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ArtMED

PROMOTING GREEN LIVING AREAS

Vision Statement
Municipality of Palaio Faliro

MUNICIPALITY OF PALAIO FALIRO
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Document Information

Project id	**Euro-MED0200882**
Project Title	**Planning for autonomous mobility on demand in the Euro-MED area**
Project Acronym	**ArtMED**
Project Mission	Promoting green living areas
Programme Priority	Greener MED
Specific Objective	RSO2.4: Promoting climate change adaptation and disaster risk prevention, resilience, taking into account eco-system based approaches
Deliverable Number	D.2.2.1
Deliverable Title	4 vision statements from the 4 PTAs of ArtMED with input from the AMOD impact assessment tool.
Work Package Number	2
Work Package Title	Transferring the AMOD impact assessment tool to ArtMED PTAs to plan autonomous mobility on demand
Activity Number	2.2
Name of Activity	Using the AMOD impact assessment tool to develop the local vision statements for autonomous mobility on demand.

Partner in charge	Municipality of Palaio Faliro
Partners involved	LP1 PO, PP4 TML, PP5 ALOT
Date of production	December 2024

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Executive Summary

Palaio Faliro is taking its first step towards envisioning a transport service for three target groups and a separate case for waste disposal. Specifically, the three user-based scenarios will cater for elderly residents, school-aged children, and the general public, all enhanced by automated vehicles. This report evaluates the technical feasibility and economic viability of implementing such a service with 1 to 3 automated vehicles for the three target groups.

According to the analysis, the foreseen deployment area and intended service are very suitable for deploying automated vehicles. The area is rather small, flat, and most of the roads are one-way, ideal for a small fleet of up to 3 vehicles.

However, the main potential bottleneck are the needs of the target groups. Elderly people who cannot move around on their own may not be able to get in and out of the vehicles without assistance. Also, since booking the trip might be a challenge, the target group would need to be carefully analysed to determine the level of assistance required.

For school children, the limitation is both the financial viability of the project, as well as the time limitations imposed due to the school's timetable. Specifically, with a fleet of only 3 vehicles, a limited mount of children can be serviced, and multiple trips need to be made to accommodate for them. Another issue is that children require adult supervision, which introduces costs that may offset the overall financial viability introduced due to not requiring a driver or a fossil fuel.

The general population use-case is hampered by the sheer size of the population, creating a huge bottleneck in services, since only a minute fraction of residents can use the service, and there is no capacity to increase the fleet size. Additionally, the repeated use of the service can cause damage to the fleet, introducing increased maintenance costs, in relation to other use cases.

The waste disposal case scenario is promising, but it does face the problem that the required vehicles are considerably more expensive and more difficult to acquire, which introduces logistical problems.

The reason multiple populations were examined was due to the economic viability of the transport service, in comparison with a conventional service with drivers, does not look as promising as other use-cases in other parts of Europe. This is due to the combination of the relatively low impact of driver wages on operations costs and the limited size of the fleet and target group. Therefore, it could be considered to expand the target group with other types of travellers such as students and tourists.

Automated transport shows great potential to improve the mobility and quality of life of its elderly residents, students and general population, within a medium-term period through the use of automated vehicles. However, it requires further examination and additional funding to allow for further analysis and testing.

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Introduction

In recent years, the development of Cooperative, Connected and Automated Mobility (CCAM), with recent examples in Oslo, Hamburg and Flanders, has shown great potential to revolutionise public transport. Within the ArtMED project, public authorities including Palaio Faliro are investigating the feasibility and viability of implementing a CCAM-based public transport service. This report examines the case of Palaio Faliro, a coastal municipality in the province of Athens with a population of 65,000, which specifically aims to improve transport in the municipality for elderly people, students, the general population, as well as assess a potential use of AMODs in waste disposal. In terms of transportation, the envisaged service would use 1-3 self-driving shuttles or taxis to provide on-demand transport from residents' homes to public services such as the Town Hall, without fixed timetables or routes. These three use-cases will utilize very similar data, as they are the same with the only difference being the target population. For the waste disposal use-case, different data will be utilized due to the significant differences in service and costs.

In order to develop a future vision for automated transport in Palaio Faliro, it is essential to address key questions both for the area and the service.

According to this, the primary objective of this report is to assess whether such a service can be effectively and efficiently implemented in Palaio Faliro. To achieve this, the report will analyse both the technical feasibility and the economic viability of the proposed CCAM service. The technical feasibility analysis will consider the current state of autonomous vehicle technology, infrastructure requirements and potential operational challenges in an urban environment such as Palaio Faliro. Meanwhile, the economic feasibility analysis will assess the costs associated with deploying and maintaining the service.

By exploring these dimensions, the report aims to provide a comprehensive understanding of the prospects for CCAM in Palaio Faliro and a realistic timeline for implementation. This will help stakeholders to make informed decisions about the adoption of innovative mobility solutions to improve the quality of life of elderly residents with reduced mobility.

Figure 1. Pilot in Lamia (GR), part of the EU project FABULOS, with automated vehicles from Auve Tech.

1. UNLOCKING THE POTENTIAL

1.1 TECHNICAL FEASIBILITY ASSESSMENT OF THE AUTOMATED SERVICE DEPLOYMENT

According to the parameters of study provided by the municipality, we assess the technical feasibility of deploying an automated transport service consisting of 1 to 3 vehicles for elderly people in Palaio Faliro area. We do this by analysing the deployment area, service model, and target group. The methodology, developed by leading CCAM experts, is explained in the 2023 European CCAM Outlook 1. For each variable, we have created a score that indicates the level of technical feasibility for automated service implementation.

1.1.1 Deployment Area

Service coverage	**Score: 7/10**

Covering a total area of 5.5 square kilometres and with a route length of 30.4 kilometres, the deployment area encompasses the entire Palaio Faliro municipality. Mapping and serving a complete area for automated transport is more complex than a short single stretch of road (a first-last mile) route. Additionally, legislation and permitting are more complicated. However, the area is still relatively small, especially compared to areas where deployment is planned in the short term, such as Oslo's Grorud Valley, which covers an area of 21.75 km2. Therefore, covering the intended service in the entire municipality can be considered a feasible endeavour.

Operational domain	**Score: 8/10**

The new service will operate within standard traffic lanes, respecting legal speed limits of 3050 km/h. These limits are ideal for predominantly one-way streets and help to maintain a safe environment for all road users. The relatively flat terrain of Palaio Faliro further simplifies operations and reduces the potential for technical challenges associated with steeper slopes. In conclusion, the absence of significant hills ensures that automated vehicles can navigate the area smoothly and reliably.

Traffic Type	**Score: 6/10**

Mixed traffic, including cars, taxis, buses, and pedestrians, poses complexities, with street parked cars adding unpredictability due to abrupt stops or sudden departures. However, predominantly one-way streets alleviate the challenges of busy multi-lane roads, facilitating smoother navigation for automated vehicles. This setup enhances feasibility for automated transport deployment. Yet, coastal areas present parking challenges, particularly during peak periods like summer and holidays, when high volumes of visitors and residents congest the area. This scenario can significantly impede automated shuttles, leading to difficulties in manoeuvring through narrow streets.

Vehicle Type	**Score: 10/10**

Given the limited size of the target group, the proposed service requires a vehicle no larger than a shuttle, with a maximum capacity of 12 passengers. The choice of a smaller vehicle is crucial both to limit initial costs and to meet demand while ensuring adequate passenger capacity. A smaller vehicle significantly increases the feasibility, flexibility and responsiveness of deploying automated transport, particularly in terms of initial cost and manoeuvrability in narrow and busy streets.

Fleet size **Score: 9/10**

An initial fleet size of 1 to 3 vehicles results in limited risk and investment, allowing for future scaling according to demand and success. This approach facilitates future implementations of autonomous mobility within and outside the district, ensuring sustainability and adaptability. Furthermore, keeping fleet numbers of low increases the feasibility of implementation, as no major structural changes are required within the transport system.

Timetable **Score: 9/10**

A flexible timetable increases the complexity of the on-demand service and requires careful consideration of ride request platforms for the overall implementation. Digitalisation is imperative in this regard. The service, which will operate within a fixed time window from 07:00 to 16:00, provides predictability and consistency and accommodates most of the daily activities. In addition, it is also preferable that the service does not operate throughout the entire day, as it allows time for maintenance, parking and charging, which become increasingly complex as the time available decreases.

Service speed **Score: 9/10**

The service is expected to adhere to the speed limits of the area (30km/h-50km/h) in order to ensure the safety of the physically impaired and to comply with regulations. In the past, pilot projects focused on maximum speeds of 15 km/h, while the new generation demonstrates the feasibility of speeds of up to 80 km/h. This advancement makes it possible to provide an automated service with higher expected speeds, improving efficiency and safety levels.

Road property **Score: 7/10**
Service coverage

The public ownership of the roads in Palaio Faliro simplifies certain operational aspects, such as route modification and maintenance. However, the public bureaucracy could take longer to implement such a service, but this depends on the administrative efficiency of the municipality and other relevant bodies.

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1.1.2 FEASABILITY AND TARGET GROUPS

Elderly Assistance	Score: 6/10

The feasibility of automated transport in Palaio Faliro is likely to be most influenced by the intended target group of 80 to 130 elderly people. On-board support from a designated driver is highly appreciated and, in some cases, even necessary, as on-board technology can provide physical and psychological support to a certain extent. It is important for the local authority to assess the need for staff assistance for persons with reduced mobility. The final feasibility will depend on various variables related to the elderly, including age, mental capacity, and levels of mistrust or confidence in automated transport.

School Transport	Score: 4/10

The proposed service area covers 5.5 square kilometres, with 30.4 kilometres of mapped routes. The relatively small size and flat terrain make the area highly suitable for automated vehicle deployment. The predominance of one-way streets further enhances navigability and safety, although peak traffic and parking congestion during school hours may pose challenges. The service focuses on 72 school children, necessitating tailored solutions such as onboard safety features and potential supervision. The small fleet size and manageable routes make it necessary to conduct two trips per bus (two in the morning and two after school), in order to reach the number desired. However, this means that the first group of children in the first trips will need to be at school almost an hour before it starts. This, alongside financial issues that arise during analysis, make it a difficult use case.

General Transport	Score: 5/10

This use case will assess the viability of a service that will run for the whole population of the municipality, which is about 65.000 people. The fleet consists of three 12-seater automated shuttles. Each bus will run 45-minute loops for 16 hours daily, completing approximately 16 trips per bus per day. This results in 48 total trips daily across the fleet. With 12 passengers per trip, the service can accommodate up to 576 riders daily. To ensure financial viability, two options will be considered, pay-per-ride and a subscription model. One of the main issues with this case is the limited number of people it can cater for, as well as the difficulty of personalizing it, to the same extent as the previous two cases, due to the sheer number of possible users. If this case is examined, we will be running it on an extended pilot to assess the viability of a more expansive service.

Waste Disposal	Score: 6/10

As urban areas grow and environmental concerns intensify, municipalities worldwide are exploring innovative solutions to modernize their public services. Waste management is a critical area where automation and electrification can bring transformative benefits. Conventional garbage trucks, while reliable, are increasingly seen as costly and environmentally detrimental due to their reliance on fossil fuels and significant operational expenses. Automated electric garbage trucks (AMODs) present an alternative that combines advanced technology with eco-friendly practices. By eliminating the need for drivers and reducing reliance on diesel fuel, AMODs promise to revolutionize waste management. This report evaluates the feasibility of deploying AMODs in Palaio Faliro, comparing them to traditional trucks in terms of costs, efficiency, and sustainability.

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1.1.3 MILESTONES FOR DEPLOYMENT FOR TRANSPORTATION CASES

Having assessed the feasibility of the use case in Palaio Faliro, the next question is what milestones need to be achieved in order to deliver the use case. Following the methodology of the 2023 European CCAM Outlook, the use case specifications show which milestones need to be achieved and whether the milestone can be achieved in the short, medium or long term. The table illustrates the feasibility of implementing a CCAM service over time. Each row represents key requirements such as regulations, social acceptance, technology performance and infrastructure adaptations. The columns represent the variables mentioned in the use case. Yellow and orange blocks highlight the interdependencies (and levels) between them, indicating which requirements need to be met for feasibility and in what timeframe it is most profitable to implement the service.

For Palaio Faliro, as shown in the table, the main requirements to launch the service are for the first three use cases (transportation):

01. Social acceptance

Based on the transportation scenarios, social acceptance is a considerable factor in the first three cases, less so in waste management. One of the challenges is that the service must cater to the unique needs of each group. For the elderly, these users often require special assistance integrated into the vehicles, tailored to their varying levels of autonomy. Elderly users may face challenges with digitalization, such as booking stops and using automated transport systems. To overcome these challenges, the service must ensure it is intuitive and easy to use. Incorporating onboard assistance can greatly enhance usability and build confidence among elderly passengers.

Student users on the other hand will require adult supervision, as well as provision of assurances to their parents that they will be safe before, during and after the trip. One major risk of this use case is if students opt to not board the bus and who is responsible in this case.

For the general population, while the burden of support is less heavy, many of the users will have similar issues as the elderly, due to Palaio Faliro being home to a generally aging population.

02. Vehicle Performance

Serving the target groups will require high technology performance to provide assistance to entering and leaving the vehicle. This relates particularly to in-vehicle technology, specially with the elderly who may require special provisions. Furthermore, the area’s narrow streets and the potential for heavy traffic congestion, particularly during holiday seasons require the automated vehicles to have performance capabilities to navigate these conditions effectively.

03. Administrative regulations

Since the service will operate in public areas, the local administration must grant the necessary authorizations and adapt existing regulations to support the service. This includes the adaptation of general permits, but also more specific regulations such as for parking spaces and other local rules needed to improve the efficiency and functionality of the automated service.

According to the timeline, all variables indicate that the municipality needs to adapt the regulations and better assess the needs of the target group. The optimal period for implementation is the medium term, from 2030 to 2035, in line with the expected drop in prices and the increased availability of automated vehicles.

In conclusion, the complexity of the use-case is predominantly determined by the target group and requires careful consideration and appropriate outreach to understand their autonomy and tailor assistance accordingly. In addition, dealing with both elderly and children has an impact on public acceptance of automated transport, with lower digital literacy rates among elderly groups and a heavier burden of responsibility in children leading to many finding the process of accessing an automated ride confusing or unsafe. It is therefore also important to tailor the service to the social aspects of this category.

	Time needed	SC	OD	TT	VT	FS	T	SS	RP	TG
Milestones		Medium	Medium complex	Medium complex	RT/AS	Small	On demand	Medium	Public	PRM
Mature regulations, simplified permit process	Mid	Priority							Priority	
High social acceptance	Mid			Priority				Secondary	Priority	Priority
High performance tech	Mid		Priority	Priority				Priority		
Safety operator removed from vehicle	Short					Secondary				
Fleet manager possible	Short					Secondary				
Remote control possible	Short				Secondary	Secondary				
Smart infra	Mid		Secondary	Secondary						
Advanced accessibility features	Long									Priority
Commercial availability	Mid				Priority					

Legend:

SC: Service Coverage · **OD:** Operational Domain · **TT:** Traffic Type · **VT:** Vehicle Type · **FS:** Fleet Size · **T:** Timetable · **SS:** Service Speed · **RP:** Road Property · **TG:** Target Group

Priority (orange) · Secondary (yellow)

Short: 2025-2029 · **Mid:** 2030-2034 · **Long:** 2035-2040

1.2 ECONOMIC VIABILITY ASSESSMENT

Besides the changes in operation of public transport systems, such as remote teleoperators instead of in-vehicle drivers, CCAM will also revolutionise the economic model of public transport, particularly the cost structure. Traditionally, public transport systems have significant operational expenditure (OPEX) due to the need for human drivers who require salaries, benefits, training and pension contributions. Automated vehicles promise to significantly reduce the costs associated vehicle operation, as the driver is expected to be replaced by remote operators who can operate multiple vehicles simultaneously.

On the other hand, the initial investment in automated transport systems results in a significant increase in up-front capital expenditure (CAPEX) due to the need for more advanced technology and vehicles, infrastructure adaptations and systems integration, such as digital mapping of the service area.

This section explores the changes in CAPEX and OPEX implied by a shift to CCAM, analysing the economic viability and cost structure of deploying an automating public transport system in PF.

However, the general economic evaluation does not aim to predict exact outcomes, but rather to highlight the positive impact of key variables directly affected by automation. It is therefore important to note that this evaluation only considers three key scenarios to provide a simple and clear understanding of the benefits of implementing an automated service, without diving into detailed budgeting. Variables related to the detailed costs of CAPEX and OPEX, such as fare demand/revenue, inflation and other specific operating costs such as on-demand operations and maintenance, are considered on a ceteris paribus basis, i.e. their possible variations are not taken into account in this analysis.

1.2.1 OVERVIEW OF COST COMPONENTS

CAPEX:

01. Vehicle cost

The initial purchase cost depends on the type of vehicle chosen for the service. The options considered in our analysis include 1) nonautomated conventional cars for comparison, 2) robotaxis and 3) automated shuttles. At the moment, shuttles are more expensive than robotaxis or conventional cars as shuttles are purpose-built vehicles while robotaxis are retrofitted conventional cars (e.g. from Renault and NIO). The type of vehicle also affects the accessibility of the service, especially for certain target groups. For example, if there are many wheelchair users, a shuttle would be more suitable than a conventional car or a robotaxi. The current average price of an autonomous shuttle is around €250,000, a robotaxi costs around €150,000. In our comparative analysis we use the price of €25.000 for a conventional car.

02. Area mapping

In order for the automated vehicles to drive in the deployment area, they need to have a digital map integrated in their software. The map entails detailed information of the road quality, height of speed bumps and curbs, and the routes + potential (bus) stops. Mapping the area for the deployment of autonomous vehicles involves initial costs that can be amortised over time, especially if the service is operated on a large scale for a long period of use. The larger the area, the higher the mapping costs. This expense is part of the initial CAPEX, but it is more cost effective to map a large area initially to allow for future service expansions. At the moment, for mapping around 30kms of routes, the costs associated are around €20,000.

03. Infrastructure adjustments

Even though automated vehicles are intelligent enough to navigate along the routes without the need for advanced V2X (or V2I) technology, some adjustments to the physical infrastructure will have to be made to smoothen the ride. Examples are clear road markings, traffic signs, and clear (bus) lanes. For an area of the size of PF, we estimate the upfront costs to be around €20,000.

This reduction has a positive impact on the municipal budget, but it's crucial to maintain the expected 1:6 teleoperator to vehicle ratio for cost efficiency, otherwise the savings will diminish and the time needed to recoup the initial CAPEX will extend.

In addition, areas with higher salaries achieve cost-effectiveness more quickly. For the analysis, we assume the costs of the driver/remote operator in PF to be around: €30,000 per year.

04. Fleet size

The size of the fleet (1, 3 vehicles) has a significant impact on the long-term cost-benefits. Larger automated fleets gain from economies of scale in CAPEX terms, as the mapping services and infrastructure adjustments are done once, and costs can be divided across vehicle units. Therefore, the average CAPEX per vehicle goes down. However, the major benefit is expected in the operating costs. Our analysis considers different fleet sizes to illustrate the different economic impacts of these options.

OPEX:

05. Operating costs of the driver

A key variable that distinguishes conventional from automated services is the cost of driver salaries. In automated services, it is currently expected that a teleoperator can manage around six vehicles from one teleoperation facility, as opposed to traditional services where each vehicle requires a driver.

EXTERNAL FACTORS:

06. Possible price fluctuation

Price variation for automated services is a critical factor. According to McKinsey, significant reductions in CAPEX for robotaxis and shuttles are expected due to technological advances, market competition, and different adoption scenarios. Estimated reductions range from 515% per year, with aggressive projections suggesting up to an 50% reduction by 2030 from 2023 levels. The pace of this price reduction influences the timing of investments.

Below we show how different scenarios, constituted by: type of vehicle, fleet size, starting date of purchase vehicles and price changes, impact the economic viability of deploying an automated transport service, in comparison with a transport service with conventional cars.

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1.3 IMPACT ANALYSIS

	Vehicles	1	1	1	3	3	3	6	6	6
CAPEX	€ x 1 vehicle	€25k	€150k	€250k	€75k	€450k	€750k	€225k	€1.35M	€2.25M
CAPEX	Mapping service (30km route)		€20k	€20k		€20k	€20k		€20k	€20k
CAPEX	Road adjusting		€20k	€20k		€20k	€20k		€20k	€20k
OPEX	1 driver salary	€30k	€30k	€30k	€90k	€30k	€30k	€180k	€30k	€30k

Conventional car · Robotaxi · Automated shuttle

The main purpose is to understand how different factors are affecting the economic viability, i.e. when the total cost of an automated transport service is lower than the total cost of transport service with a conventional car, as the OPEX of the shuttle and robotaxi fleets amortises their initial CAPEX.

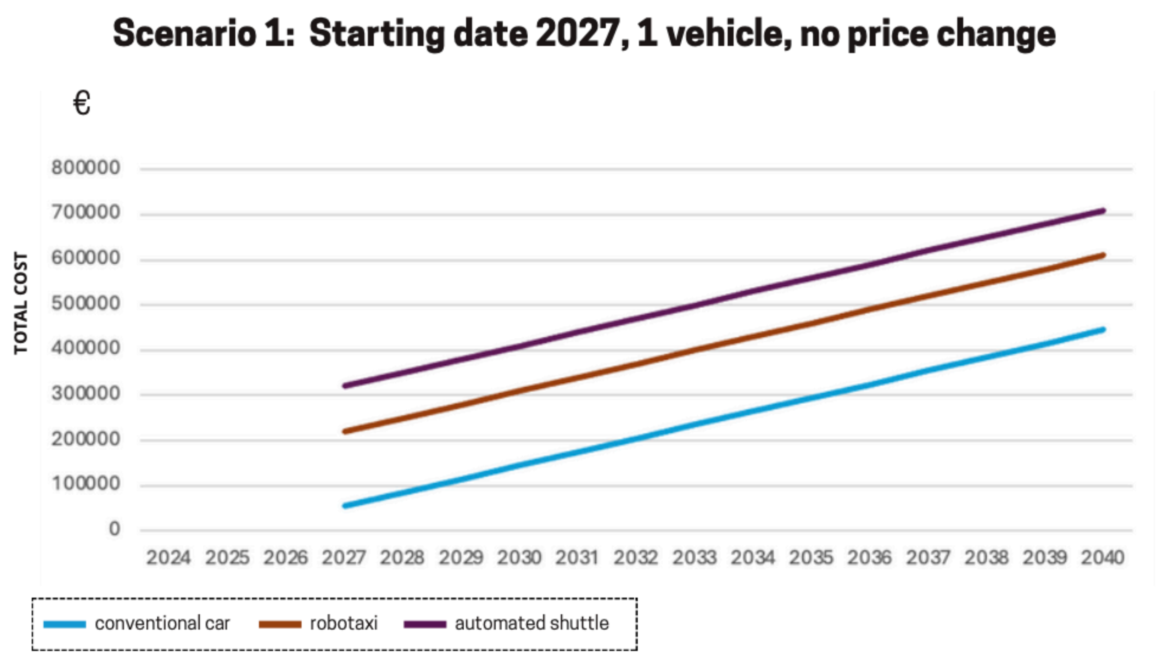

Figure 2. Scenario 1: Starting date 2027, 1 vehicle, no price change

The initial capital expenditure (CAPEX) for both the robotaxi and the automated shuttle is significantly higher than that of the conventional car. For instance, in 2027, the CAPEX for a robotaxi is €190,000, while for an automated shuttle, it is €290,000. In contrast, a conventional car requires only €25,000.

In terms of operational expenditure (OPEX), there is no difference as the shuttle, the robot-taxi and the conventional car are all operated by one person, either remotely or in the car itself. Therefore, with only one vehicle, the high CAPEX is a significant burden. However, as the fleet size increases, the financial viability improves, as shown in the next scenario.

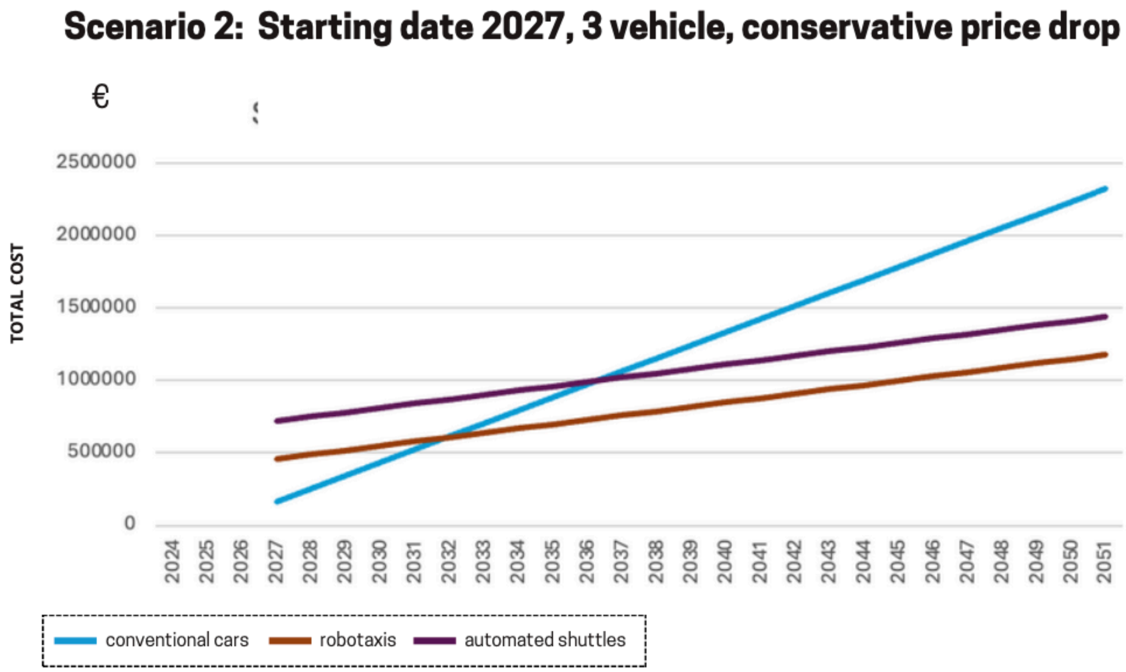

Figure 3. Scenario 2: Starting date 2027, 3 vehicle, conservative price drop

The graph compares the three types of vehicles - conventional cars, robotaxis and automated shuttles - now consisting of a fleet of three vehicles. Here, it is assumed that the service will start in 2027, with a conservative price decrease of 2% to 5% between 2024 and 2027. The initial capital expenditure (CAPEX) for three shuttles is approximately €600,000, for three robotaxis €430,000 and for three conventional vehicles €75,000. The graph shows that the break-even point could be reached for in 2032 for the robotaxis and in 2037 for the automated shuttles. In fact, the operating expenses (OPEX) for the two automated services gradually recoup the initial investment, but not quickly, as the teleoperator to vehicle ratio is 1:3 instead of the more efficient 1:6 due to the fleet size. However, it is clear that the fleet size and price reduction forecasts have a significant impact on the economic viability and cost-effectiveness of implementing an automated service.

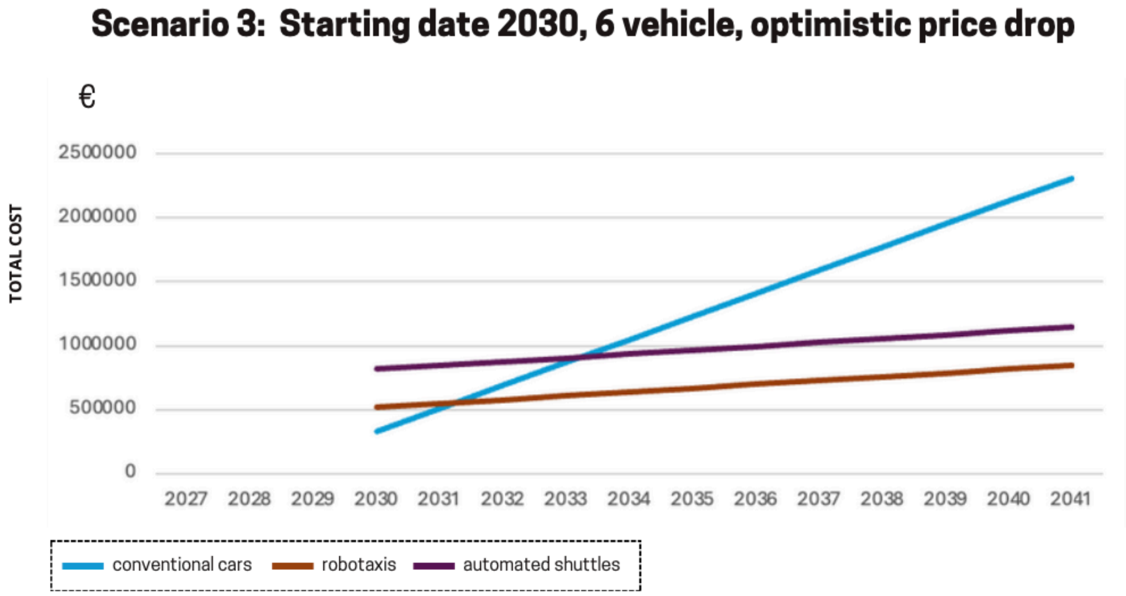

Figure 4. Scenario 3: Starting date 2030, 6 vehicle, optimistic price drop

The CAPEX for a fleet of 6 robotaxis will be around €490,000 in 2030 in the optimistic scenario that prices have dropped by about 50%. The CAPEX for 6 automated shuttles in this scenario is estimated at €785.000. With a fleet of 6 vehicles, the OPEX per year for conventional cars is €180,000, while for robotaxis and automated shuttles it's €30,000, because the ratio of 1:6 teleoperators per automated vehicle is maintained. This means that the OPEX savings are fully realised with a larger fleet. With the lower CAPEX and maintained OPEX, the break-even point for implementing the service is reached much earlier, after 3 years of operation of the Robot taxis and after 5 years for the automated shuttles. To sum up, this optimistic scenario highlights the potential for future developments and cost reductions in automated vehicle technology, making it a more viable option for elderly transport services in the near future.

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1.4 CONCLUSION FOR TRANSPORTATION CASES

The analysis of CCAM in Palaio Faliro shows promising potential for improving transport services with AMODs, as both the deployment area and the proposed deployment model are feasible for implementation in the short to medium term. The municipality's relatively compact size and favourable terrain, coupled with advances in automated vehicle technology, support the practical application of self-driving shuttles or taxis.

Economically, however, the small scale of the proposed service presents challenges. High initial capital expenditure (CAPEX) is a significant barrier, although expected technological advances and price reductions over the next decade may mitigate these costs. Increasing the size of the target group, and therefore the size of the fleet, could improve the economic viability. As the cost of automated vehicles falls, and with potential subsidies and funding from European Union programmes such as the Connecting Europe Facility (CEF) from 2027, EU structural funds (e.g. ERDF) and European Investment Bank (EIB) financial instruments such as ELENA, the economic outlook for the service becomes more favourable.

The main challenge remains to address the specific needs of the target groups. If the service is targeted at older people who require extensive physical or mental assistance, the feasibility is significantly reduced due to the need for on-board support and the potential reluctance to adopt automated solutions. For children, special safety provisions need to be taken into consideration, as well as scheduling problems with school. On the other hand, targeting people who require minimal assistance and special provisions increases the feasibility and user acceptance of the service, but faces difficulties in terms of population size and service capacity.

While there are significant technical and economic Deployment area considerations, further detailed analysis and budgeting could enable Palaio Faliro to implement a CCAM service by 2030. Part of this work will be supported by the ArtMed project, but securing EU funding will also be crucial to accelerate the preparation and partially cover the initial high CAPEX investment.

In conclusion, the results highlighted in this document mark the first step towards realising the vision of automated mobility in the municipality, thus outlining the necessary actions for this service deployment and laying the foundation for further implementations.

1.4.1 KEY RECOMMENDATIONS

- Detail the needs of the target audience. Analyse what support they need to use the service. Consult the market to find out to what extent technology will be able to support people with reduced mobility.
- Develop a more detailed investment and budget plan (within of the Interreg ArtMED project) to detail cost scenarios and (potential) revenues.
- Involve stakeholders such as the Road and Transport Authority to discuss regulations for deployment.
- Explore (EU) funding programmes such as the Connecting Europe Facility (CEF) from 2027 onwards, EU Structural Funds (e.g. ERDF) and European Investment Bank (EIB) financial instruments such as ELENA to support all the above activities and ultimately provide financial support for the required investment.

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- Increase knowledge of automated transport in Palaio Faliro by getting involved in EU networks, and learning from other cities, projects and implementations in Greece and abroad.

1.4.2 MILESTONES FOR DEPLOYMENT OF WASTE MANAGEMENT CASE

As urban areas grow and environmental concerns intensify, municipalities worldwide are exploring innovative solutions to modernize their public services. Waste management is a critical area where automation and electrification can bring transformative benefits. Conventional garbage trucks, while reliable, are increasingly seen as costly and environmentally detrimental due to their reliance on fossil fuels and significant operational expenses. Automated electric garbage trucks (AMODs) present an alternative that combines advanced technology with eco-friendly practices. By eliminating the need for drivers and reducing reliance on diesel fuel, AMODs promise to revolutionize waste management. This report evaluates the feasibility of deploying AMODs in Palaio Faliro, comparing them to traditional trucks in terms of costs, efficiency, and sustainability.

The main challenge in this case remains the availability of vehicles, the technology required and the upkeep of it, as well as costs of AMOD conversion in case of unavailable vehicles. These significantly affect the timeline in terms of fleet size.

One of the advantages of this use case is the simplicity of necessary permits, as waste disposal is entirely on the local authorities and does not require heavy bureaucracy from any other authority, unlike transportation. A disadvantage, however, on top of the availability of technology is that waste disposal trucks are significantly more difficult to handle than shuttles and will therefore require more careful infrastructure planning and possibly remote control if necessary.

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	Time needed	SC	OD	TT	VT	FS	T	SS	RP	TG
Milestones		Medium	Medium complex	Medium complex	RT/AS	Small	On demand	Medium	Public	PRM
Mature regulations, simplified permit process	Mid	Priority			Priority					
High social acceptance	Mid									
High performance tech	Mid				Priority		Secondary	Secondary		
Safety operator removed from vehicle	Short					Secondary				
Fleet manager possible	Short					Secondary				
Remote control possible	Short				Priority	Secondary				
Smart infra	Mid		Secondary	Priority						
Advanced accessibility features	Long									
Commercial availability	Mid				Priority	Priority				

Legend:

SC: Service Coverage
OD: Operational Domain
TT: Traffic Type
VT: Vehicle Type
FS: Fleet Size
T: Timetable
SS: Service Speed
RP: Road Property
TG: Target Group

Priority
Secondary

Short: 2025-2029
Mid: 2030-2034
Long: 2035-2040

Conventional Garbage Trucks vs. Automated Electric Garbage Trucks

Cost Breakdown (12 Years, 40 km/day) for Conventional Garbage Truck (Diesel)
Fuel Costs: €87,600
Maintenance Costs: €26,280
Driver Salaries: €252,000
Initial Purchase Cost: €300,000
Total Costs: €665,880

Cost Breakdown (12 Years, 40 km/day) for Automated Garbage Truck (AMOD, Electric):
Energy Costs: €35,040
Maintenance Costs: €17,520
Driver Salaries: €0
Initial Purchase Cost: €500,000
Total Costs: €552,560

Operational Efficiency:

AMOD trucks leverage advanced sensors and autonomous navigation systems to optimize routes and minimize energy consumption. This technology also reduces the risk of human error, contributing to safer and more reliable operations. Conventional trucks, on the other hand, depend on manual operation, which can lead to inefficiencies and higher fuel consumption due to suboptimal routing and idling.

Initial Purchase Costs:

The initial purchase price of a conventional diesel garbage truck is approximately €300,000, reflecting the standard cost for a reliable, mid-range vehicle used in municipal waste management. In comparison, the cost of an automated electric garbage truck is estimated at €500,000. This higher price accounts for the integration of advanced autonomous driving technologies and electric drivetrain components, which are essential for efficient and sustainable operations. While the upfront investment for AMOD trucks is higher, the substantial long-term savings and environmental benefits justify the cost.

Operational Costs:

- Diesel trucks incur significantly higher fuel and maintenance costs due to the mechanical complexity of internal combustion engines and the fluctuating cost of diesel fuel.
- Driver salaries form a major portion of the operational costs for conventional trucks, accounting for over 68% of their total expenses. This cost is entirely eliminated with AMODs.

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Environmental Impact:

Diesel trucks contribute substantially to greenhouse gas emissions and air pollution. For every liter of diesel burned, approximately 2.68 kg of CO_2 is emitted.

AMOD trucks, powered by electricity, have a significantly lower carbon footprint. Even when accounting for emissions from electricity generation, their environmental impact is minimal compared to diesel trucks.

Long-term Financial Benefits:

- Over 12 years, AMOD trucks offer savings of €113,320 compared to conventional trucks, representing a reduction of over 17% in total costs, including the purchase price.
- The lower maintenance requirements of electric drivetrains and the elimination of fuel costs contribute to these savings.

Scalability and Future Potential:

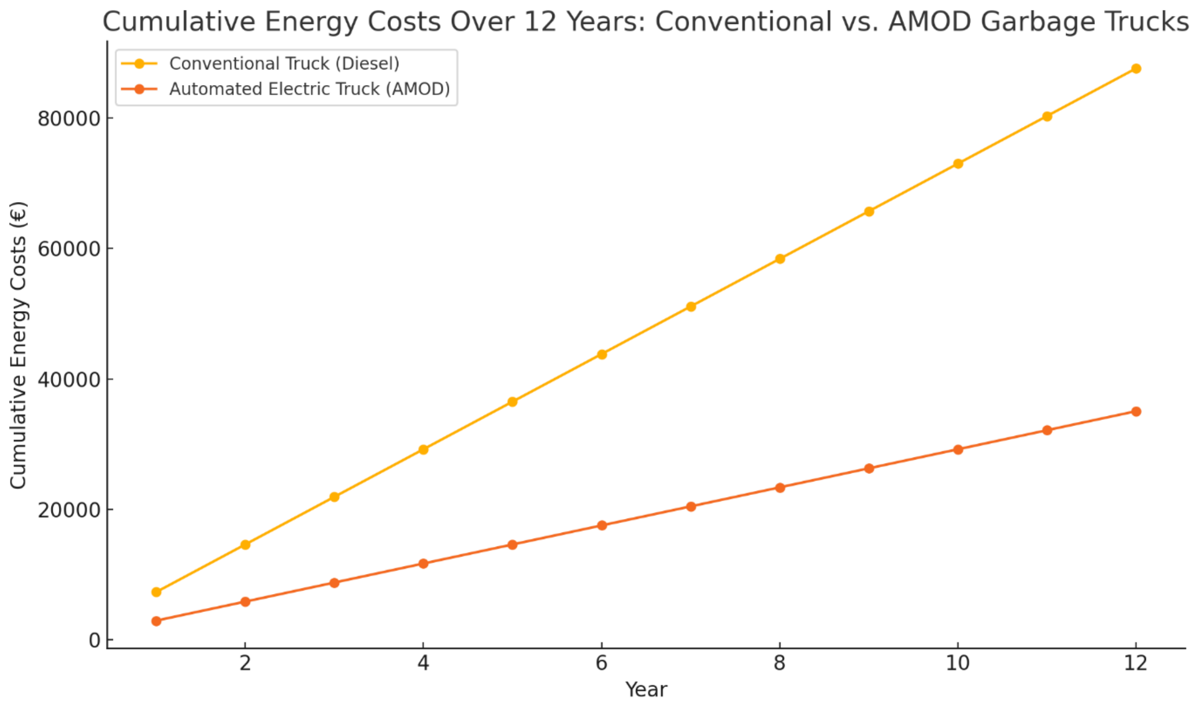
As battery technology continues to improve and the cost of autonomous systems decreases, AMOD trucks are expected to become even more cost competitive.

The transition to AMODs positions Palaio Faliro as a leader in sustainable urban waste management.

Detailed Cost Analysis

Fuel and Energy Costs:

Conventional trucks consume approximately 13,333 liters of diesel over 12 years, assuming an efficiency of 3 km per liter. With diesel prices averaging €1.5 per liter, the total fuel cost amounts to €87,600. AMOD trucks consume approximately 14,600 kWh of electricity over the same period, assuming an efficiency of 1 km per kWh and an electricity cost of €0.2 per kWh. This results in a total energy cost of €35,040.

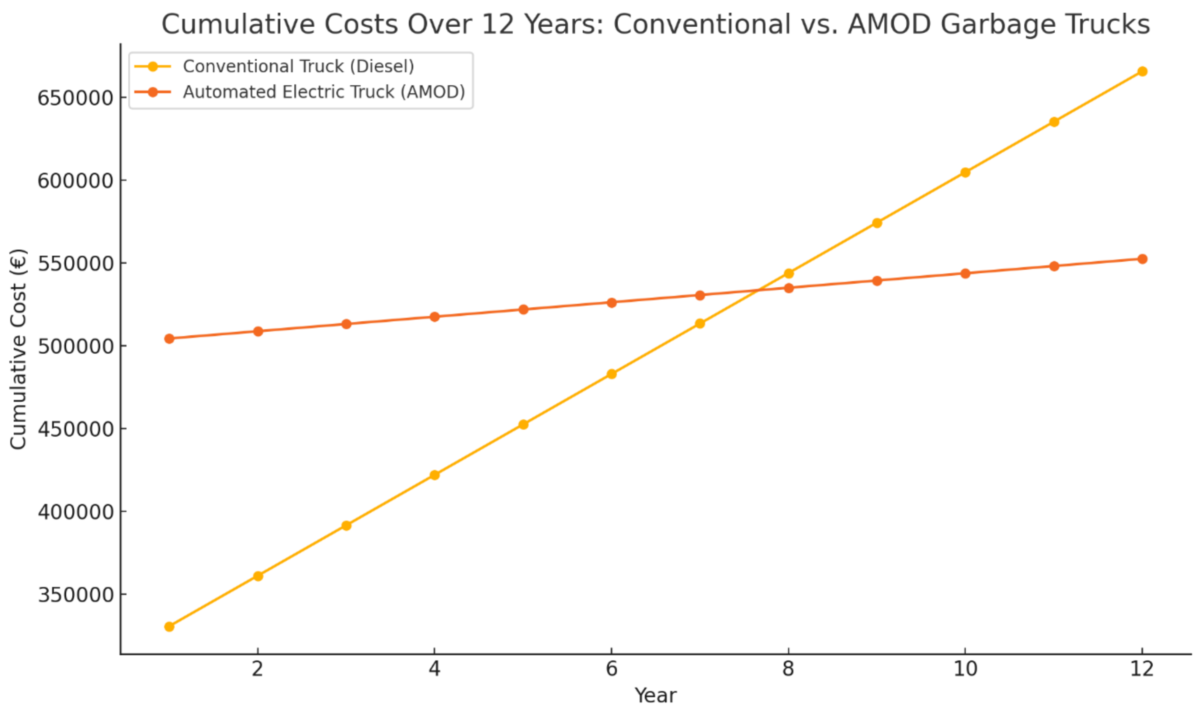


Maintenance Costs:

Conventional trucks require regular engine maintenance, oil changes, and part replacements, resulting in an average annual maintenance cost of €2,190. AMOD trucks, with fewer moving parts and no internal combustion engine, have an average annual maintenance cost of €1,460, primarily for battery checks, software updates, and minor repairs.

Driver Salaries:

Conventional trucks require full-time drivers, with annual salaries averaging €21,000, including benefits. Over 12 years, this totals €252,000. AMOD trucks eliminate this expense entirely, as they operate autonomously.



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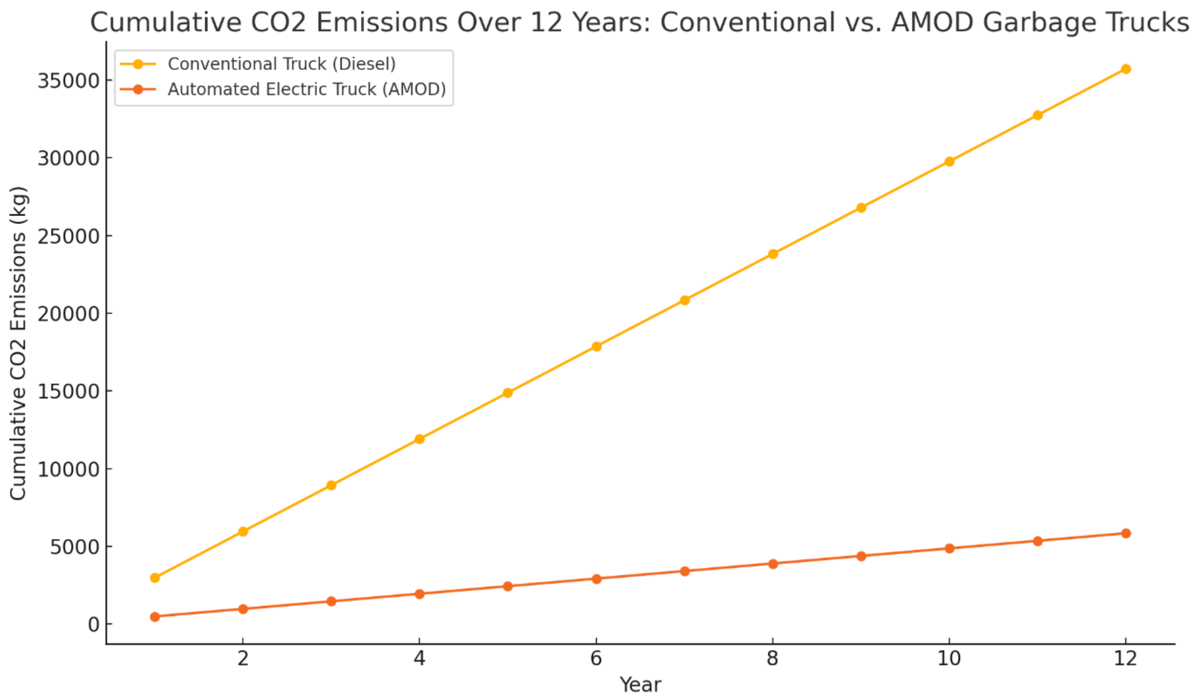
Environmental Benefits

CO2 Emissions:

Conventional trucks emit approximately 35,733 kg of CO2 over 12 years, based on their diesel consumption. AMOD trucks produce negligible direct emissions. When accounting for electricity generation, their total CO2 footprint is approximately 5,840 kg over the same period, representing an 83% reduction in emissions.



Noise Pollution

Diesel engines generate significant noise, especially during early morning operations. AMOD trucks operate almost silently, reducing noise pollution and improving the quality of life for residents.

1.4.3 Feasibility Study of Waste Disposal Case

In order to create this project the following preparatory activities will need to be undertaken:

- Conduct a detailed analysis of current waste collection routes and traffic patterns.
- Assess the energy requirements and availability of charging infrastructure.
- Infrastructure Preparation:
- Install charging stations at strategic locations, such as waste collection depots.
- Enhance road infrastructure with clear markings and smart traffic management systems to support autonomous navigation.

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In terms of Vehicle Procurement:

- Collaborate with reputable manufacturers to acquire AMOD trucks equipped with state-of-the-art safety and navigation features.
- Ensure vehicles meet European Union safety and environmental standards.

Training and Monitoring:

- Train municipal staff to oversee the operation and maintenance of autonomous vehicles.
- Implement real-time monitoring systems to track performance and address any issues promptly.

A Pilot Program will be implemented, with the following framework:

- Launch a 6-month pilot to evaluate the performance, cost-effectiveness, and public acceptance of AMOD trucks.
- Gather feedback from residents and staff and adjust operations based on findings.
- Based on feedback create a Challenges and Mitigation Strategies guide to be used to improve service

Initial Investment

The upfront cost of AMOD trucks and associated infrastructure is higher than conventional trucks. However, these costs are offset by lower operational expenses over time.

Explore funding opportunities through European Union grants and partnerships with technology providers to ease the financial burden.

Public Acceptance

Educate residents about the benefits of AMOD trucks through community engagement initiatives.

Address safety concerns by highlighting the rigorous testing and fail-safe mechanisms of autonomous systems.

Regulatory Compliance

Work closely with local and national authorities to ensure compliance with regulations governing autonomous vehicle operations.

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1.4.4 Conclusion of Waste Disposal Case

Adopting self-driving garbage trucks in Palaio Faliro represents a forward-thinking approach to waste management. By leveraging advanced technology, the municipality can achieve significant cost savings, enhance operational efficiency, and reduce its environmental footprint. While the transition requires careful planning and investment, the long-term benefits far outweigh the initial challenges.

This initiative not only positions Palaio Faliro as a leader in sustainable urban management but also sets a precedent for other municipalities seeking to modernize their public services. Through strategic implementation and community collaboration, Palaio Faliro can pave the way for a cleaner, greener future.

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