Guidelines for organisational set up to launch fully autonomous mobility services in large public areas - Experience of the City of Gdansk | Sohjoa Last Mile

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Summary of partner role in relation to launching the pilot

The Municipality of Gdansk is a partner in the consortium of the Sohjoa Last Mile project, which is an extension of the Sohjoa Baltic regular stage project. Both projects received funding from the Interreg Baltic Sea Region program.

The road to autonomous last mile transport in Gdansk stated in 2016, the City got involved in the Sohjoa Baltic project application led by the Metropolia University of Applied Sciences. Upon successful application, in 2019 Gdansk implemented as small scale pilot of an autonomous bus on the public road. This was the first autonomous bus pilot in Poland.

Based on the success of the first pilot, key actors involved in mobility and transport management across the municipality, agreed that it is worthwhile taking a step further and implement a more advanced pilot. The plan was to test remote supervision and remote-control opportunity as well as to remove the operator from inside of the vehicle.

Consequently, together with majority of partners from the Sohjoa Baltic consortium, and again with leadership of the Metropolia University, the Municipality of Gdansk applied for an extension stage project in order to implement truly driverless pilots. The piloting cities besides Gdansk included Kongsberg and Tallinn.

When the project application was approved by the funding body the City of Gdansk decided to continue with an organisational set up developed for the purpose of the Sohjoa Baltic project back in 2018. It was then, when a local project steering committee was set up, including representatives of:

- Municipal Office in Gdansk (Active Mobility Unit)
- Gdansk Road and Greenery Management
- Gdansk Buses and Trams
- Public Transport Management in Gdansk

Besides the local steering committee, the Active Mobility Unit intended to exchange knowledge with Associate Organisations involved during the Sohjoa Baltic project, including:

- Ministry of Infrastructure
- Pomeranian Marshal's Office
- Municipal Road Safety Council
- Gdansk University of Technology
- Pomeranian Association of Urban Transport Supporters.

From the application stage of the regular stage project, both projects were coordinated by the same person employed by the Active Mobility Unit, which ensured

consistency and continuity of autonomous last mile transport initiatives within the municipality.

The role of project partner was not only to implement an autonomous bus pilot but also to outsource a legal analysis to develop a synthesis of desirable legal changes towards regular autonomous public transport for the first and the last mile and to share results with potentially interested academic, government and the industry.

Until 2021, there was no other Polish municipality or organisation to run an autonomous bus pilot in the country. Consequently, the role of Gdansk in Sohjoa Last Mile project was not only to further explore potential of autonomous mobility within the chain of public transport but also to share knowledge on the national level via the ARTS workshop. The workshop was supposed to be organised after successful implementation of the pilot.

As within the regular stage project, the intention of the Municipality of Gdansk was to establish a show route on a public land within the Gdansk Roads and Greenery Management and to outsource majority of the pilot related services. The Municipality's role in launching the pilot was the land owner and the Contracting Authority.

Pilot preparation and implementation activities, their location and timeframe

The preparation for the fully driverless autonomous bus pilot in Gdansk started in January 2021. The local project leader liaised with potential service providers across Europe e.g. with companies known to the partner since the first pilot preparation and thanks to knowledge exchange within the Sohjoa Last Mile consortium.

Simultaneously the local project coordinator consulted more experienced project partners to collate technical specifications of the bus, teleoperation etc.

As a result, based on the Active Mobility Unit expectations, the municipal Public Procurement Office prepared the open tender. The tender was announced on 31st May 2021 and resulted in one offer from a Finnish company Roboride. Unfortunately, the offer was invalid and the tender had to be renounced. The second open tender resulted in a valid offer from Roboride, submitted on 6th August 2021.

The pilot route

The project partner intended to organise a pilot in enclosed area that is a municipal land. Since during the first autonomous bus pilot in 2019 an opinion poll was carried out and a significant number of responders indicated that the good area of operation would be cemeteries, the largest one was chosen as a pilot site.

The largest municipal cemetery in Gdansk occupies a vast area, about 50 ha, between Kartuska Street and Armii Krajowej Avenue. From the south-west it borders on Cedrova

Street. The main entrance to the cemetery and parking area leads from Łostowicka Street.

The spatial composition of the cemetery takes advantage of the natural, undulating terrain. The area is divided into 79 individual burial plots, of different sizes and shapes resulting from the network of roads between which they are located.

The main alley of the Cemetery does not have a status of a public road. It is a green planted asphalt avenue leading from the main entrance of the Cemetery in ul. Łostowicka to the entrance in ul. Cedrowa. Its cross-section is variable. The alley consists of two lanes in the section between the initial and the second autonomous bus stop, and one lane at remaining length of the route.

Vehicles are allowed to travel on the road at a speed not exceeding 5 km/h. During the presentation, observations of operators and persons responsible for implementation showed, that this limit was not respected.

The lack of designated parking spaces and pedestrian traffic lines make the area difficult to navigate with an autonomous bus.

For the bus presentation, stops with the following infrastructure have been prepared:

- posts with stop signs,
- timetable signs,
- envelopes marking the place of stopping,
- no-stopping signs within at the end stops.

Additionally, passenger information displays in electronic paper technology have been placed at the end stops.

Pedestrian and car traffic was maintained on the route in accordance with the Cemetery regulations. Cyclists could also be seen appearing along on the route, even though according to Cemetery rule of conduct, there should be no cyclists.

At junctions the right-hand rule was considered to be in force. The lack of rules of the road for pedestrians, vehicles and bicycles and the lack of parking zones strongly affected the daily autonomous bus service. Funeral processions set off several times a day from the chapel located near the stop at Łostowicka Gate. All this created disorganised mixed traffic.

Organiser of the pilot and service provider

The Municipality of Gdansk does not own an autonomous bus or knowhow to programme it and operate. Therefore, it was decided, that the delivery of the bus and all the complementary services would be outsourced. As it was expected that the value of the contract would exceed the bid-at-three EU threshold, the procedure of an open tender had to be implemented.

For the purpose of smooth outsourcing of the service as well as preparing the sample service agreement, the following definitions were developed:

1) **Bus** - an autonomous vehicle, moving in an automated and remote manner, in accordance with the Technical Requirements, which constitute Annex to the Service Agreement,

2) **Teleoperation** - a mode of transmitting commands from a control unit to an executive unit, i.e. from a place physically distant from the Bus, through a transmitter operated by an operator to a receiver integrated with the Bus or connected to it using a wireless interface,

3) **Autonomous mode** - use of the self-driving capability of the Bus by equipping the vehicle with software, laser distance measuring sensors and cameras, and consequently with the ability of perception, obstacle detection and artificial intelligence analysing the data from the sensors, equivalent to reasoning and situation awareness,

4) **Vehicle Operator** - a person in control of the Bus throughout the journey located on board the Bus or outside the Bus at a remote-control distance, holding a category D1 driving licence, equipped with a hand-held remote-control controller available on board the Bus or outside the Bus, trained by the Contractor in the operation of the Bus and its maintenance, including to intervene in emergency situations and to bring the Bus to the loading point and provide basic information to passengers,

5) **Demonstration route** - a green planted asphalt avenue leading from the main entrance of the Cemetery in ul. Łostowicka to the entrance in ul. Cedrowa in Gdansk, along which the Bus will move in an automated manner and with the use of teleoperation, programmed taking into account arrangements with the Cemetery Manager,

6) **Emergency situation** - a set of external or internal circumstances that require stopping the vehicle, bypassing an obstacle or other intervention of the Vehicle Operator,

7) **Force Majeure** - weather phenomena of an abnormal character, e.g., heavy rain, flood or windstorm or events caused by other traffic participants or acts of vandalism, or related to the pandemic virus, e.g., SARS_COV2 quarantine or staff absence making it impossible to temporarily implement the subject of the agreement.

The expectation of the Municipality of Gdansk was that a result of the procurement one electrically driven autonomous last mile bus would be operated on a route marked off the public road network, i.e., along a footpath within an enclosed area where, apart from pedestrian traffic, motor vehicle and Melex traffic are also permitted. Delivered bus was to comply with all minimum requirements as follows:

- Electric 2WD
- Range between charges at least 60 km
- Onboard charger with necessary accessories for charging
- At least eight (8) persons capacity
- Seats for at least four (4) persons
- Accessibility to persons with disabilities
- Operating temperature from -5 to +35 ˚C
- Obstacle detection around the vehicle (360 degrees for roundabouts and non-priority intersections)
- Automation level 4 (SAEJ3016)
- Driving in rain
- Driving in continuous wind of <55 km/h
- Driving in conditions of reduced visibility e.g., during foggy weather
- Safety button
- Automated & Manual mode with the onboard remote controller
- Can be operated on fixed routes stopping on every bus stop of the route
- Programmable turn-signals
- Programmable side safety limits to operate safely and with reasonable velocity in tight spaces.
- Possibility of remote operation and remote supervision
- Ability to automatically handle junctions without traffic lights (normal traffic rules in junctions)
- Ability to handle the left turns in crossing
- Air conditioning.

The expected service was to consist of free transport of passengers along a pre-programmed route with the length of about 1100 m, moving at the speed of about 12 km/h, **for a minimum period of 24 operating days**, at least **6 days a week** (obligatorily including Saturdays and Sundays), not earlier than from the beginning of June 2021 and until 15th of November, 2021 at the latest, in accordance with the timetable prepared by the Economic Operator and approved by the Contracting Authority.

The subject of the contract also included other activities necessary to perform the service, such as:

- Transporting the vehicle to and from Gdańsk at the risk and expense of the Economic Operator;
- Technological and logistic consultations in relation to the route selected by the Contracting Authority;
- Providing software with a license;
- Programming the Bus to drive on the Show Route, according to the map prepared by the Contracting Authority, to move at a speed of approx. 12 km/h;
- Marking the route in consultation with the Gdańsk Road and Greenery Authority;
- Marking the bus by placing a sticker on the side body with the logos of the Employer, the project and the co-financing institution, and displaying the same logos on the screen inside the vehicle (if the vehicle delivered is equipped with a display);
- Designation and marking of bus stops in consultation with the Gdańsk Road and Greenery Authority, along with the provision of bust stop plates with the timetable and information on co-financing the project;
- Providing Bus operation by trained Vehicle Operators or providing training to at least two designated drivers with category D1 driving licence, to whom the Economic Operator will assign the role of Operators;
- Maintenance of a third-party liability insurance policy as regards business activities related to the performance of the subject of the contract, for an amount not less than 5,000,000.00 PLN, and presenting a copy of the current policy along with a proof of its payment at least 5 business days before starting the presentation.
- Keeping data statistics and granting permission to disseminate them publicly;
- Taking care of technical condition and operational performance of the Bus, its parking or garaging and charging;
- Complying with the requirements specified in Polish law as regards prevention of a viral pandemic, including disinfection of the vehicle and taking other measures to ensure the safety of passengers and operators.

The service of demonstrating an autonomous bus on a show route in Gdansk was provided by Roboride - an operator supporting urban mobility, located in Tampere, Finland. The Roboride partnered with AuveTech, which supplied and programmed the bus and was responsible for operator training and daily operations. Roboride's technological partner in this project was Trapeze Poland (part of Trapeze Group, specialising in IT solutions for public transport) located in Wroclaw, Poland. Even though the Ordering Party expected a minimum of 24 operational days, extra points

were awarded for additional working days. Roboride offered the total of 30 operational days.

Main results of activities

The Contracting Authority delivered Iseauto autonomous vehicle, an SAE Level 4 and M1 category vehicle developed and manufactured by Auvetech OÜ, based in Tallinn, Estonia.

Iseauto can carry a maximum of eight people and travels at speeds of up to 25 km/h. It has a 25-kW electric motor. The battery capacity is 16 kWh, the weight is 1925 kg and the maximum operating time is 8 hours. Technical details are available at https://auve.tech/rd/.

The chosen bus allowed to carry out steering in teleoperation mode (without an operator on board), and to avoid obstacles in autonomous mode (after the operator has confirmed that it is safe). In addition, the right-hand rule was programmed at intersections, allowing the vehicle to let other road users in the priority zone pass. Speed in autonomous mode was limited to 13 km/h for safety reasons.

The pilot started on 7th October and was to cover 30 operational days. The presentation of the bus ended on 12th November 2021. A break in the service was planned between 30th October and 2nd November due to holidays and the ban on vehicular traffic at the Cemetery. The additional days were also due to the inability to provide the service on the days the Cemetery was closed due to extremely bad weather conditions.

The service was performed for a minimum of 5 hours per day. In the last days of the pilot, the hours were extended to nearly 6 hours. The vehicle was to make three trips per hour. A trip was understood to be a two-way trip, so it started and ended in one place. Four stops located in characteristic points of the necropolis were prepared on the route. All stops were equipped with posts with the sign of the autonomous vehicle, timetables in paper and e-paper format at terminal stops; stopping places have been marked out in the form of sticker envelopes and no-stop signs at critical points at the end stops.

Vehicle Operator and Passenger Assistant and their interventions

The Economic Operator had the option to provide the operation of the Bus by trained Vehicle Operators or to provide training to at least two drivers with D1 category, indicated by the Ordering Party, whom the Economic Operator would commission as Vehicle Operators. Therefore, four drivers of Gdansk Buses and Trams company were trained to act as Vehicle Operators. However, during the training it was decided to entrust them with the role of travel assistants instead. The control of the vehicle and

supervision of the teleoperation was taken over by an experienced Vehicle Operator of the Contracting Authority.

The designated bus drivers were very committed, but the technological barrier had a significant impact on smoothness and safety. Proper control (remotely and from inside the vehicle) required experience in the rapid operation of manual and virtual 'sticks' - similar to games using market-leading video consoles and their pads.

As a result, the bus drivers, trained as travel assistants, were responsible for informing and welcoming passengers, assisting with seating and baggage handling, and reporting on passenger numbers and unusual situations. Additionally, they made sure that passengers were wearing seat belts and reminded them to cover their mouths and noses.

In terms of teleoperation, i.e. remote supervision and control, this element was performed from two locations: Estonia and from the control centre prepared in Gdańsk. In this mode, the operator supervised the view from the cameras in order to give orders to the vehicle in the safest possible way. In critical situations, he took over the control and manually steered the vehicle remotely.

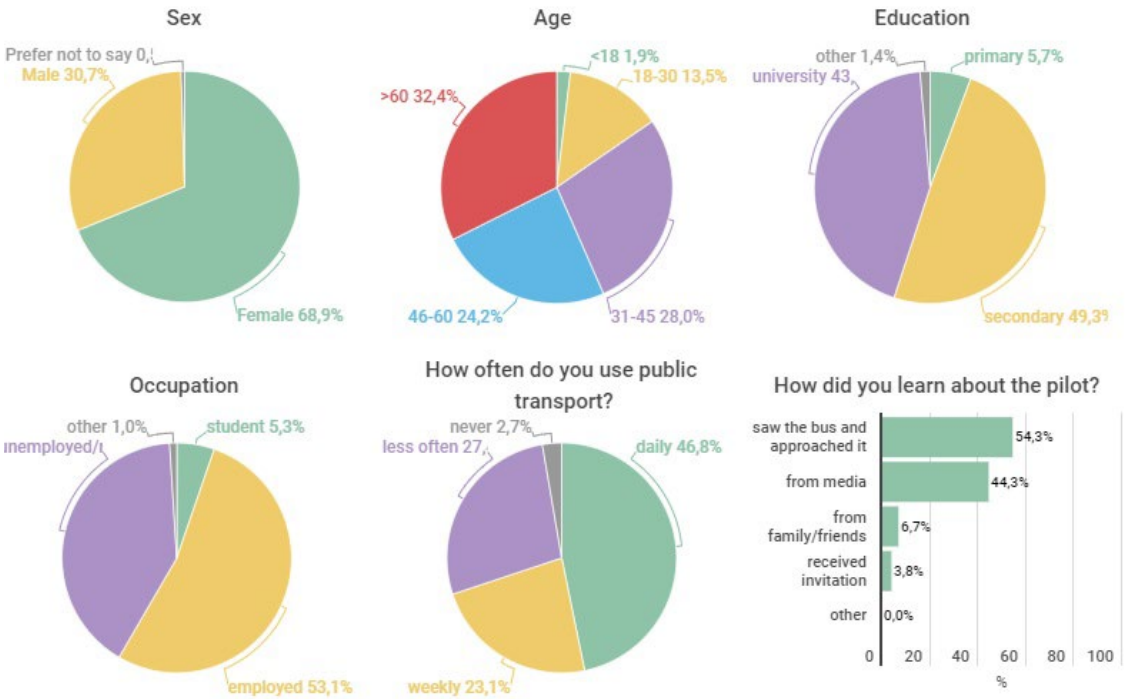
Statistics

Table 1. Number of passengers, journey times, distance, speed, teleoperation

No of courses	*Date*	*No of passengers*	*Average travel time*	*Distance travelled (km)*	*Average speed in km/h (including stops)*	*Teleoperation*
15	2021-10-07	17	19m 00s	33.00	7.07	
15	2021-10-08	66	20m 24s	33.00	6.52	
15	2021-10-09	98	19m 56s	33.00	6.63	
15	2021-10-10	99	18m 52s	33.00	7.01	
15	2021-10-11	55	18m 24s	33.00	7.03	
15	2021-10-12	64	18m 32s	33.00	7.14	
15	2021-10-13	34	18m 52s	33.00	7.01	
15	2021-10-14	64	16m 56s	33.00	7.88	NO
15	2021-10-15	62	19m 36s	33.00	6.79	NO
15	2021-10-16	131	18m 00s	33.00	7.33	NO
15	2021-10-17	113	21m 52s	33.00	6.20	NO
15	2021-10-18	36	15m 24s	33.00	8.60	NO
15	2021-10-19	34	18m 36s	33.00	7.12	NO
15	2021-10-20	92	18m 00s	33.00	7.33	NO
10	2021-10-21	34	19m 30s	22.00	6.82	NO
15	2021-10-23	65	20m 40s	33.00	6.41	NO
1	2021-10-24	1	32m 00s	2.20	4.13	NO
15	2021-10-25	74	20m 36s	33.00	6.42	NO
15	2021-10-26	81	15m 48s	33.00	8.40	NO
15	2021-10-27	94	25m 00s	33.00	5.28	YES
15	2021-10-28	129	23m 44s	33.00	5.86	NO
15	2021-10-29	100	25m 52s	33.00	5.20	YES
15	2021-11-03	63	18m 24s	33.00	7.32	NO
15	2021-11-04	36	18m 20s	33.00	7.40	NO
15	2021-11-05	28	20m 00s	33.00	6.60	YES
15	2021-11-06	47	20m 08s	33.00	6.60	NO
15	2021-11-07	65	20m 00s	33.00	6.60	NO
17	2021-11-08	29	20m 17s	36.60	6.42	YES
17	2021-11-09	48	22m 53s	37.40	5.86	YES
15	2021-11-10	51	22m 24s	33.00	6.02	YES
15	2021-11-11	107	25m 52s	33.00	5.27	YES
450	TOTAL	2017	20m 27s	989.20	6.65	7

The bus made 450 trips, carried 2017 passengers and covered over 989 km. Some of the passengers filled in passenger surveys. These were paper based questionnaires distributed by passenger assistants to fill in on the site and evaluate their experience.

The sample included 222 respondents, that used the bus between 11th October and 11th November. The key demographic characteristics of the sample are illustrated below.



The majority of respondents were women (68,9%) and the most numerous age categories represented were 'over 60 years of age' - 32% and between 31 and 45 – 28%. Their perceived safe onboard and traffic safety was rated highly and this result was shared by all the demographic categories.

Date	No of interventions	Reasons for intervention
2021-10-07	3	3 x Stoppages due to funeral processions
2021-10-08	4	3 x Stoppages due to funeral processions 1 x Bypassing a parked vehicle (not enough space for autonomous bypassing)
2021-10-09	0	
2021-10-10	0	
2021-10-11	1	1 x Stoppages due to funeral processions
2021-10-12	2	1 x Stoppages due to funeral processions 1 x Bypassing a parked vehicle (not enough space for autonomous bypassing)
2021-10-13	0	

2021-10-14	2	2 x Stoppages due to funeral processions
2021-10-15	5	2 x Removing the obstacles on the route 2 x Stopping at the request of a passenger 1 x Stoppages due to funeral processions
2021-10-16	1	1 x Stoppages due to funeral processions
2021-10-17	0	
2021-10-18	0	
2021-10-19	3	2 x Intervention due to bus stop obstruction 1 x Stopping at the request of a passenger
2021-10-20	2	2 x Stoppages due to funeral processions
2021-10-21	1	1 x Stopping a vehicle for TV coverage
2021-10-23	13	9 x Manual crossing due to heavy traffic 8 x Stopping at the request of a passenger 1 x Stoppages due to funeral processions
2021-10-24	1	1 x Manual crossing, number of cars preventing movement through the cemetery, blocked bus stops.
2021-10-25	0	
2021-10-26	0	
2021-10-27	6	3 x Stoppages due to funeral processions 3 x Stopping at the request of a passenger
2021-10-28	0	
2021-10-29	0	
2021-11-03	0	
2021-11-04	1	1 x Stopping at the request of a passenger
2021-11-05	8	4 x Stoppages due to funeral processions 4 x Obstructed passage by a undertakers' vehicle, manual bypassing necessary
2021-11-06	3	3 x Shortening of route due to funeral and blocking of passage at one of stops
2021-11-07	0	
2021-11-08	5	4 x Reduced route due to funeral and blockade on one of the end stops 1 x Stoppages due to funeral processions
2021-11-09	3	3 x Stoppages due to funeral processions
2021-11-10	4	3 x Stoppages due to funeral processions 1 x Obstructed passage by a undertakers' vehicle
2021-11-11	0	
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Technical capabilities and risks when driving without a safety driver in a closed area

Potential risk whilst driving in a closed area depends on type of the area chosen for operation, traffic organisation within, type of the vehicle used and teleoperation set up.

The area chosen in Gdansk was the largest cemetery, more fully described in guidelines for organizational setup section. The autonomous bus carried passengers on an alley,

which was not a public road and therefore there is no formal traffic organization and no formal test route approval procedures. However, the area administrator developed rules of procedures at the cemetery and all visitors to the area, are to respect those. According to these rules the cemetery is open for visitors from 7.00 a.m. until dusk. Staying in the cemeteries after dusk is forbidden.

Persons over 65 years of age and persons with physical disabilities with a valid disability card are allowed entry to the Cemetery in motor vehicles daily during the specified time period e.g., between 10 am and 3 pm on Sundays and holidays.

Vehicles allowed to enter the cemeteries are: municipal services related to the administration and supervision of the area, Police, Municipal Police, Ambulance Service, Fire Brigade and security company.

Entrepreneurs, in order to provide cemetery and funeral services, are allowed to enter with vehicles of the total weight up to 1.5 t., on working days, after prior notification to the administrator. Vehicles driving on cemetery roads are obliged to behave with utmost caution, travelling at a speed not exceeding 5 km/h, not to disturb funeral ceremonies and not to block cemetery roads and paths.

Funerals in cemeteries may be performed from Monday to Friday from 9 a.m. to 3 p.m. and on Saturdays from 9 a.m. to 2 p.m.

All of the above rules affect safety within the area, as all the vehicles move on the same alley as pedestrians. It is estimated that between 50 and 70 cars enter the cemetery on weekdays.

During the course of the service in Gdansk the Economic Operator assessed that the number of cars entering the pilot route is higher, especially on weekends. He also brought to local SLM project coordinator's attention, that the vehicles entering the route exceed the limit of 5 km/ hr. Both factors, combined with large numbers of pedestrians and occasional cyclists' movement raised safety concerns in relation to removing the operator from inside of the vehicle and operating with remote supervision and occasional remote control. The Vehicle Operator, even though the room for remote control and teleoperation was provided in a distance of over 1 km from the pilot route, preferred to be onboard and manually overtake obstacles e.g. car parked alongside the route.

Safety concerns expressed by the service provider were also motivated by the fact that they were unable to provide internet connectivity along the entire route. Cellular network coverage in the cemetery wasn’t sufficient. The full provisioning of the teleoperation service required 6-10 Mbit bandwidth. Unfortunately, there was 200 m area in the route, where the bandwidth was not in the range. For the safety reason in this area service provider decided not to rely on remote observation.

Regarding particular 200 m part of the route, the Economic Operator decided to take two actions:

1) the speed of the vehicle was reduced to 5 km/h
2) leave a safety driver in the vehicle, but not conducting vehicle control tasks.

A teleoperation from a more remote center (in Estonia) was also tested but the speed of the vehicle decreased so much, that this solution was abandoned.

At the same time local remote-control center relied on local internet providers, all four that offer services on Polish market. Still The Economic Operator wasn't able to achieve a sharp picture of the route and its surroundings on all three monitors. The quality of the vision differed at times, and when the internet slowed down the two external monitors had a blurry image at the edges.

As a result, the service provider decided not to literally follow the service agreement and not to remove the vehicle operator from inside of the vehicle at a cut-off date, even though simultaneously, there was always a Travel Assistant onboard.

Throughout the pilot duration the Economic Operator tried to introduce teleoperation at least to some extent. They have performed number of analyses how to solve the challenge. The route was supposed to be driven in full teleoperation mode starting from the cut-off date specified in the contract but it turned out impossible. The cut-off date was then delayed by two weeks and finally a decision was made to teleoperate on weekdays and to move with a Vehicle Operator onboard on weekends, so that he could manually overtake vehicles from inside of the bus, without having to rely on variable bandwidth.

As it turned out during the pilot, potential risk whilst driving in a manual mode and or remotely controlling the bus depends on the technology used and the make and model of the vehicle, communications network and reaction time of the Vehicle Operator. As the Contracting Authority learned at the final stage of the pilot, in Iseauto safety sensors are not on whilst using the manual mode of operation.

Implementation process in relation to legislation, surveillance plans, underway adjustments

On the domestic front, the lack of legislation directly addressing autonomous vehicles has led the Ministry of Energy to come out in front of the autonomous revolution by introducing the Electromobility and Alternative Fuels Act on 22 February 2018. The law introduced a definition of an autonomous vehicle, which was defined as "a motor vehicle equipped with technologies and systems that exercise control over the movement of that vehicle and allow it to move without the intervention of the driver, who can take control of the vehicle at any time." The regulation also implemented the possibility of testing automated vehicles on public roads The project partner was confronted with the interpretation that, on the basis of these regulation, it is possible to only test a vehicle which is at most on the third level of automation,

as well as with interpretations that it is also possible to use vehicles on the fourth and fifth level.

Testing of autonomous vehicles in road traffic on public roads may only take place if safety requirements are met and a special permit is obtained - this is not a permit to register such a vehicle, but only a permit to conduct tests on a specific basis (Articles 65-65n of the Act on Road Traffic);

- the permit is issued by the traffic management authority on the road upon written request of the test organiser;
- the application for a permit must be accompanied by a document of third-party liability insurance of the test organiser, together with proof of payment of the premium for this insurance (the insurance will be conditional, subject to obtaining the permit), as well as (from July 2019) a copy of the decision on professional vehicle registration;
- only selected entities are able to obtain a decision on professional vehicle registration (especially entrepreneurs involved in testing new vehicles and manufacturers' testing units), and test drives will only be allowed with vehicles that have never been registered before - neither in Poland nor abroad;
- in order to obtain the permit, it will also be necessary to obtain the consent of the road manager (managing authority) and to have no objections from the owner of the property located along the planned test route, and to meet additional statutory requirements.

In order to enable lawful tests of autonomous vehicles, it would be necessary to modify the statutory conditions for obtaining permission to test autonomous vehicles as regards the need to have a decision on professional vehicle registration (it would be advisable to allow, for example, temporary registration dedicated to autonomous vehicles or any registration, including foreign ones), or to change the legal structure of professional vehicle registration (introduce an exception for autonomous vehicles);

- It is also necessary to clarify the possibility to separate the functions of the research work organiser (e.g. a municipal organisational unit) from the research work operator (e.g. the vehicle manufacturer);
- It would be recommended to extend the catalogue of entities entitled to obtain a decision on professional registration also to local government units (and their subordinate units);
- It would be advisable to extend the definition of an autonomous vehicle to include slow-moving vehicles and to consider the possibility of testing them without registration;
- It would be advisable to extend the definition of autonomous vehicles to include slow-moving vehicles and to consider the possibility of testing them without registration; the regulation on the exclusion of testing in the case of opposition of at least one owner of property along the planned test route should also be modified.

Taking into account that the definition of an autonomous vehicle in Polish legislation is relatively new and that obtaining permission for relatively short tests involves a lot of

administrative work, it was decided that it would be more rational to set up a demonstration route outside the public road network. This made sense, especially as the second pilot project in Gdansk was to be more technically advanced and use remote supervision instead of having the Vehicle Operator inside the vehicle at all times.

The project partner intended to organise a pilot in enclosed area that is a municipal land. Since during the first autonomous bus pilot in 2019 an opinion poll was carried out and a significant number of responders indicated that the good area of operation would be cemeteries, the largest one was chosen as a pilot site. The cemeteries, same as municipal roads are managed by the Gdansk Roads and Greenery Managing Authority, whose representatives are part of the SLM local steering committee. Consequently, the municipality only had to seek approval of this body to carry out a test. Since the alley at the cemetery is not a public road, no formal traffic organisation project needed to be approved or implemented. The service provider had to assess the situation at the cemetery and observe the rules of order of the place.

It was however expected that a service provider will deliver and programme a bus that is already registered, will be temporarily registered in Poland or to present an affidavit attesting to the possession of a slow-moving vehicle not exceeding a speed of 25 km/h. Consequently, such an affidavit was presented.

The responsibility for the pilot was borne by the Contracting Authority, which resulted, inter alia, from the following provisions of the contract:

- delivery of the bus together with the software licence at its own cost and risk,
- the Contracting Authority was obliged to carry out technological and logistical consultations with regard to the show route,
- programming the Bus to drive on the show route, as agreed with the cemetery manager,
- providing the operation of the bus by trained Vehicle Operators or providing training to drivers with D1 category, indicated by the Ordering Party and hiring them as Vehicle Operators,
- having throughout the duration of the agreement a civil liability insurance policy with respect to business activities associated with carrying out the subject matter of the contract for an amount not less than 5,000,000.00 PLN
- daily bus operation, including taking care of its technical condition and operational efficiency.

Human perception towards the driverless bus together with recommendations on the future LoD (language of driving)

The human perception towards an autonomous bus in Gdansk pilot can be considered from at least two perspectives of a bus passenger and potential passenger and from the perspective of other traffic participants.

At times when both the Vehicle Operator and the Travel Assistants were onboard the perception of passengers was very different to the time, when the bus was remotely supervised from the remote-control center. From the first days of the pilot, the Tavel Assistants were encouraging the more reluctant or shy visitors of the cemetery to use the autonomous bus service. These persons were then more confident to get onboard and some of them became regular passengers.

According the passenger survey over 54% of respondents saw the bus at the cemetery and approached it, which indicates that they were eager to use the shuttle and be assisted with their mobility need.

In future pilots it would be useful to implement two-way communication, if only in the form of a button with communication on demand at the time of teleoperation. If there is no travel assistant on board, the operator might not know that the passenger wants to get off at a different place than the scheduled stop. At the same time, passengers could then be informed if they are overbooked, if they need to cover their mouths and noses, or if they are advised to fasten their seat belts.

When it comes to other traffic participants, they were often surprised to see a bus passing them. Situations in which an autonomous bus moving through a cemetery was filmed and photographed by other visitors were not uncommon.

In order to facilitate the smooth piloting of the bus, the Economic Operator recorded voice announcements in Polish, kindly asking people to remove themselves from the route. Thanks to recorded audio information for other traffic participants at the cemetery, pedestrians as well as drivers of other vehicles knew that an autonomous bus was approaching them. They could also react to a request to leave the route. The recording of the message "Please leave the route" replaced the sound of the horn and was activated with a button by the vehicle operator.

The Economic Operator also recorded announcements of the names of each stop, which were heard by passengers.

During the pilot in Gdansk no LoD signs were developed or used.

Communications network requirements for remote-control driving and an evaluation of mobile network to carry out remote control functionality

However, 5G network will be important for commercial deployments of autonomous vehicles, in pilots similar to the one implemented in Gdansk, a 4G network will be sufficient under provided that certain conditions are met. These conditions include a

stable connection ensured throughout the area (in the case of teleoperation) with a transmission speed (sending data, not receiving) of not less than 10 mbps.

As it turned out during the pilot, providing adequate infrastructure requires time of min. two to three months. This process consists of an initial survey of network coverage, design of a solution for the area and implementation. Depending on the capabilities of the current infrastructure, this can be a user priority or provision of additional transmitters in the required area that strengthen the network signal. Unfortunately, due to the timeframe of the project, this was not feasible. The contract was signed on 15th September 2021 and the pilot was to be completed by 15th November 2021. According to Economic Operator this situation strongly affected the delay and launch of the teleoperation mode understood as provision of the service without a Vehicle Operator onboard in a way that the safety of all traffic participants is ensured.

The Economic Operator also reported that the situation around the cemetery strongly affected the network quality. There was a significant decrease in the speed and quality of internet connectivity at peak times around the cemetery due to increased number of vehicles around. The decrease was also experienced at weekends when there was an increase in the number of visitors. The speed required to carry out teleoperations in a secure manner is a minimum of 10 mbps upload.

When the number of mobile phone users in the area increased, the speed often dropped to 5-6 mbps and sometimes to 2 mbps and a complete lack of connectivity. When bandwidth was reduced, the Vehicle Operator monitoring the vehicle from the remote-control centre was not able to fully assess the situation around the vehicle due to the significant delay and poor quality of the camera image transmission. In moments of fading, he lost communication with the vehicle, which made it impossible to react and make decisions.

During the pilot, the networks of the four largest available operators in Poland were used, however, none of them allowed to achieve appropriate transmission quality at all times. Some of them did not even cover the entire route.

Conclusion on communications network downfalls from the perspective of the Ordering Party

The Contracting Authority had informed potential bidders during the ongoing open tender procedure, that this is up to them to provide network connectivity along the route. Even though the contract was signed late due to long offer evaluation period in the Municipality, the Economic Operator hadn’t expressed concerns prior to signing the contract, the teleoperation might be problematic. The only concert the Ordering Party was aware of, was the ability to carry out a full length of the pilot if the force Majeure happens. Still, the conclusion after the completed pilot is that more time is

necessary between the contract signing date and implementation, for the preparation of all components of the service. For future implementation of the autonomous bus pilot with teleoperation mode, it is suggested to state in the contact a minimum duration of the teleoperation activities within the whole pilot, rather than a cut-off date for implementation of this mode.

Driverless autonomous bus findings - obstacles in the process and recommendations for best practices

The significant obstacles to the implementation of autonomous bus pilots are many.

From the Project Partner's point of view, it is the fact that the market for bus rental and accompanying services is still young and it is a producer and service provider market rather than a buyer market - demand exceeds supply.

In Europe, there are no unified regulations governing the implementation of this type of technology, which may make potential contractors wary of implementing their services in countries where they lack experience yet.

Public procurement procedures also make commissioning services in the area of autonomous last mile transport challenging. In Poland, for example, tenders must be submitted electronically and signed with a qualified electronic signature. In Poland, bids in tenders are submitted via a portal launched by the national Public Procurement Office: https://miniportal.uzp.gov.pl/About, which has been developed in Polish language only. This makes it difficult for foreign bidders to become interested in public procurement proceedings. This is one of the reasons why, even before the tender was announced, the local project coordinator contacted potential service providers informing them about the expected scope of services and the public procurement requirements and procedures. The tender documentation was simultaneously announced in two languages (i.e. Polish and English) and the Contracting Authority was prepared to answer inquiries regarding the ongoing tender bilingually as well.

Another obstacle to the implementation of the pilot was the fact that the time for its preparation was relatively short, due to the fact that the Sohjoa Last Mile project was a continuation of another project.

The commissioning of high-tech services by a technical university is also different from that of a local authority, which has less knowledge of transport automation and teleoperation.

Especially the aspect of removing the operator from the vehicle and teleoperation, including remote supervision and remote control of the vehicle, was difficult to implement, and the experience from Gdansk is a lesson not only for the ordering party, but also for the companies involved in the service.

Nevertheless, the difficulties experienced and overcome by the Project Partner are valuable lessons for the future. In subsequent projects related to the implementation of the last mile autonomous transport, Gdansk will start with the experience of two earlier pilots and will correct the requirements and stipulations of the model contract for the provision of services.

Summary of recommendations for further development or research topics related to the output

Important if not the most important topic is truly driverless operation, which is connected with the need of remote supervision and remote control. As the Sohjoa Last Mile pilots shown, there are many approaches and technical solutions that might be adopted and different approaches to teleoperation. It is important to choose the optimal approach for each location and transport organiser. Therefore, feasibility studies might be another key step for further development of autonomous last mile services.

Finally, it is important to constantly monitor the state of art of autonomous vehicles and how the market for these and related services develops. For instance, different vehicles and companies have different approach to remote control and manual diving mode. Until the pilot in Gdansk, it wasn't clear to the project partner, that in Iseauto the safety sensors are off, when the vehicle is driven in manual mode. This wasn't the case for EZ10.

Also, as the market for autonomous mobility services develops and the services eventually become more affordable, it would be worthwhile to focus on autonomous fleet management and optimisation as well as on incorporating autonomous first and last mile connection into intermodal mobility chain.

Another issue that certainly needs further monitoring in view of the dynamic changes taking place is the legal regulation of autonomous mobility. At the moment, the law has not kept pace with the development of technology. Currently, at least in Poland, the law regulates the testing of autonomous vehicles, but does not provide for the launch of permanent public transport connections using autonomous vehicles.

Finally, the autonomous mobility is an interesting field for social science research as well as for creative marketing communications.