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transportes metropolitanos de lisboa

Investment Plan

Feasibility study of TML's
DRT use cases

Interreg Euro-MED

Co-funded by the European Union

ArtMED

Interreg Euro-MED

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ArtMED

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Related work package	Work Package 2
Related activity	A 2.3. Using the AMOD impact assessment tool to develop local investment plans for autonomous mobility on demand.
Responsible partners	TML – Transportes Metropolitanos de Lisboa, E.M.T., S.A.

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01 Introduction

The Lisbon metropolitan area (LMA) comprises eighteen municipalities covering an area of approximately 2,800 km2 and concentrating 2.8 million inhabitants, almost 1/3 of the country's population (see Figure 1). Most of its population (~72%) lives on the north bank of the Tagus River, however, the highest population growth occurs in the municipalities of the south bank, with an increase of 3.7 percent in the number of residents in the last decade.

The area is served by a multimodal public transport network including suburban and regional rail, metro and light metro, bus, and ferry services, all integrated into the Navegante ticketing and fare system. Private cars are responsible for 57,6% of the commuting trips in the region, followed by public transport with 25,4% of the share and active modes (walking and cycling) with 17%. In the last decade, and especially after the COVID-19 pandemic, there has been an increase in the use of private transport and active modes of transport while the share of public transport has decreased.

Like all large urban areas around Mediterranean Europe, it faces mobility and transport problems for passengers and goods.

The diversity of the metropolitan territory, with densely populated areas contrasting with less dense regions, underlines the need for a more adaptable and flexible transport offer, integrating transport models that better meet the varied needs of the population.

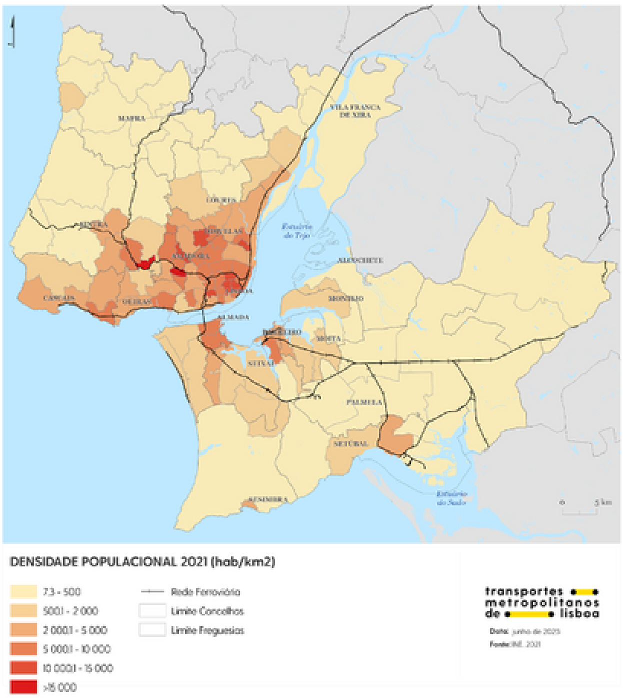

Figure 1 – Lisbon Metropolitan Area

As part of ArtMED, partners have previously developed Vision Statements for four local use cases. At this stage, TML has already identified the two (out of the four) use cases where DRT technology could add the most value. In order to support decision making, TML is currently aiming to develop an overall Investment Plan (IP) for the selected use cases to provide high level decision makers with an overview of the feasibility of implementing such solutions.

The IP will focus on outlining the **key milestones**, the **timing** and the **overall investment amount** for each of the use cases for the successful deployment and integration of these solutions. The IP will enable TML to assess whether further analysis and allocation of resources to these initiatives is justified by providing indicative figures and addressing critical milestones, such as:

- **Financial and Resource Management**
- **Policy and Regulation**
- **Infrastructure and Technology**
- **Operations and Management**
- **Stakeholder Engagement and Capacity Building**

02 Use case descriptions

As described in the ArtMED deliverable *Best Practices Collection*, there are several variations in business models and service levels on DRT, depending on various factors such as:

- Route type
- Scheduling
- Fleet composition
- Service coverage
- Integration w/ existing PT networks
- Technological features
- Branding choices

In this context, Figure 2 classifies and summarises the different operational schemes among which PTOs (Public Transport Operators) can choose when implementing DRT in their local communities.

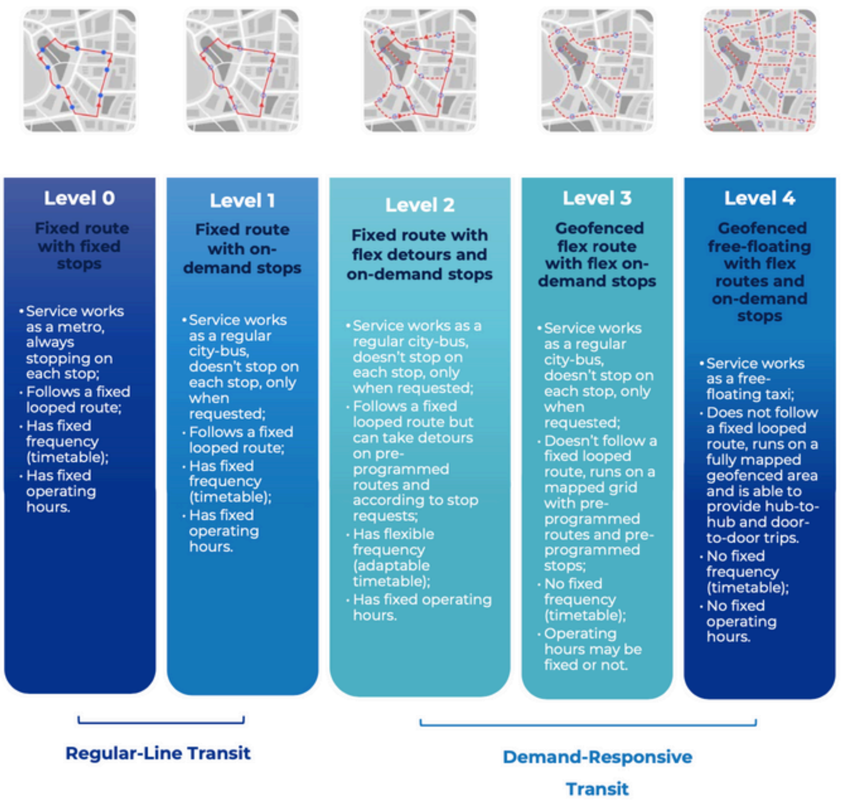

Figure 2 – Typology of DRT services. Source : adapted from Antonialli (2021b, p.11).

02.1 Use case 01: DRT in a deviation to a certain stop

The current scenario of **use case 01** consists of a line serving a very sparsely populated area, with a fixed detour that always runs, even when there are no passengers getting on or off at the stops (see Figure 3).

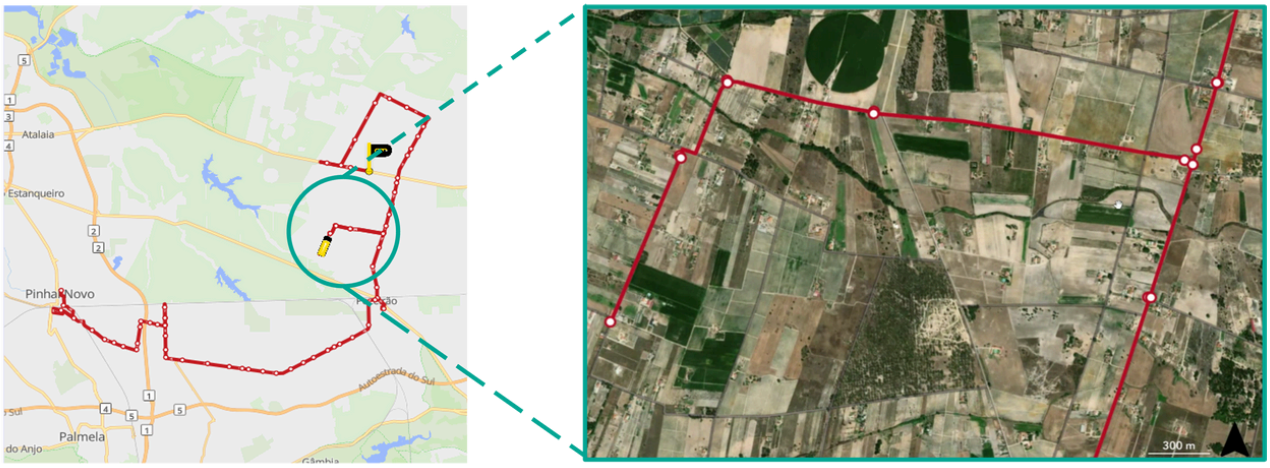

Figure 3 - Use case 01 (line 4521)

The main idea in this use case is that the bus will continue to operate as a conventional service on the main route – with fixed stops and timetables – but it will incorporate the on-demand feature on the fixed detour to serve these stops only at the request of passengers, using the same vehicle for the diversion (classified between **Level 0 and Level 1** – Figure 2).

Note that by incorporating the on-demand feature, the same bus line could **offer a wider range of diversions** from the main route without the extra cost of running them all every time – the diversion would only run if and when someone requested it.

To request this service, passengers will be able to **book it by validating at the stop or by booking via app / web / phone**.

It is important that the service can be requested at short notice, as long as it is done before the diversion takes place.

In this use case, the main objective is to **improve the accessibility of low demand areas**, where the economic viability of conventional public transport is very low, and the allocation of resources could be considered inefficient. This service will be aimed at all citizens who live in or visit the area covered, where the absence of the deviation would mean a considerable walking distance to connect with the main public bus service. This is aggravated by the fact that these roads typically have several junctions and crossings without sidewalks, used by pedestrians, motorcyclists, cyclists, cars, buses, etc.

02.2 Use case 02: DRT to main transport stations or interfaces

The current scenario of **use case 02** consists of six very similar lines operating in a neighbourhood – with very limited frequency and demand (see Figure 4).

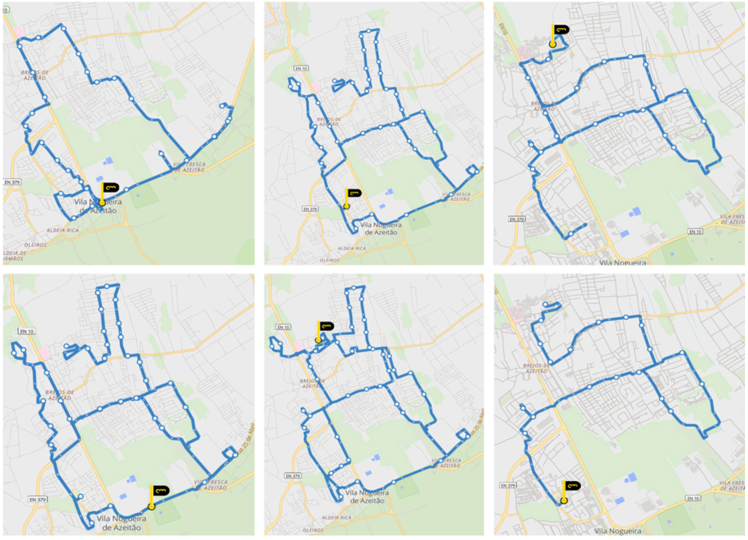

Figure 4 - Use case 02 (lines 4463, 4464, 4465, 4466, 4467 and 4468)

In this use case, the idea is to convert these lines into a **fully dynamic service with a flexible route and timetable**, serving the analysed neighbourhood (classified between **Level 3 and Level 4** – Figure 2). It will operate within the geofenced neighbourhood on a 'corner to corner' basis where routes will be automatically defined in real time and communicated to the driver to **better meet real demand and reduce journey times.**

This service will have both physical and virtual stops to take advantage of existing stops and increase the flexibility and coverage of the service. To request this service, **passengers will also be able to book it by validating at the physical stops or by booking via app / web / phone**. As in the previous use case, it is important that the service can be requested at short notice, as long as it is done before the diversion takes place.

Here, the main objective is to **increase connectivity and social inclusion** by providing flexible transport during off-peak hours. This service will be aimed at all citizens living in or visiting the area covered, where the absence available public transport would mean a considerable walking distance to connect with the main public bus service. This is also aggravated by the fact that these roads typically have several junctions and crossings without sidewalks, used by pedestrians, motorcyclists, cyclists, cars, buses, etc.

03 Defining responsibilities

For a better understanding of **the local role structure** and for a comprehensive overview of the **DRT landscape in the Lisbon Metropolitan Area**, it is important to **identify clear responsibilities** for the key milestones associated with the deployment and integration of DRT solutions on the two selected use cases (see Figure 5).

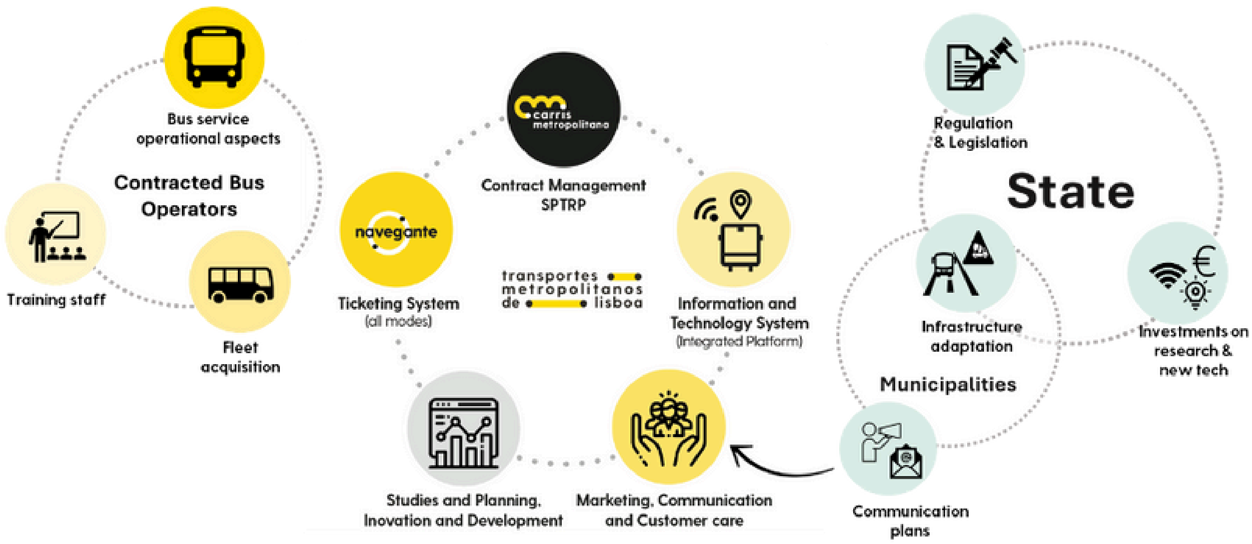

Figure 5 - TML stakeholders' overview

Financial and Resource Management

To integrate these on-demand services (use case 01 and 02) into the regular public transport services contracted for the region, TML will take responsibility for **securing funding for DRT projects**, for **strategic evaluation of economic impact** (e.g. developing cost-benefit analysis models for DRT investments), and for **general resource allocation** (e.g. deciding on the geographical limits of DRT and the number of buses required).

The responsibility for the detailed resource allocation and evaluation / optimisation of resources for DRT lies with the current Operator (e.g. deciding how many drivers are needed and evaluating service KPIs).

Finally, the Government is responsible for securing funding for all public transport services and infrastructure (e.g. charging infrastructure). Note that this is a strategic decision rather than a formal responsibility.

Policy and Regulation

TML is responsible for conducting **policy impact assessments** for DRT integration, **assessing the social and ethical implications** of this new service and establishing **compliance monitoring systems.**

As for the Government, it is responsible for developing DRT-specific regulations and policies, and for keeping the legal framework for DRT up to date.

Also, as TML is based in the Portuguese capital, it is expected that the Government will also be interested in contributing to and following up on the results of the impact assessments and social / ethical implications of DRT (although this is not part of their core responsibilities).

Infrastructure and Technology

As TML aims to integrate on-demand services into the regular public road transport services contracted for the Lisbon Metropolitan Area, it will be responsible for financing the operation. TML is responsible for the **planning of DRT-compatible physical infrastructures** (e.g. deciding and planning of the location of services), for the **planning and development of DRT-compatible technical infrastructures** (e.g. apps for service request and monitoring), for the **implementation of traffic management systems** for DRT (e.g. to promote the harmonisation of the metropolitan area) and for the **establishment of technology partnerships** for DRT.

Both the Government and the Municipalities are responsible for maintaining the public roads on which DRT will be deployed (depending on road ownership). Municipalities are also responsible for implementing traffic management systems for DRT, developing smart city integrations in their local scenarios and for the implementation and maintenance of the physical stops.

The Operator is responsible for developing the infrastructure for charging or fuelling DRT and for implementing traffic management systems for DRT (on the vehicle side).

Operations and Management

TML is mainly responsible for the strategic overview of operations. This includes **planning the DRT operational protocol architecture**, establishing **customer service guidelines** for DRT, **monitoring** DRT operational efficiency and **planning technological resources** for DRT **scheduling and dispatching systems**. As the transport authority, TML will play a key role in involving stakeholders throughout the development and implementation of the services.

For the remaining operational tasks, the Operator is responsible for the development of DRT operating protocols, the training of staff for DRT operations, the monitoring and management of DRT operating efficiency and the implementation of DRT scheduling and dispatching systems.

Stakeholder Engagement and Capacity Building

TML is responsible for organising **DRT awareness and education campaigns** and for establishing **feedback mechanisms** from DRT users. To this end, TML will develop comprehensive **communication plans** for DRT-related updates, distribute information related to DRT updates, conduct **workshops and seminars** on DRT technologies and facilitate public **forums and discussions** on DRT. With all the information collected, TML should also exchange **experiences and best practices** with other transport authorities and municipalities.

Municipalities are also responsible for organising local DRT awareness and education campaigns. Municipalities should co-organise the communication plans for DRT and facilitate workshops, seminars and public forums to promote discussions on DRT.

If requested, the Operator should also participate in the co-organisation of the communication plan for DRT awareness and education campaigns and may also be requested to distribute information on board related to DRT updates.

For a better visualisation of the synergies between stakeholders on the key responsibilities for the integration and deployment of DRT systems, described above, see Figure 6.

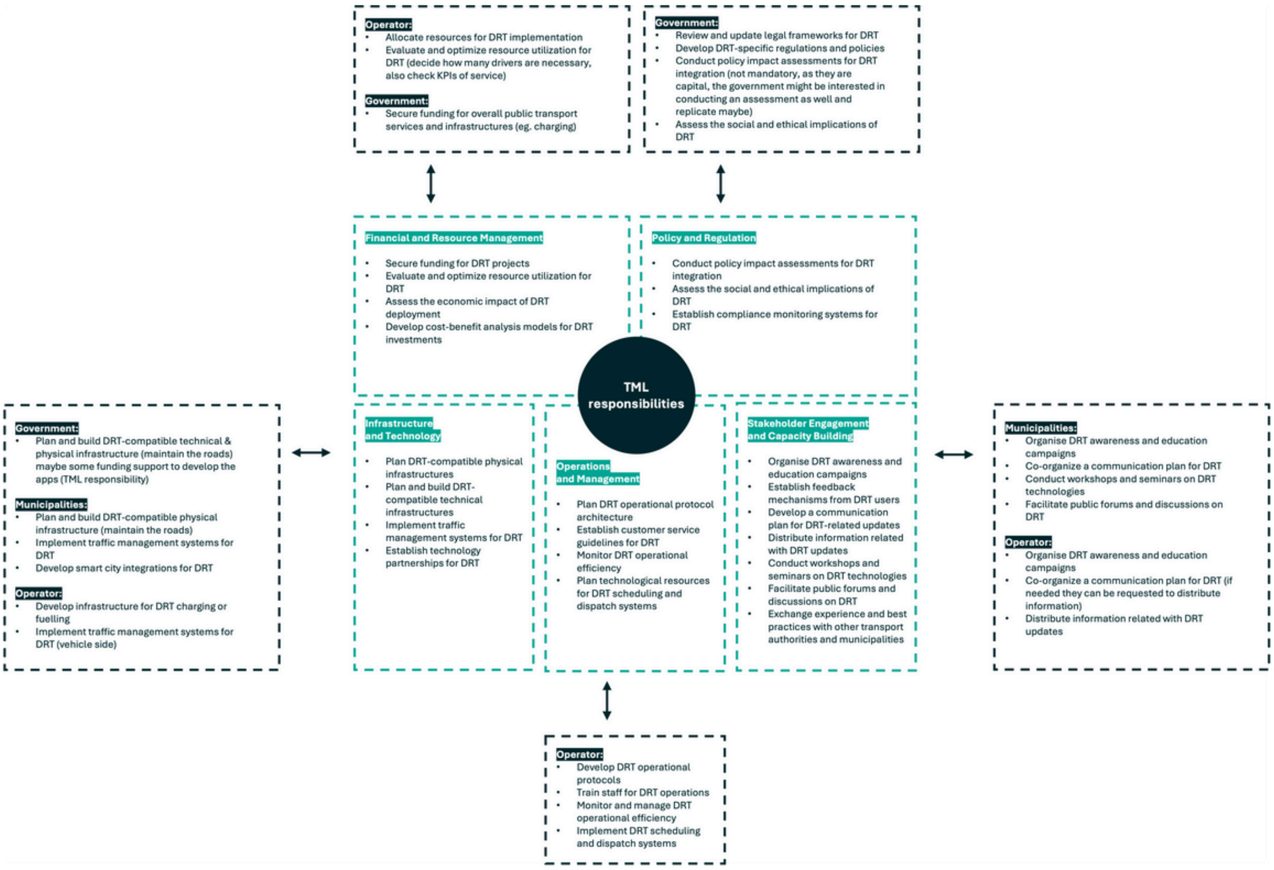

Figure 6 – TML responsibilities overview

04 Roadmap to implementation

The current cost structure of TML is based on price and service subsidies – no changes are planned for on-demand transport. In this case, 55% of the costs are covered by subsidies (of which the municipalities contribute at least 8.5% of the amount paid by the state), 44% by fares and the rest by service provision (see Figure 7). In the case that DRT providers would enter the TML landscape, they would be contracted directly by them to provide the service.

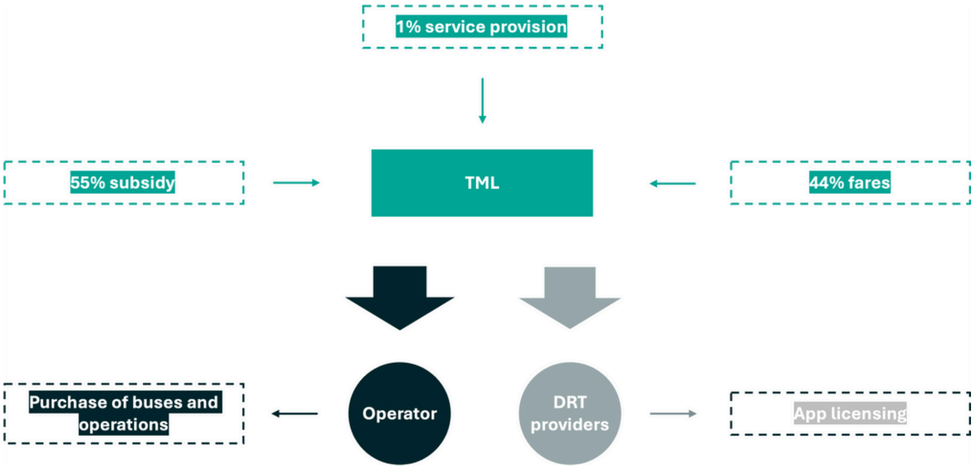

Figure 7 - TML costs structure overview

04.1 Costs structure

In order to assess the financial feasibility of both use cases, the following categories were analysed:

Capital Costs (CAPEX):

Involves significant investment in the acquisition, upgrading or maintenance of long-term assets for public transport, focusing on building and improving the capacity and quality of the system for long-term benefits.

Operational Costs (OPEX):

Refers to the ongoing costs required for the day-to-day operation and maintenance of public transport systems, to ensure the smooth and continuous operation of the services.

Note that the cost figures presented in this chapter are derived from preliminary analysis (broken down to the nearest unit) and are intended as a first approximation to support decision making. Further refinement and validation will be required as additional data becomes available.

Therefore, for both use cases, an analysis of the **costs for the conventional lines** (current operation as is) and an **estimation of the costs for the DRT system** proposed for each specific use case was carried out. A difference between the costs was then calculated to get an overall idea of **the financial difference** that the implementation of these use cases would represent.

For use case 01 it was assumed that the size of the fleet (10 vehicles) and the frequency of operations would remain the same for both the conventional service and the DRT scenario. However, for the DRT scenario it was assumed that the loop would only take place 30% of the times. The results of these calculations for year 1 can be seen on Figure 8.

Use case 1 (year 1) – DRT in a deviation to a certain stop

		Conventional	DRT	Difference
OPEX	Human resources (drivers' costs)	285.604 €	285.604 €	0 €
OPEX	Fuel and energy	109.940 €	108.057 €	1.883 €
OPEX	Maintenance	5.776 €	5.677 €	99 €
OPEX	Marketing and public awareness	- €	20.000 €	-20.000 €
	TOTAL OPEX	401.320 €	419.338 €	-18.018 €
CAPEX	Buses and on-board equipment	270.354 €	270.354 €	0 €
CAPEX	Infrastructure (service request interface at the bus stop)	- €	45.600 €	-45.600 €
CAPEX	Upgrade mobile app (dispatch tool)	- €	182.400 €	-182.400 €
	TOTAL CAPEX	270.354 €	498.354 €	-228.000 €
	TOTAL	**671.674 €**	**917.692 €**	**-246.018 €**

Figure 8 - Use case 01 costs structure (year 1)

In use case 01, the cost analysis revealed that while the **OPEX for the DRT scenario remains similar to the conventional service**, there is a **higher CAPEX associated with DRT implementation**. However, it was seen that over a 10-year period (usual life cycle of most public transport contracts), OPEX costs are projected to increase by 4%, while CAPEX costs are projected to increase by 8%. This results in a **total cost increase of 6% in the DRT scenario** compared to the conventional public transport system.

For use case 02 it was assumed that the size of the fleet would be halved for the DRT scenario. Thus, instead of the 10 vehicles of the conventional current system, 5 vehicles are considered for the DRT. In this scenario, it is also taken into account that by implementing the DRT system, the empty kilometers are reduced to 10% (since the buses will not go to the depot as often) and the vehicles will be kept in the flexible perimeter during the operating time. Finally, it was also considered that half of the time the vehicles will be stopped at the flexible perimeter. The results of these calculations for year 1 can be seen on Figure 9.

Use case 2 (year 1) – DRT to main transport stations or interfaces

		Conventional	DRT	Difference
OPEX	Human resources (drivers' costs)	149.136 €	244.583 €	-95.447 €
OPEX	Fuel and energy	57.408 €	47.075 €	10.333 €
OPEX	Maintenance	3.016 €	2.473 €	543 €
OPEX	Marketing and public awareness	- €	20.000 €	-20.000 €
	TOTAL OPEX	209.560 €	314.131 €	-104.571 €
CAPEX	Buses and on-board equipment	270.354 €	135.177 €	135.177 €
CAPEX	Infrastructure (service request interface at the bus stop)	- €	45.600 €	-45.600 €
CAPEX	Upgrade mobile app (dispatch tool)	- €	182.400 €	-182.400 €
	TOTAL CAPEX	270.354 €	363.177 €	-92.823 €
	TOTAL	**479.914 €**	**677.308 €**	**-197.394 €**

Figure 9 - Use case 02 costs structure (year 1)

For use case 02, the DRT scenario showed a **more significant impact on costs**, especially in terms of OPEX. OPEX is expected to increase by 50% over 10 years, reflecting the higher operational requirements for the DRT. **CAPEX, on the other hand, which is initially 73% higher (year 1), is expected to decrease by 25% after the 10-year period**, mainly due to the reduced number of vehicles required for this new service and the reduced capital investment needs over time. Despite the reduction in CAPEX, the combined effect results in an **overall cost increase of 13% in the DRT scenario** over the 10-year period, compared to the conventional service.

Comparing the two use cases individually with a combined scenario gives a clearer picture of the cost implications of DRT implementation (see Figure 10). In use case 01, **total costs increase by 6% over 10 years**, driven by a relatively small increase in OPEX (4%) and a significant increase in CAPEX (8%). In use case 02, the costs are more significant, with OPEX increasing by 50% and CAPEX initially high but decreasing by 25% over the 10-year time period, **resulting in a total cost increase of 13%** in the same period.

When the two use cases are combined into a single scenario, some cost efficiencies can be observed, particularly in CAPEX. CAPEX decreases by 10% compared to the conventional services due to shared infrastructure and resources. However, the OPEX remains significant, increasing by 20% over 10 years. Overall, the **total costs in the combined scenario increase by 7%** compared to the conventional system.

Totals (year 10) - use case 01, 02 and combined use cases		Conventional	DRT	Difference
use case 01	TOTAL CUMULATIVE OPEX	4.013.200 €	4.193.380 €	-180.180 €
	TOTAL CUMULATIVE CAPEX	2.703.540 €	2.931.540 €	-228.000 €
	TOTAL	6.716.740 €	7.124.920 €	-408.180 €
use case 02	TOTAL CUMULATIVE OPEX	2.095.600 €	3.141.310 €	-1.045.710 €
	TOTAL CUMULATIVE CAPEX	2.095.600 €	1.579.770 €	515.830 €
	TOTAL	4.191.200 €	4.721.080 €	-529.880 €
combined	TOTAL CUMULATIVE OPEX	6.108.800 €	7.334.690 €	-1.225.890 €
	TOTAL CUMULATIVE CAPEX	4.799.140 €	4.328.910 €	470.230 €
	TOTAL	10.907.940 €	11.663.600 €	-755.660 €

Figure 10 - summary table total costs (year 10)

This comparison shows that while the **combination of use cases helps to mitigate CAPEX** to some extent, operational costs remain a significant challenge in all scenarios. Use case 01 shows a more subtle overall cost increase (simpler use case), while use case 02 highlights the higher operational burden of DRT systems (more complex use case). The combined approach balances these results to some extent, but still underlines the need for further optimisation and use case combination to effectively manage OPEX and improve the overall cost-effectiveness of DRT implementations.

04.2 Future Scenario: Cooperative, Connected, and Automated Mobility

When evaluating future scenarios for DRT deployment, it is important to consider the potential impact of Cooperative, Connected, and Automated Mobility (CCAM) as CCAM works efficiently as a ride-hailing (DRT) service. CCAM replaces human drivers with “digital drivers,” allowing vehicles to operate autonomously while being supervised by teleoperators from a control center. A single teleoperator can oversee and remotely operate approximately six vehicles, significantly reducing labor costs. The feasibility of this technology is already being demonstrated by large-scale automated taxi fleets in the United States and China, while Europe has begun its first large-scale deployments, such as the integration of automated vehicles into Oslo's public transport system (see **here**). These developments show that CCAM is no longer a distant concept but a technology increasingly ready for practical, large-scale implementation.

From a financial perspective, CCAM is particularly relevant for DRT use-cases with significant downtime or multiple deployed vehicles.

In scenarios with high downtime, automated vehicles eliminate driver-related costs during idle periods, improving cost-efficiency. Similarly, economies of scale in multi-vehicle operations further enhance financial viability. In this study, use case 02 – a pure ride-hailing service – is likely to benefit most from CCAM, as vehicles are expected to experience substantial downtime between rides in areas with lower or inconsistent demand.

While initial deployment of automated buses will face high CAPEX costs, the savings from reduced driver expenses may not immediately offset these investments. However, as mass production scales up, CAPEX costs will decline, making CCAM an increasingly viable and economically attractive solution for DRT systems. Anticipating this transition allows decision-makers to strategically position current DRT investments to integrate and capitalize on CCAM advancements in the near future.

04.3 Hidden societal costs

It is important to note that it is not only the financial costs that are important in the decision-making process. Every public transport operation has hidden societal costs - known as **externalities**.

Externalities are the by-products of any public transport operation that are usually paid for by society as a whole rather than by the individual who causes them. These costs include pollution, noise, congestion, accidents and climate change impacts that are not directly reflected in the price of transport services. Here's how these costs are often absorbed:

Government and Taxpayers:

Governments bear the financial burden of dealing with externalities through infrastructure repairs, health costs (e.g. from air pollution or accidents) and environmental mitigation projects. These costs are covered by public funds collected through taxes.

Affected Individuals:

Local communities near transport hubs or busy roads face direct consequences such as poor air quality, noise and health problems, which they pay for indirectly through medical bills, reduced property values or reduced quality of life.

The ArtMED calculation tool was used to calculate the externalities associated with each of the use cases. This calculation used the average values of a traditional ICE (international combustion engines) bus, adjusted for inflation, in the Portuguese context (see Figures 11 and 12).

For use case 01 (Figure 11), the **externalities caused by the DRT service are about 2% lower** than those caused by the conventional service. Although this reduction is small, it highlights the potential of DRT systems to deliver environmental and societal benefits even in use cases where limited changes are implemented.

Use case 1 – DRT in a deviation to a certain stop	Conventional	DRT	Difference
EXTERNALITIES			
Accident costs	89.340 €	87.810 €	1.530 €
Air pollution costs	16.560 €	16.276 €	284 €
Noise costs	29.998 €	29.484 €	514 €
Congestion costs	135.066 €	132.752 €	2.314 €
Climate change costs	30.355 €	29.835 €	520 €
Well-to-thank emissions costs	8.384 €	8.240 €	144 €
Habitat damage costs	2.854 €	2.805 €	49 €
TOTAL	312.557 €	307.202 €	5.355 €

Figure 11 - Externalities use case 01 (year 1)

In use case 02 (Figure 12), **externalities are significantly reduced by 18%** compared to the conventional service. In this use case it is clearly seen that the DRT service provides a more favourable compromise between financial costs and societal benefits. Although the total costs for the service increase by 13%, the reduction in externalities outweighs this increase in costs.

Use case 2 – DRT to main transport stations or interfaces	Conventional	DRT	Difference
EXTERNALITIES			
Accident costs	46.652 €	38.254 €	8.398 €
Air pollution costs	8.647 €	7.091 €	1.556 €
Noise costs	15.664 €	12.845 €	2.819 €
Congestion costs	70.528 €	57.833 €	12.695 €
Climate change costs	15.851 €	12.998 €	2.853 €
Well-to-thank emissions costs	4.378 €	3.590 €	788 €
Habitat damage costs	1.490 €	1.222 €	268 €
TOTAL	163.210 €	133.833 €	29.377 €

Figure 12 - Externalities use case 02 (year 1)

04.4 EU funding opportunities

EU grants offer a significant opportunity to finance DRT systems, particularly in addressing CAPEX investments. While DRT projects are typically low-scale, low-CAPEX investments and often and fall under the thresholds for large-scale grants such as the Connecting Europe Facility (CEF), they can become eligible by integrating into a broader regional investment programme. This strategy aligns with CEF's focus on comprehensive infrastructure development and sustainable mobility initiatives across the EU. In addition, smaller-scale funding programmes like LIFE, Horizon Europe, and Interreg can provide complementary support for innovative and flexible transport solutions such as DRT. By strategically combining these mechanisms, up to 80% of CAPEX costs can realistically be funded. This means, in particular the CAPEX related to the software and additional infrastructure can be funded. The purchase of buses is probably not eligible.

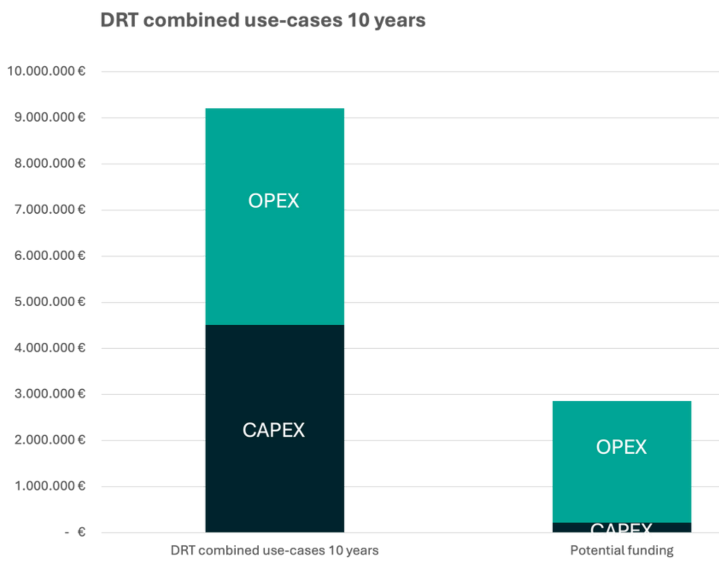

Figure 13 – DRT combined use cases and potential funding (year 10)

However, financing 80% of CAPEX alone does not fully resolve the cost gap compared to conventional transport systems. Over a 10-year period, total DRT costs for combinning use-case 1 and 2, would still remain approximately 13% higher, compared to 22% without grants. To address this financial gap further, grants supporting operational expenditures (OPEX) must also be considered. While OPEX-focused grants are less available and typically cover smaller volumes compared to CAPEX funding, opportunities such as the ELENA grant from the European Investment Bank (EIB) can provide substantial support. ELENA covers up to 90% of operational costs over a four-year period, offering a critical bridge during the early implementation phase when DRT systems require time to scale and achieve higher utilization rates. By leveraging both CAPEX and OPEX grants, DRT systems can be deployed more feasibly and transition toward long-term financial sustainability, ultimately becoming competitive with conventional transport solutions (see Figure 13).

04.5 Market consultation

To better understand the potential implementation of DRT systems, it is essential to examine the current market landscape and best practices.

According to the findings of the ArtMED *Best Practices Collection*, Via (see here) is the dominant player in the global DRT market. However, in the European context, Padam Mobility (see here) leads with a slightly larger market share than Via. Other prominent providers operating in Europe include Spare (see here), Liftango (see here), Shotl (see here), Ne-mi (see here) and ioki (see here). In particular, ioki is supported by Deutsche Bahn, Germany's national railway operator, which explains the strong presence of technology providers in the German market. Another highly competitive market for DRT solutions, with a high diversity of active providers, is the UK.

The *Best Practices Collection* has also categorised best practices and successful use cases into several different contexts. As both TML use cases can be classified into rural (use case 01) and suburban contexts (use case 02), more details are compiled below.

In **rural areas**, DRT services usually address coverage gaps by providing flexible, demand-driven solutions. These systems often replace underused conventional routes with more efficient operations, such as dynamic routing between virtual stops or running fixed routes only when needed (similar to **TML use case 01**).

Collaboration with local taxi services is also a common approach, particularly to connect remote villages with nearby towns, providing access to essential services. Examples of rural DRT initiatives include:

- “Transporte a Pedido” in Médio Tejo, Portugal (see link)
- ”Clic.cat” in Girona, Spain (see link)
- “Miobus Oltrepò” in Oltrepò Pavese, Italy (see link)

In **suburban areas**, DRT systems usually aim to optimise the use of public transport resources by improving connectivity, reducing waiting times and extending coverage. These services often serve as first and last mile solutions, linking residential neighbourhoods with major transit hubs and city centres (similar to **TML use case 02**). Minibuses with a capacity of up to 30 passengers are typically used to efficiently meet local demand. Examples of suburban DRT include:

- “elMeuBus” in Barcelona, Spain (see link)
- “TAD IDFM” in Île-de-France, France (see link)

Another factor, which must be considered with the planning of the introduction of a DRT service, is the different kinds of **technology solutions**, which are available on the market for the different specifications of the use cases.

The most basic form of DRT is the **Dial-a-Ride** solution, which involves phone-based scheduling with manual vehicle dispatch. While this method is straightforward and requires minimal technological infrastructure, it often suffers from inefficiencies in vehicle allocation and higher operating costs due to its reliance on manual processes. A step forward is **Telematic and Dispatch-based DRT**, which integrates computer-aided vehicle dispatch and live tracking for operations. This system often includes some degree of route optimisation, typically planned a day in advance for the next operational shift. Although this approach improves on manual systems by providing better operational control, it still requires manual data entry and periodic fleet optimisation, which can limit its flexibility.

More advanced systems such as **Ridehail** or **On-Demand DRT** introduce full automation into scheduling and vehicle dispatch. These systems are designed to efficiently handle last-minute passenger bookings by queuing multiple requests and dynamically allocating available vehicles. However, while this model is effective at responding to real-time demand, it can be less reliable for pre-scheduled bookings, resulting in inconsistent pickup times for passengers with advanced reservations.

The most sophisticated approach is **Dynamic DRT**, which uses continuous optimisation of fleet movements to maximise efficiency. This technology accommodates both advanced and last-minute bookings, ensuring that passenger requests are matched to available vehicles with a guaranteed pick-up option. Dynamic DRT also encourages pooling of trips, further improving resource utilisation. However, the downside is that advanced bookings are prioritised, which can occasionally reduce responsiveness to last-minute requests.

Each of these technologies offers distinct advantages depending on operational objectives, passenger needs and local context. For TML's use cases, **Ridehail** or **Dynamic DRT** would be the most suitable options, as these technologies are better equipped to efficiently optimise resources while accommodating both advanced and last-minute bookings, ensuring a higher level of service and adaptability.

04.6 High-level timeline

If and when TML decides to pursue the implementation of the DRT use cases, here is an overview of the most important steps that should take place, followed by a high-level yearly timeline.

Phase 1: Planning and feasibility (0–1 year)

The initial phase focuses on assessing the viability of a DRT service and laying the groundwork for its implementation. Here, detailed studies should be carried out to understand the mobility needs of the target areas, with particular attention to gaps in existing public transport services. This phase includes:

1. Assess mobility needs: Developing a comprehensive analysis of transport demand, user requirements and geographical constraints in identified locations.

2. Technical and financial assessments: Determining the technical feasibility and economic sustainability of the proposed DRT solutions.

3. Stakeholder engagement: Working with local authorities, public transport operators and community groups to gain support, gather feedback and ensure alignment with local policies. A strong communication strategy should also be developed to raise public awareness and inform residents about the project at an early stage.

4. Regulatory review: Identify and address legal and regulatory requirements at regional, national and European level to ensure compliance for DRT services.

Phase 2: Pilot testing and infrastructure development (1-3 years)

Once the initial groundwork is complete, the focus should shift to pilot testing and building the necessary infrastructure to support the DRT services. The aim here is to test the service under real conditions and make adjustments before scaling up (iterative process). This phase includes:

1. Pilot the service: Introducing on-demand shuttle services in selected areas as a case study, enabling data collection and evaluation.

2. Prepare the infrastructure: Establish key systems such as digital fleet management platforms, booking systems and vehicle monitoring. In the case of electric or hybrid vehicles, charging infrastructure should also be installed.

3. Community feedback: Actively gathering user input during the pilot phase to refine operational aspects (e.g. routes, schedules and service features) and to ensure that DRT services complement existing public transport networks to improve connectivity and coverage.

4. Training programmes: Provide training for transport operators, staff and drivers to effectively manage DRT systems and digital platforms. Awareness campaigns should also be conducted to familiarise residents with the new services.

Phase 3: Full implementation and service optimisation (3-5 years)

The final phase involves scaling up the DRT services to a wider area based on the pilot results, together with continuous monitoring and performance optimisation. Activities in this phase will focus on ensuring the efficiency, sustainability and long-term viability of the service. This phase includes:

1. Service expansion: Rolling out DRT systems to additional target areas, ensuring seamless integration with regional and intercity public transport networks.

2. Service optimisation: Refining operational models through real-time data analysis and performance metrics to improve efficiency and reliability of the services.

3. Monitoring and reporting: Establishing mechanisms for ongoing performance evaluation, such as public reports to provide transparent updates on service operations and outcomes.

4. Sustainability planning: Securing long-term funding sources to maintain and improve the service, while developing strategies for future expansions and technological advances.

By following this general timeline, TML will be able to effectively implement DRT services within its service area, ensuring that the system meets the mobility needs of both rural and suburban areas, while remaining adaptable to evolving transport needs. For a visual overview, see Figure 14.

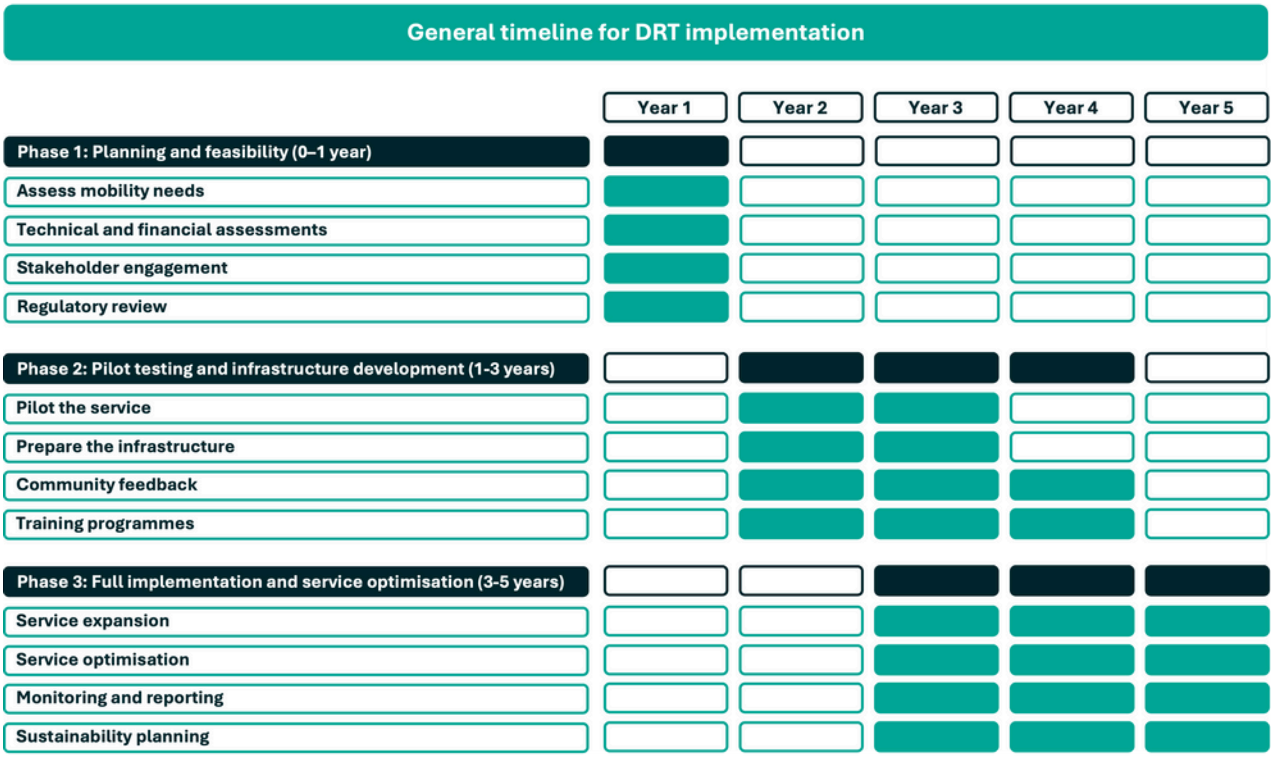

Figure 14 – High-level timeline for DRT implementation

05 Closing remarks

In summary, the implementation of DRT services for the two TML use cases presents a mix of challenges and opportunities, highlighting the need for careful strategic planning and execution to maximise the benefits of this transition. The main findings of the variation of costs for the DRT service compared to the conventional one in year 10, are presented in Figure 15.

Variations summary (year 10) - use case 01, 02 and combined use cases

	use case 01	use case 02	combined
OPEX variation	+4 %	+50 %	+20 %
CAPEX variation	+8 %	-25 %	-10 %
Total cost variation	**+6 %**	**+13 %**	**+7 %**
Externalities variation	-2%	-18 %	-7 %
Grant variation	-	-	-19 %

Figure 15 – Variations summary of the DRT service compared to the conventional one (year 10)

Main conclusions:

- Even if DRT is focused on small scale deployment (i.e. where mass transit of conventional public transport is not economically viable), it still makes sense to create scale by expanding use cases, as the cost of software / dispatching application can be shared across use cases. Therefore, we advise to **explore more use cases that are relevant for DRT.**
- If the higher up-front costs can be covered by grants, DRT becomes as financially viable, if not more so, than conventional public transport. We advise you to **consider EU grants** to cover a substantial part of both the initial CAPEX and OPEX.
- For use cases with significant downtime (use case 02), CCAM should be seriously considered in the future as Europe begins to show more mature deployment.
- Once you have discussed financial viability with the government, you can **take into account and explore the total wider "societal costs" for DRT**, as the estimate shows a significant reduction, which is beneficial to total public expenditure.
- For DRT, the **timeline for implementation depends primarily on TML and some legislative issues**, as the market and technology are already ready for implementation.

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