. ***Satisfaction*** will result in a degree how the policy measure solves the users' needs. Satisfaction will be given by evaluation of the policy measure as pleasant/unpleasant, irritating/likeable, undesirable/desirable.
6. ***Usefulness*** is related how the policy measure will support the users' objectives and their transport service use behavior. A potential user can find a specific policy measure effective but not for his own travelling needs. Usefulness is stated as the degree to which a person believes that implementing a specific policy measure will enhance his/her performance.
7. ***Affordability*** is related to socio-economic status of users. It may be assumed that the socio-economic status will affect the user acceptance of a specific policy measure. In cases of some policy measures it can be expected that low income groups should be more opposed to its acceptance. The willingness to pay will depend on income, and it can be assumed that higher willingness will imply a higher acceptance of some policy measures.

User acceptance of policy measures will be estimated based on the responses of experts which will rate each policy measure against each indicator of user acceptance by using the a 5-tier scale (from 'very low' to 'very high'). Those measures that have low user acceptance rate (*less than 2.5 on a 1-5 scale*) against the specific indicator will be the subject of additional analysis. Additional analysis will result in a strategy for improving the user acceptance of a specific policy measure against a "critical" user acceptance indicator.

5.3 Application to Padua pilot

According to the methodology explained in chapter 5.2, the set of alternative policy measures was defined and the survey was designed (added as the Annex 3) to collect the opinions related to the most critical aspects of policy implementation feasibility and user acceptance.

5.3.1 Set of alternative policy responses and stakeholders involved and role

The relevant stakeholders participating in this use case are listed below.

- APS Holding S.p.A. (city parking, car sharing, and shared mobility services provider);
- BIV S.p.A. (Public transport operator);
- Padua Municipality – Environment Department;
- Padua Local Police;
- Padua Fair;
- Padua Municipality - Mobility Department;
- Padua Municipality – Public Works Department;
- Cityporto (Logistics Operator).

Table 19 Alternative policy measures (PM): stakeholders involved and role.

Alternative policy response	Stakeholders involved and role
PM1 Integration of NEXT with Local Public Transport and development of modal shift	Padua Municipality (Administration): political road-map, funding Padua Municipality – Mobility dept.: advisor, regulatory aspects APS Holding S.p.A., BIV S.p.A.: direct beneficiary Local Police: support for traffic and safety issues Padua Municipality – Public Works Dept., Environment Dept., Padua Fair: indirect beneficiary
PM2: Development of innovative solutions as support for logistic operators	Padua Municipality (Administration): political road-map, funding Padua Municipality – Mobility Dept.: regulatory aspects Cityporto: advisor, direct beneficiary Padua Fair: advisor, potential direct beneficiary Local Police: support for traffic and safety issues Padua Municipality – Public Works Dept., Environment Dept.: indirect beneficiary
PM3: New function / office dedicated to the development and management of freight logistics and Local Public Transport	Padua Municipality (Administration): political decision, funding Padua Municipality – Mobility Dept.: direct beneficiary Cityporto, B.I.V. S.p.A, APS Holding S.p.A.: advisor, direct beneficiary Padua Fair: direct beneficiary Local Police: support as intersector advisor Padua Municipality – Public Works Dept., Environment Dept.: indirect beneficiary
PM4: Set-up of specific procurement procedures for innovative mobility solution	Padua Municipality (Administration): political decision, funding Padua Municipality – Mobility Sector: direct beneficiary Cityporto, B.I.V. S.p.A., APS Holding S.p.A.: advisor, direct beneficiary Padua Fair: indirect beneficiary

5.3.2 Set of alternative policy responses and interrelationships

Table 20 shows the most preferred policy measures included in the feasibility assessment and the interrelationship with the mobility solution:

Table 20 Alternative policy measures (PM) and interrelationships.

	PM1 Integration of NEXT with Local Public Transport and development of modal shift	PM2: Development of innovative solutions as support for logistic operators	PM3: New function / office dedicated to the development and management of freight logistics and Local Public Transport	PM4: Set-up of specific procurement procedures for innovative mobility solution
PM1 Integration of NEXT with Local Public Transport and development of modal shift	X	The implementation of the corresponding PM2 can increase the benefits to passenger transport if the integration will be put in place.	The integration of NEXT with existing services must necessarily pass through an analysis of the demand, and of the transport needs. It is necessary to manage and coordinate a sixed system (traditional lines) with a flexible system (the NEXT).	The integration with Local public Transport requires the development of new updated procedures that include innovations in terms of transport mobility, and improve the efficiency of the synergy between public and private.
PM2: Development of innovative solutions as support for logistic operators	The implementation of the corresponding PM 1 can increase the benefits for freight if the integration in the city centre or in "last-mile" will be put in place.	X	The creation of a dedicated office is aimed at facilitating the implementation of the PM 2. The management of logistical aspects requires specialized resources and a robust know-how, both in specific technical (logistics) and economic-administrative subjects.	The development of innovative solutions for logistic operators requires the development of new updated procedures that include innovations in terms of transport mobility, and improve the synergy between public and private.
PM3: New function / office dedicated to the development and management of freight logistics and Local Public Transport	During the discussion with the stakeholders it emerged that the integration of NEXT with the Public Transport requires resources, skills, know-how, data management and relationships between the various subjects. This highlights the need	The development of PM2 requires resources, skills, know-how, data management and relationships between the various subjects. This highlights the need for coordination, to be	X	The definition and implementation of specific procurement procedures requires specialized resources and a robust know-how, both in technical and economic-administrative matters.

	PM1 Integration of NEXT with Local Public Transport and development of modal shift	PM2: Development of innovative solutions as support for logistic operators	PM3: New function / office dedicated to the development and management of freight logistics and Local Public Transport	PM4: Set-up of specific procurement procedures for innovative mobility solution
	for coordination, to be implemented with a dedicated office.	implemented with a dedicated office.		This process is optimized if a dedicated office is set up.
PM4: Set-up of specific procurement procedures for innovative mobility solution	The integration with Local public Transport requires the development of new updated procedures that include innovations in terms of transport mobility, and improves the synergy between public and private.	The implementation of innovative solutions for logistic operators requires the development of new updated procedures that include innovations in terms of transport mobility, and improve the efficiency of the synergy between public and private.	Staff /personnel with relevant skills, know-how and competences can dedicate the right amount of time to define specific procurement procedures for innovative mobility solutions.	X

5.3.3 Implementation feasibility

The survey' questions (six in total) aim to evaluate the selected alternative measures against the most critical dimensions of feasibility – technical, financial, political and administrative feasibility as it has already explained in the Methodology section.

The survey received via Qualtrics platform for implementation of the use case 1 in Padua pilot was translated in local language. To collect the data, Padua organized a workshop. The objective was, to provide participants of the survey with the information and the results (unofficial) of trials and simulations, and briefly explain the methodology of evaluation and the areas of evaluation. This methodology was detected of the utmost importance to get useful results from T4.5. During the workshop, a high-level dialogue was carried out with stakeholders and Mobility Councillor (who attended the workshop also), generating positive acceptance about proposed policies.

All the involved stakeholders participated into the workshop. Afterwards, the surveys (for feasibility and user acceptance) was officially sent to the stakeholders by e-mail and then filled by themselves. The stakeholders were asked to express a double assessment, from the perspective of the stakeholders and from the point of view of the potential users' group.

In total 8 respondents participated in the Feasibility Survey. The structure of the respondents as well as their share is illustrated on Figure 15.

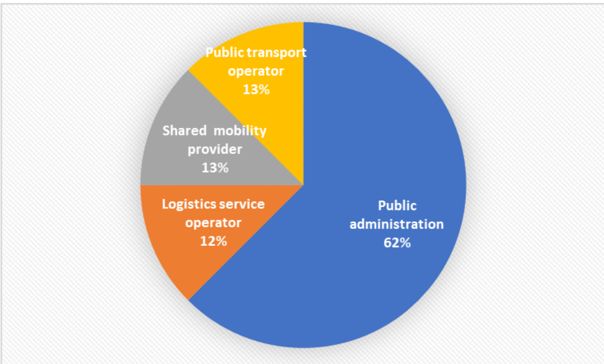

Figure 15. Use case 1 -Feasibility study: The structure and share of respondents.

The responses were analysed and used to identify the relevant questions related to potential policy measures (PMs) infeasibility (identification, analysis, how mitigating the risk). Then, these questions were the object of discussion in the second round of feasibility assessment.

Column three in Table 21 contains the relevant questions for PM implementation, risk identification, analysis and mitigation in Padua Pilot. Column four includes a summary of the responses collected during the second stage of the data collection.

In order to explain the misalignments that emerged from some numerical evaluation of the survey questions, each stakeholder was reached separately and asked to indicate the reasons for the score given about feasibility issues.

From this further analysis, it emerged that in several situations low average scores do not represent a negative assessment, but rather they express somehow the degree of stakeholders' involvement or how they are affected by the policy measure.

Annex 2 includes the detailed analysis of the complete responses.

Table 21 Implementation feasibility - Second stage: Responses to misalignments.

Policy measure	Dimension Criteria	Questions for PM implementation risk identification, analysis and mitigation	Second stage responses
PM1. Integration of NEXT with Local Public Transport and development of modal shift	Acceptability: Urban Logistics Operator		

Policy measure	Dimension Criteria	Questions for PM implementation risk identification, analysis and mitigation	Second stage responses
			the application of policy 4 is considered fundamental to ease the implementation of policy 1.
PM2: Development of innovative solutions as support for logistic operators	Acceptability: Public Sector Stakeholders	What are the reasons for unacceptability?	Like for policy 1, the aforementioned public stakeholders are not strategic players for the adoption of this measure. In fact, they are not significantly affected by the adoption of this policy. The low score has to be intended not as a negative assessment, rather like a sort of "involvement score" in the implementation of the policy.
		Measures for overcoming/reducing the acceptability barriers	The evaluation of the acceptability of the different types of stakeholders clearly highlights who is the strategic player (for policy 2, Cityporto). Evaluation of different new scenarios: in order to increase the score in this area, further potentialities involving other public players, previously unexplored since they are outside the scope of the project, could be investigated. As example, these could involve: the use of NEXT at the service of the logistics of health care material logistics for COVID-19-19 emergency. Other potential contexts could be those related to the procurement process for the public furniture/materials, or the needs of the Culture Sector (museums, theatres, libraries,). In both cases, the big size of the elements is a limiting factor.
PM3: New function / office dedicated to the development and management of freight	Feasibility: Resources availability	Why there are not resources available?	Even if there is the need and the will from Public Administration, it is not easy to create a new office and hire new staff within the Public Administration, due to the bureaucracy of resource allocation and selection process.

Policy measure	Dimension Criteria	Questions for PM implementation risk identification, analysis and mitigation	Second stage responses
logistics and Local Public Transport			Inside the stakeholders' organization, there is already an internal equilibrium, with defined job- roles. A new office in this sense would represent a new cost which should be adequately compensated. The question shows that it is more likely that this policy will be implemented within the perimeter of the Municipality. Indirectly, the scores express this, even in this case low score doesn't represent a negative assessment, but an estimation about these difficulties.
		Is there any chance to make resources available? How?	Yes. Within the PA, the challenges to be faced are represented by political will and bureaucratic complexity, but there are the several chances to make it available. For financing, it could also be conceivable to find external private resources through a public-private synergy (to be evaluated).
	Financial: Indirect costs	What are the indirect costs?	The question has been misunderstood by most of the stakeholders, since they expressed an assessment about the entity of the costs and not on their impact. The low average score therefore clearly identifies reasonably limited costs. The indirect costs are additional non-financial impacts, for example: derived costs in terms of time for Municipality to interface with the world of logistics (and therefore, of resources for creating contacts, synergies, etc.), the indirect costs linked to the home-work movements of people who will work in this office (eg traffic-congestion, possible accidents, etc).
		Will these costs be outbalanced by the benefits	Definitely yes, as emerges also from indirect benefits assessments.

Policy measure	Dimension Criteria	Questions for PM implementation risk identification, analysis and mitigation	Second stage responses
PM4: Set-up of specific procurement procedures for innovative mobility solution	Feasibility: Resources availability	Why there are not resources available?	Similar considerations of previous point can be applied to this policy response. Difficulties are related to new human resources equilibrium needed to be reached among offices that will be in charge to participate in the set-up process and following its implementation.
		Is there any chance to make resources available? How?	Yes. Within the PA, the challenges to be faced are represented by political will and bureaucratic complexity of resources allocation, which must be set up and approved in advance.
	Financial: Fixed/ operational &maintenance costs	What are the fixed/ operational costs?	The question has been misunderstood by most of the stakeholders, since most of them expressed an assessment about the entity of the costs and not on their impact. The adoption of this policy reveals an increase in the operative costs in terms of time of the administrative and technical staff. In fact, this will lead to an increase in terms of hours worked, eg. for the payment of overtime. Fixed costs could be represented by cost to the purchase of new management software with regular fee, the economic resources to be necessarily dedicated to the training of personnel in this specific area, possible costs linked to the use of new office spaces required for the function or functions that deal with the set-up. Also external consultancy costs or the implementation of an internal management system can be classified as fixed costs.
		Will these costs be outbalanced by the benefits	Definitely yes, as emerges also from indirect benefits assessments.

5.3.4 User acceptance

Figure 16 shows the structure and share of respondents of the user acceptance surveys. There were 8 participants and the data were collected as described in section 5.3.3

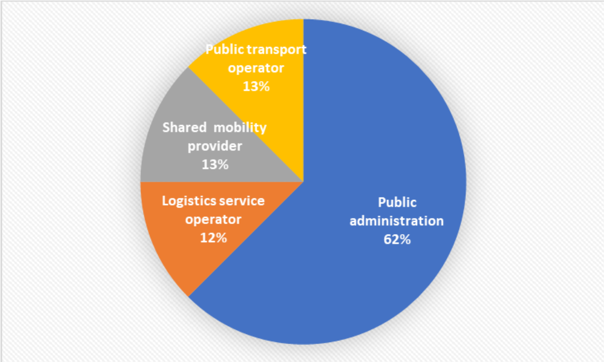

Figure 16. User acceptance study: The structure and share of respondents.

They believe they meet their needs and understand how they can solve the urban mobility challenges. Moreover, participants think the proposed policy measures are acceptable and affordable. Therefore, the second stage was not required. Annex 3 includes the analysis of the complete responses.

5.3.5 City-led policy response

PM1 “Integration of NEXT with Local Public Transport and development of modal shift” is considered feasible by all the stakeholders participating during the first stage of the data collection except for the Cityporto, the logistics operator, and the public sector (Local Police, Firefighters, Civil protection) that expressed a low level of acceptability. The reason reported by Cityporto during the second stage of the T4.5 process is that its business results are independent of this measure. This doesn’t reflect a negative assessment, but somehow the involvement degree in this Policy Measure. However, it was highlighted how there may be an increase in the benefit if the integration with takes place in the city center or in the last mile. The public sector stated a similar motivation as they are not directly involved. The evaluation is not a negative assessment, rather like a sort.

PM2 “Development of innovative solutions as support for logistic operators” follows a similar score as PM1, but stakeholders are exchanged. PM2 receives a lower score by the Public Sector, which is the best beneficiary of PM1. PM1 obtains a lower score for Cityporto, the best beneficiary of PM2. The reasons are mutually the same explained for PM1.

In none of the cases does it mean that they do not accept it, simply that their level of preference is lower since it does not imply a direct impact on their business. The obtained results highlight who are the strategic partner for these measures (BIV for PM1 and Cityporto for PM2) and the dependency of PM1 and PM2 with PM4 “Set-up of specific procurement procedures for innovative mobility solution”, with PM4 a fundamental policy to ease the implementation of PM1 and PM2. Moreover, they believe the level acceptability of PM2 may increase if they explore new business cases (eg. health care service providers) that may involve additional stakeholders and increase the level of acceptance.

PM3 “New function/ office dedicated to the development and management of freight logistics and Local Public Transport” and PM4 “Set-up of specific procurement procedures for innovative mobility solution” are measures considered not feasible from the point of view of resources available and for the fixed and operational & maintenance costs. In both cases, the low score refers to the dependency of the public administration typified by the excessive and rigid bureaucracy is the main hurdle. They may require an organisational change or the definition of new roles with financing repercussions (raising fixed costs for purchasing new software and operation costs for administrative and technical staff working hours). Although the benefits will balance the additional costs, these PMs establishment is complex as they need political will and be approved in advance.

In conclusion, PM4 and PM3 are the most effective measures for supporting the introduction of modular, electric vehicles in the cities public sphere, one of the most disruptive solutions for improving urban mobility. Indeed, the field tests and the impact assessment reflect that the modularity rather than autonomous driving (that currently has to be intended as “driver-assistance”) is the most relevant characteristics of the NEXT system. Finally, managing innovative solutions like this unprecedented one would definitely benefit from these measures. More agile processes are required to demonstrate the benefits and accelerate the transition to the mobility of the future. For this, it is necessary for the public administration to prioritize this transition through the allocation of resources to the management of the transition of urban mobility. Finally, PM1 and PM2 would reinforce the adoption and acceptance of the pods, especially by those agents that would benefit the most from their definition.

6 Summary and outlook

Within the SUMP Padua framework, its goals address to fostering the use of more environmentally friendly transport modes, developing new e-mobility systems to reduce pollutant emissions, fossil fuel consumption and mitigating climate-change. The other SUMP key goals aim to gradually reduce the role of road transport, and improving the effectiveness and efficiency of urban logistics and freight transport. The achievement of these ambitious but necessary objectives, has to be accomplished by the pursuit of an improvement in socio-economic sustainability, which translates into the need to offer better accessibility to users.

In response to this challenge, as a part of the SPROUT project, the consortium, represented by Venice International University and Padua Municipality, launched a pilot implementation of a disruptive innovative transport system based on cutting-edge technologies carrying both passengers and freight (cargo-hitching). Sustainability assessment of the pilot impact was the core of task T4.3.

The system was then tested in an area of the city (Longhin Street) specifically chosen to carry out the tests for an overall period of three months, and where a reserved lane was created. Two pods were then tested, in different configurations (single pod or coupled system), also testing the joint system.

The technical performance of the system was then assessed, monitoring the functional parameters and electricity consumption. Based on the data collected during the trials, the sustainability assessment was carried out, verifying the target KPI value.

High remarkable outcomes were demonstrated in terms of traditional fuels consumption reduction compared to traditional means of transport, and in terms of environmental quality improvement, since the relevant reduction of emissions of CO2 and pollutants (NOx, PM10). All the sustainability impacts were fully achieved.

The main innovation of the system is the modularity and flexibility of its use, which makes it possible to optimize times and distances compared to traditional forms of mobility. This brings a positive impact on the aspects linked to traffic congestion, also thanks to the reduction of public space waste (many private cars usually travel with just the driver on board). This innovative transport system also allows, to have a very low environmental impact, thanks to electrification of the system. The pods are designed to operate also with autonomous driving, even if the current regulation at the moment does not currently allow it. While the European regulation on autonomous driving needs a future evolution, the trials conducted can be seen as a first “SPROUT” for its gradual introduction; in this sense, the coupling system, which was technically tested, is a necessary step for the subsequent introduction of NEXT system’s autonomous driving.

A total driverless scenario was tested through Virtual Reality. Moreover, needs of the elder people were considered following the UI/UX design principles to make the NEXT system an inclusive mobility solution that meets also the vulnerable users’ requirements.

Besides the physical trials, a simulation on a larger area was carried out, through a light cost-benefit analysis. The results of the simulation for the hypothesized scenario showed significant savings in terms of operating costs and travel times compared to the current mobility scenario. Although from the high economic level an initial investment of resources is necessary (in terms of fixed costs), the analysis highlighted how, over long-time horizon, the implementation of the new mobility systems would have a significant positive impact, with high revenues and lower operational costs

The most significant advantages would be achieved by integrating passenger and freight transport; this result calls innovative PPP schemes to address proficiently the combination of freight and passenger resources.

Before the definition of policy responses T4.4 – Formulation and prioritisation of alternative policy responses), the next step was to identify, the criteria to be considered in order to evaluate positive responses from proposed alternative. The alternative policy responses have been then prioritized for each pilot city through the Multi-Actor, Multi-Criteria Analysis (MAMCA). The expected integration of the NEXT modular transport system as a regular freight/ passenger transport service, extended to a large part of the urban area for most of the stakeholders was assessed as largely positive in terms of accessibility, connectivity, reduction of traffic and air pollution, integration with other systems. Financial feasibility was expected to have negative impact for public transport stakeholder.

The last stage of the Work Package 4 was the assessment of city-specific policies for harnessing the impact of new mobility solutions (T4.5). The Identified Policy Measures were:

- PM 1: Integration of Next with Local Public Transport and development of modal shift;
- PM2: Development of innovative solutions as support for logistic operators;
- PM3: New function / office dedicated to the development and management of freight logistics and Local Public Transport;
- PM4: Set-up of specific procurement procedures for innovative mobility solution.

These policy responses were discussed with stakeholders in a dedicated workshop. Stakeholders were asked to assess the policy measures in terms of acceptability and users' acceptance through a detailed survey. A second stage response was necessary to explain some misalignments for feasibility. For users' acceptance no second stage response was necessary.

Policies 1 and 2 were considered feasible by the stakeholders; some differences were highlighted between the 2 main stakeholders, who considered them to be the PM1 and PM2 independent of each other. The other public operators (Local Police, fire Fighters, Civil Protection...) were not evaluated as key stakeholders for PM1 and PM2. The implementation of identified policy responses identified were considered overall positive and desirable by involved stakeholders, with some differences.

From a financial point of view, it was pointed out by the public transport operator that PM 1 requires a robust initial investment effort, but from an operational point of view it seems to

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Annexe 1: T4.4 Templates

1.Problem identification template- SIS step 1

Goal

- Develop a list of alternative policy responses for each pilot
    - Based on:
        - T3.3- Policy impact assessment of future urban mobility scenarios
        - T4.2- Results from the operational assessment of the pilots
- Prioritisation of alternative policy responses
    - Through multi-actor-multi-criteria analysis (MAMCA)

Input needed

In order to develop and prioritise the alternative policy responses, the answer to the following questions is needed:

1. What is the main problem you encounter in relations with your pilot?
2. What are the possible (policy) solutions to this problem?

An example could be as follows:

1. Main problem encountered: the integration of autonomous pods with surrounding traffic does not happen properly and creates dangerous situations.
2. Possible policy solutions:
    a. Making the area around the pods' path a 30km/h zone;
    b. Developing a smart traffic light system that favours the pods so that car traffic is halted when they need to cross.

In order to ensure the correct development of this Task 4.4, we need the **main issue** you encounter with your pilot, and at least 2 possible solutions to that issue. Of course, it is possible to offer more than 2 solutions as well.

The template below needs to be filled in and sent to by **Oct. 30, 2020**.

Template

Please fill in the template below. If you have more than one regarding the pilot, feel free to add an extra item to the list. However, the first issue should be the **main one**.

Main issue with the pilot

- Description of the problem encountered:

- Description of the possible policy solutions to the problem:
    1. ...
    2. ...

2. Stakeholder criteria request for Budapest- SIS step 3

Dear SPROUT stakeholders,

We are now a year and a half into the project. Up to now, we have inventoried the drivers of the transformations in urban mobility, and developed scenarios for the future of urban mobility in your city. To those of you who participated in the workshops to help build the scenarios, thank you again! You can take a look at the scenarios and their visualisations (under the 'Resources' tab). As you may also know, pilot projects are now underway to test an innovative urban mobility solution in your city.

As part of the next step in the SPROUT project, we are looking at alternative policy responses for the pilots being implemented, based on issues that the SPROUT team uncovered during the implementation. This will be done through a modified multi-actor multi-criteria analysis (MAMCA), which is an evaluation that takes into consideration different stakeholders and their priorities.

As one of the first steps of the process, we need your input. We want to know what your objectives are with regards to your city's urban mobility environment, in terms of the pilot that is being implemented, in the next 10 years. Below, you will find two short descriptions of the pilot. The first is the pilot as it is today; the second description is a situation where policy changes have been implemented as a result of the pilot. What we would like to know from you is the following: if we were to implement the alternative, what factors are important in your eyes that we need to pay attention to? In other words, **what makes a good alternative better than a bad alternative**? These factors can be positive, but also negative. To give you an idea of what we mean, these are a few example criteria against which alternatives can be evaluated: traffic safety, cost, accessibility, air pollution, noise, impact on other transport] TJETt[(ed8(on)4i)5] TJETQ E

3. Expert evaluation form- SIS step 4

To be filled in by the scientific partners

Instructions:

In this phase of the Task 4.4 Multi-Actor Multi-Criteria analysis, we have collected local stakeholders' objectives with regards to your pilot. For this next step, we ask you to **evaluate the two scenarios** (the situation with and without the pilot) against these objectives. In order to do this, the table below lists all the stakeholder criteria that need to be evaluated. For each criterion, the following question needs to be answered: how does the second scenario (i.e. the scenario with the pilot implementation) score in terms of this objective? The drop-down menu allows you to choose between:

- Very negative;
- Negative;
- Slightly negative;
- No change;
- Slightly positive;
- Positive;
- Very positive.

For example: if I were to implement parcel lockers at a metro station, I could have the following evaluation:

- Very positive in terms of accessibility to customers (customers can now access their parcels any time they want);
- Negative in terms of financial feasibility (there is a cost associated with the implementation of the lockers).

In order for us to understand the evaluations, please write a (short) justification in the last column. If the evaluation is based on figures that are at your disposal, please also include those (for example, if you have a concrete implementation cost for the lockers in the example above, this needs to be added in the justification column).

Many thanks!

The SPROUT Team

4.Stakeholder evaluation form Padua - SIS step 5

VRIJE
UNIVERSITEIT
BRUSSEL

English

Intro and stakeholder group

You are invited to take part in a European funded project called SPROUT, which aims at developing innovative policy responses to urban mobility challenges. We ask you to fill in the following questionnaire as part of the stakeholder evaluation of the pilot of the automated NEXT pods in Padua. It will take no longer than 5 minutes. You can withdraw at any moment. By participating in the survey, you consent to use the data you provide in SPROUT and to make them publicly available in anonymised form. Your privacy will be respected in any case. For more information regarding SPROUT and the data you provide, please contact privacy@zlc.edu.es

Thank you very much for your collaboration.

To which of these stakeholder groups do you belong?

- ◯ BIV S.p.A
- ◯ APS Holding S.p.A
- ◯ Padua municipality- environment
- ◯ Padua municipality- mobility
- ◯ Padua local police
- ◯ Padua Fair
- ◯ Cityporto

APS Holding S.p.A criteria

Below you can see the criteria that you indicated as being important for a successful project. Please indicate how important you feel each criterion is for you, on a scale from 0 to 10 (0 = not important at all, 10 = extremely important).

	0	1	2	3	4	5	6	7	8	9	10
Reduction of urban air pollution	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Integration of services/connectivity	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Accessibility	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

BIV S.p.A

Below you can see the criteria that you indicated as being important for a successful project. Please indicate how important you feel each criterion is for you, on a scale from 0 to 10 (0 = not important at all, 10 = extremely important).

	0	1	2	3	4	5	6	7	8	9	10
Financial feasibility	○	○	○	○	○	○	○	○	○	○	○
Impacts on other transport systems	○	○	○	○	○	○	○	○	○	○	○
Integration with public transport	○	○	○	○	○	○	○	○	○	○	○
Traffic reduction	○	○	○	○	○	○	○	○	○	○	○
Reduction in greenhouse gas emissions	○	○	○	○	○	○	○	○	○	○	○
Reduction of urban air pollution	○	○	○	○	○	○	○	○	○	○	○

Padua municipality- environment

Below you can see the criteria that you indicated as being important for a successful project. Please indicate how important you feel each criterion is for you, on a scale from 0 to 10 (0 = not important at all, 10 = extremely important).

	0	1	2	3	4	5	6	7	8	9	10
Reduction in private vehicle use	○	○	○	○	○	○	○	○	○	○	○
Reduction of urban air pollution	○	○	○	○	○	○	○	○	○	○	○
Reduction in greenhouse gas emissions	○	○	○	○	○	○	○	○	○	○	○

Padua municipality- mobility

Below you can see the criteria that you indicated as being important for a successful project. Please indicate how important you feel each criterion is for you, on a scale from 0 to 10 (0 = not important at all, 10 = extremely important).

	0	1	2	3	4	5	6	7	8	9	10
Reduction of urban air pollution	○	○	○	○	○	○	○	○	○	○	○
Traffic reduction	○	○	○	○	○	○	○	○	○	○	○
Accessibility	○	○	○	○	○	○	○	○	○	○	○

Padua local police

Below you can see the criteria that you indicated as being important for a successful project. Please indicate how important you feel each criterion is for you, on a scale from 0 to 10 (0 = not important at all, 10 = extremely important).

	0	1	2	3	4	5	6	7	8	9	10
Increased public transport network offering	○	○	○	○	○	○	○	○	○	○	○
Integration with other transport systems	○	○	○	○	○	○	○	○	○	○	○

Padua Fair

Below you can see the criteria that you indicated as being important for a successful project. Please indicate how important you feel each criterion is for you, on a scale from 0 [illegible]

[illegible]

5	6	7	8	9	10		0	1	2	3	4
○	○	○	○	○	○	Integration of services/connectivity	○	○	○	○	○
○	○	○	○	○	○	Accessibility	○	○	○	○	○

Cityporto

Below you can see the criteria that you indicated as being important for a successful project. Please indicate how important you feel each criterion is for you, on a scale from 0 to 10 (0 = not important at all, 10 = extremely important).

	0	1	2	3	4	5	6	7	8	9	10
Very last-mile accessibility for freight	○	○	○	○	○	○	○	○	○	○	○
Traffic reduction	○	○	○	○	○	○	○	○	○	○	○

Stakeholder ranking

Below you can see the different stakeholder groups that are impacted by or impact the Padua pilot. Please rank the stakeholder groups from most impacted (1) to least impacted (7).

APS HOLDING S.p.A.

BIV S.p.A.

Padua municipality- environment

Padua minicipality- mobility

Padua local police

Padua Fair

Cityporto

Pilot improvement

How could the pilot be improved, in your opinion?

Do you see other alternative policy responses that could benefit the pilot implementation?

- ○ Yes
- ○ No

What other alternative policy responses do you think could benefit the pilot implementation?

Conclusion

Thank you for your answers!

If you have any questions, don't hesitate to get in touch with us!
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sara.marie.tori@vub.be
geert.te.boveldt@vub.be

If you are interested in staying up to date with the SPROUT project, visit sprout-civitas.eu.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grand agreement No 814910.

Annexe 2: T4.5 Implementation feasibility

Technical feasibility dimension aims at assessing the pool of resources that each of the alternative policy responses requires.

According to the opinion of the involved stakeholders, the policy measure PM3 and PM4 represent a critical alternative from the aspect of technical feasibility since its average rating value (5-tier scale) falls slightly below the 2.5 threshold (Figure 17).

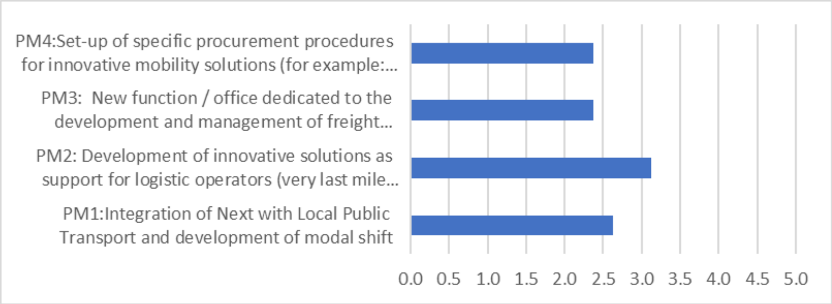

Figure 17. Assessment of policy measures against the technical feasibility dimension

In order to assess potential risks as well as the risk mitigation strategies for the implementation of PM3 and PM4 from the technical feasibility aspect a round table will be organized.

Financial feasibility includes evaluation of following cost categories: direct costs, indirect costs, fixed costs as well as operations and maintenance costs; as well as the selected benefit categories: direct and indirect benefits.

According to respondent opinions (Figure 18 - Figure 23) the following conclusions are derived:

1. From the aspect of indirect costs, PM3 requires an additional analysis, about fixed costs PM4 require additional analysis. PM4 requires an additional analysis for the operations and maintenance
2. From the aspect of the rest of the cost categories (direct and indirect costs), all the PMs are considered as feasible.
3. From the aspect of indirect benefits, all policy measure will produce positive outcomes.

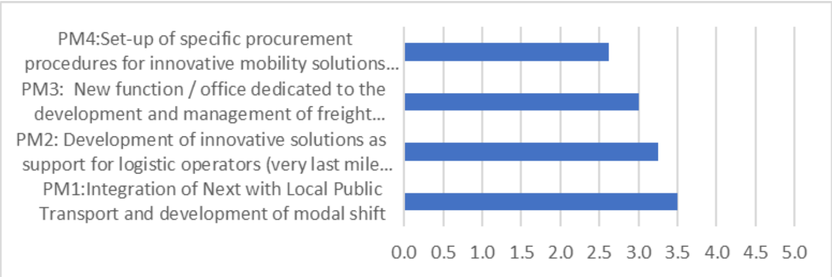

Figure 18. Assessment of policy measures against the financial feasibility dimension: Direct costs

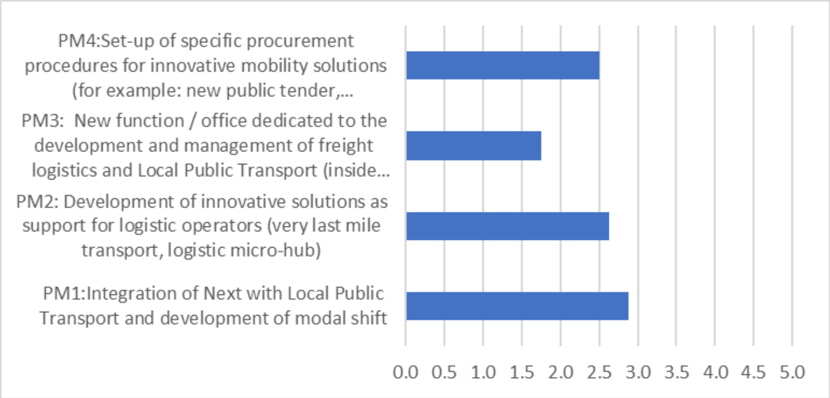

Figure 19. Assessment of policy measures against the financial feasibility dimension: Indirect costs

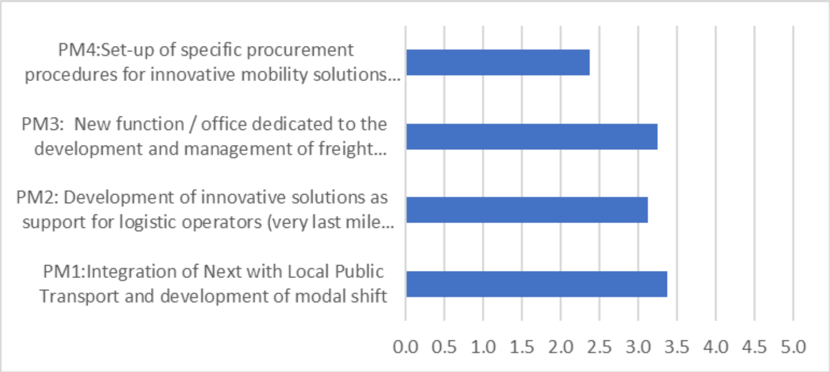

Figure 20. Assessment of policy measures against the financial feasibility dimension: Fixed costs

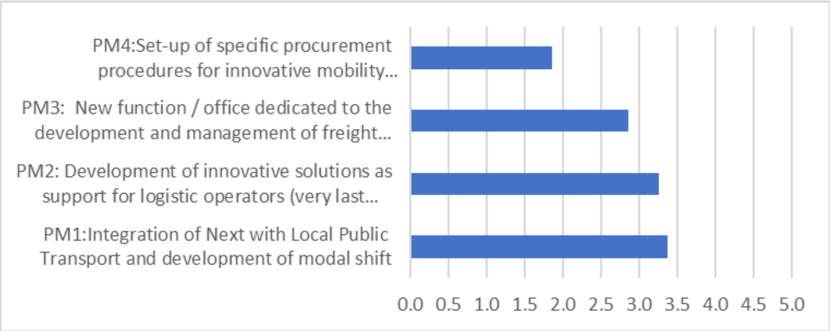

Figure 21. Assessment of policy measures against the financial feasibility dimension: Operations and maintenance costs

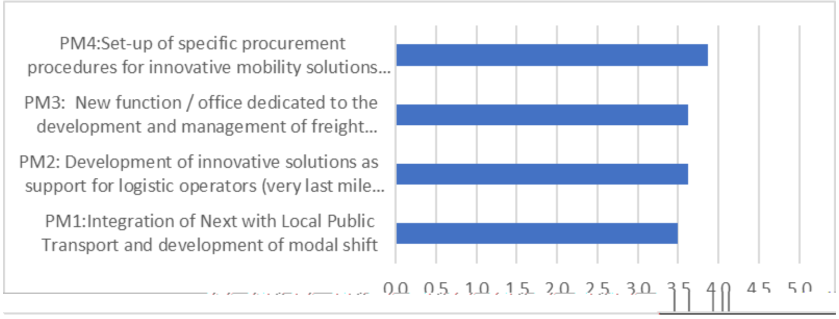

Figure 22. Assessment of policy measures against the financial feasibility dimension: Direct benefits

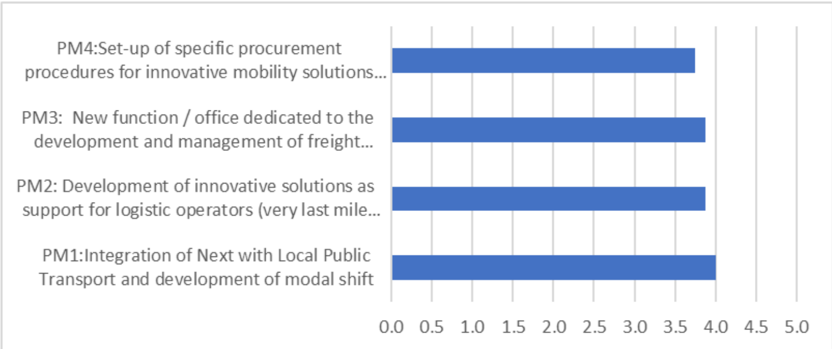

Figure 23. Assessment of policy measures against the financial feasibility dimension: Indirect benefits

Political feasibility includes evaluation of acceptability of alternative policy measures from the aspect of relevant stakeholders. According to the graphs below, all the stakeholders score the PMs quite positively except PM1 for urban logistics operators and PM1 and PM2 for public sector stakeholders. These policies measures require an additional analysis.

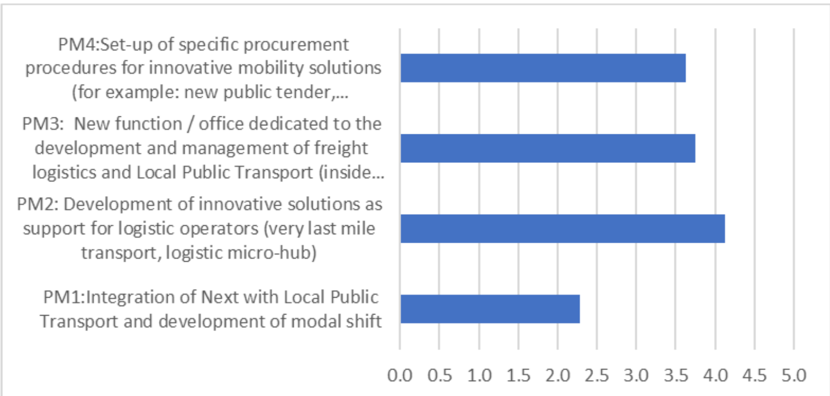

Figure 24. Acceptability of alternative policy measures from the aspect of Urban Logistics Operator.

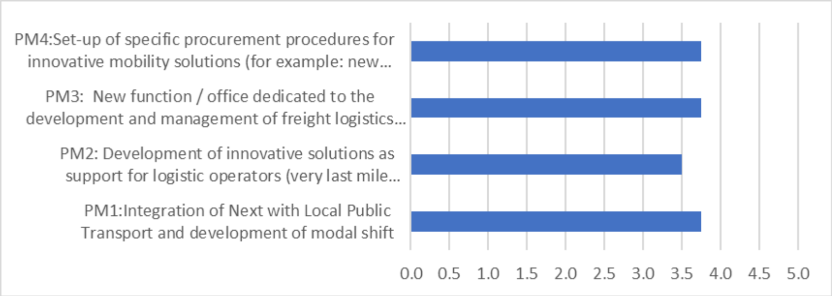

Figure 25. Acceptability of alternative policy measures from the aspect of Public administration.

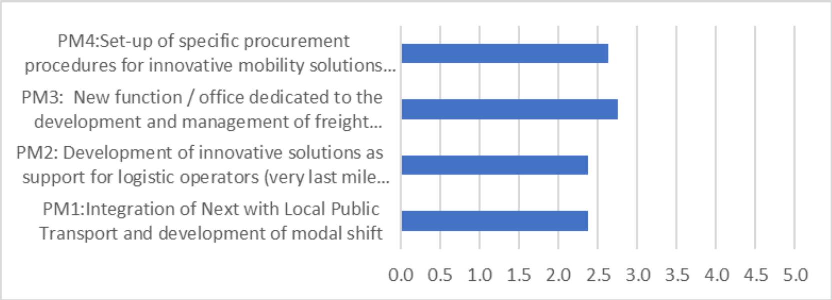

Figure 26. Acceptability of alternative policy measures from the aspect of Public sector stakeholders

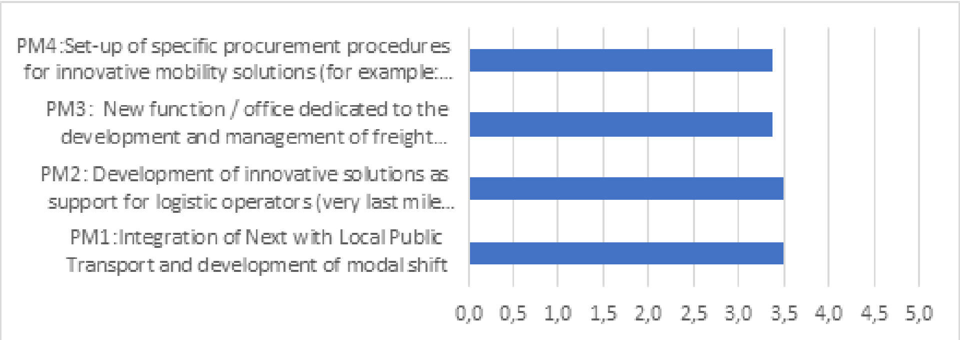

Figure 27. Acceptability of alternative policy measures from the aspect of data/tech company

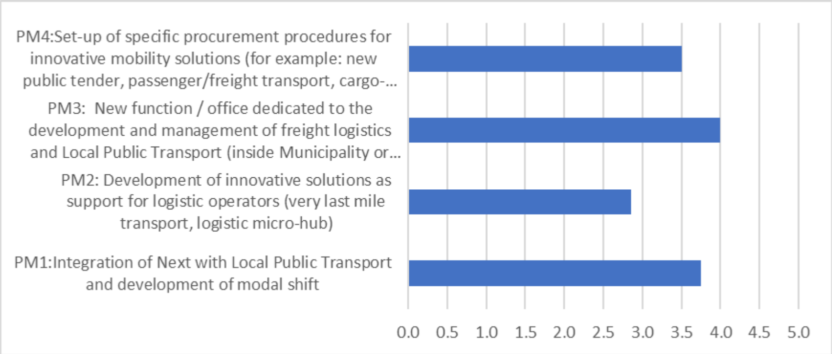

Figure 28. Acceptability of alternative policy measures from the aspect of public transport operator.

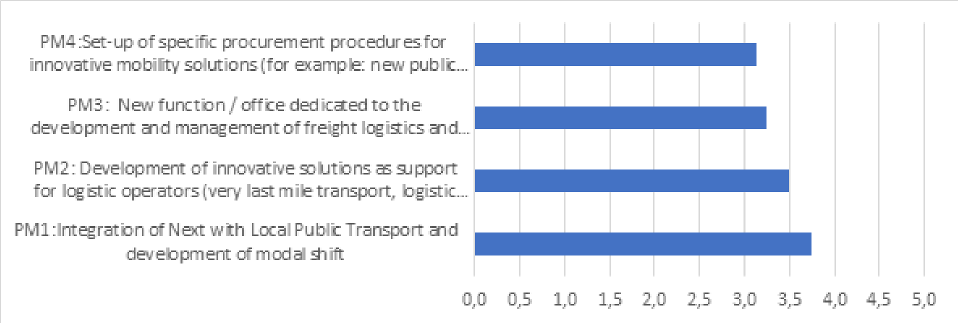

Figure 29. Acceptability of alternative policy measures from the aspect of new mobility service provider

Administrative operability and capability are the main criteria for assessment of policy measures against the political feasibility. (Figure 30 - Figure 31). No policy measure required additional analysis.

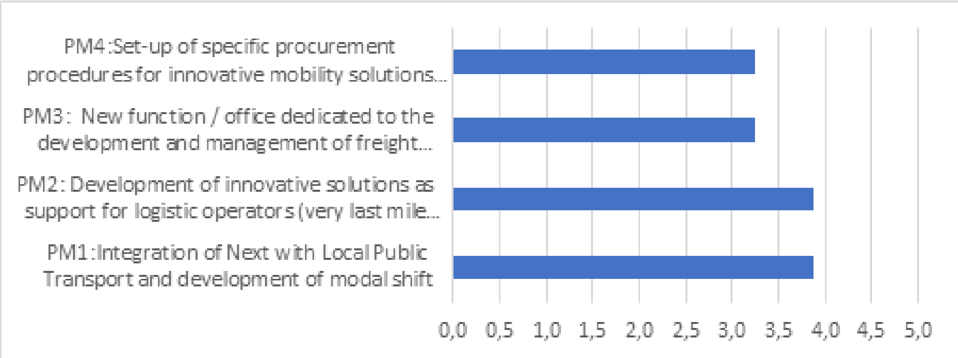

Figure 30. Assessment of policy measures against the political feasibility dimension: Administrative operability

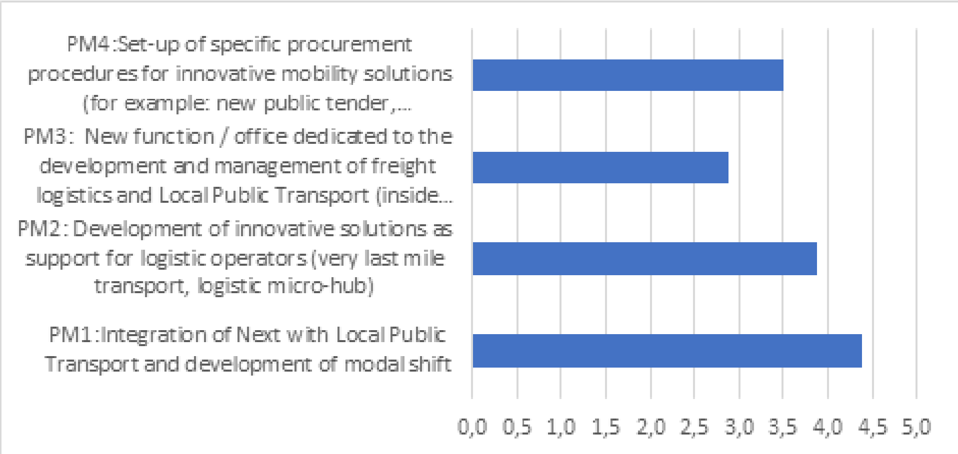

Figure 31. Assessment of policy measures against the political feasibility dimension: Administrative capability

Annexe 3: T4.5 User acceptance

Criteria "Personal and social aims" is assessed by the extent a specific PM fulfills the needs of the respondents. According to the survey results (Figure 32) all PMs are fully reflecting the social and personal aims of the users.

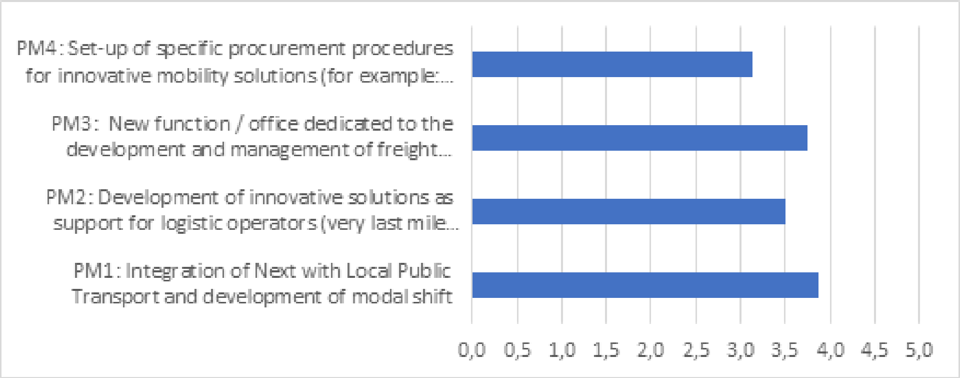

Figure 32. Assessment of policy measures against the user' personal and social aims

High problem perception reflects an increased willingness to accept a specific policy measure. According to the survey results (Figure 33 - Figure 40) UC1 respondents have a good user' perception of the urban mobility challenges.

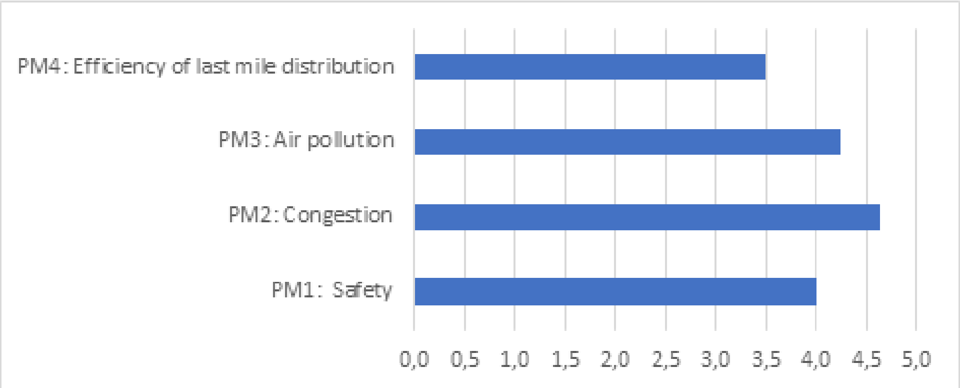

Figure 33. Assessment of policy measures against the user's problem perception

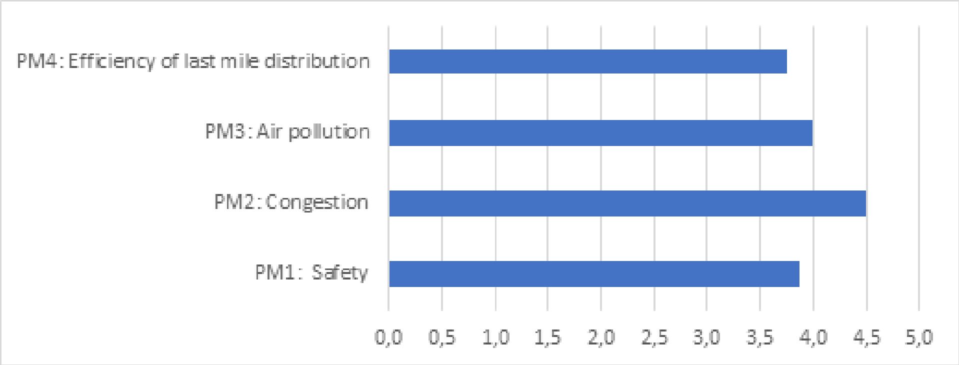

Figure 34. Assessment of policy measures against the stakeholder's problem perception

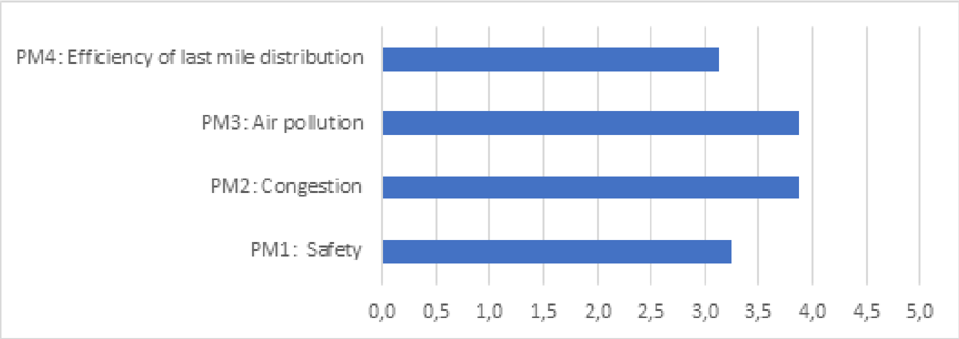

Figure 35. Assessment of policy measures against the user' problem awareness.

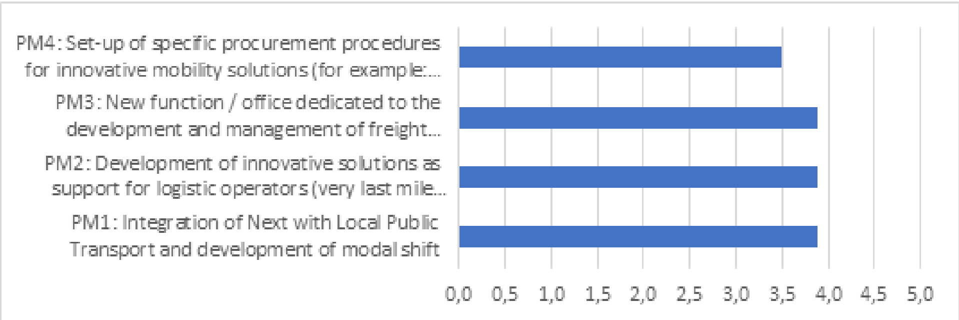

Figure 36. Assessment of policy measures against the stakeholder' awareness about policy measure

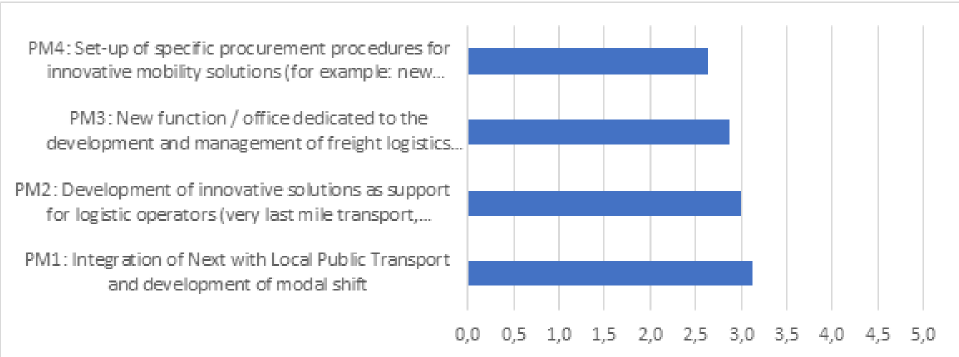

Figure 37. Assessment of policy measures against the user' awareness about policy measure

User' satisfaction with proposed solution, policy measure in this case, reflect the degree by which the policy measure solves the users' needs. According to the survey results the users are satisfied with proposed policy measures.

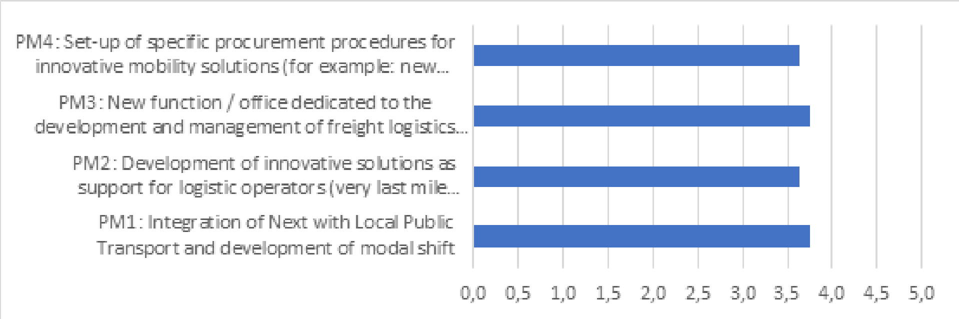

Figure 38. Assessment of policy measures against the stakeholder' satisfaction with a policy measure.

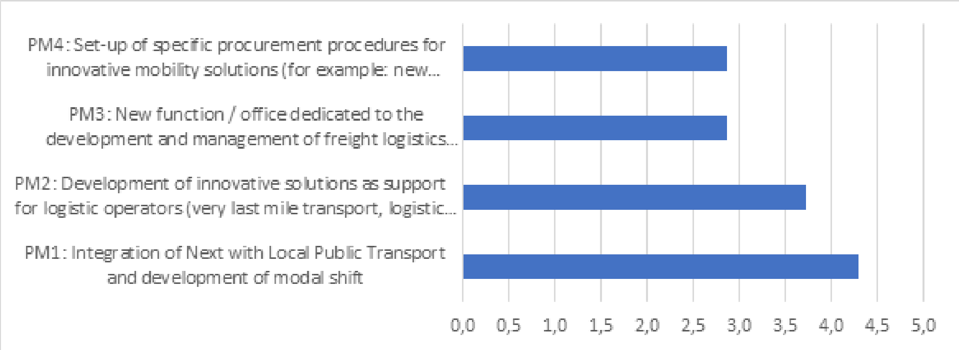

Figure 39. Assessment of policy measures against the user' satisfaction with a policy measure.

Affordability of the policy measures from user perspective is also one of the determinants of the success of a specific policy measure. Based on its socio-economic status the users express their preference towards a specific policy measure.

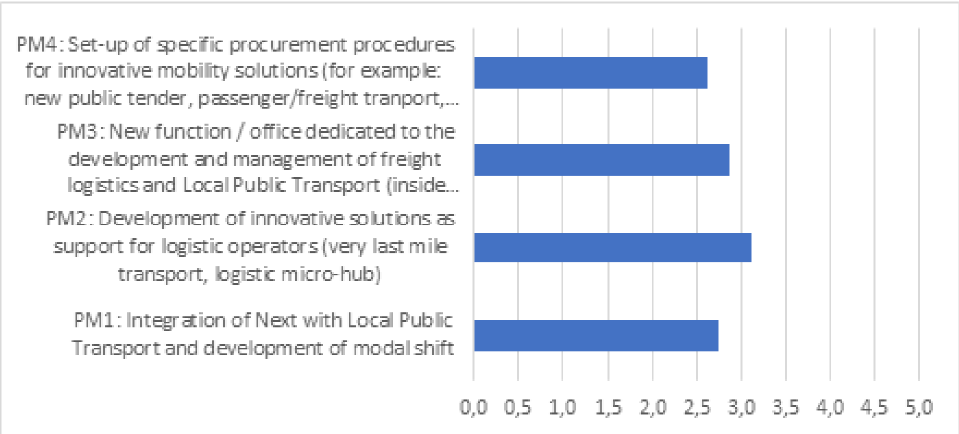

Figure 40. Assessment of policy measures against the users' affordability of policy measures.