Current and Potential Mobility in Venice

By:
John Bonina
Sean R Cody
Michael Panicci
Katherine Smith

Fabio Carrera, Advisor
Peter Hansen, Advisor

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Contact:
ve17-move@wpi.edu

Website:
https://sites.google.com/site/ve17move/

Abstract

This project investigated the limits of the current transportation and parking systems, evaluated improvements to these systems, and explored innovative changes. We analyzed the current car parking availability and potential alterations. We investigated current boat parking regulations, and proposed additional temporary boat parking spots, and created a smartphone application design to regulate boat parking. We analyzed reconfiguring water bus service throughout the historic city and adding a subway line to the city's infrastructure. The analyses created by this project are an important first step in improvements to Venice's transportation and parking systems.

Executive Summary

The transportation and parking systems in the historic city of Venice have gone through many changes. From the railway bridge in 1846 to the Piazzale Roma car garage in 1934, little has changed since these earlier innovations. The historic city's only modes of transportation are still walking or by boat, and temporary boat parking is extremely limited. Combined with the ever-increasing tourist population, travel through the historic city has become increasingly difficult for business visitors and even for the residents of Venice.

This project's mission was to investigate current transportation and parking systems in Venice and explore potential improvements. Our objectives were to:

1. Assess current transportation and parking systems within Venice.
2. Explore improvements to the current water bus and boat parking systems.
3. Research innovative transportation and parking options as well as their impacts.

We explored several topics including car parking, boat parking, express boat lines, and a potential subway system. We formed separate methodology for examining each topic and have arrived at several results and recommendations.

Boat Parking

We analyzed the locations of over 1,600 rive, places along canals where boats can park, which are located throughout the historic city. Almost all of these are limited to 15 minutes of usage. Among these 1,600 spots, 91 allow for one-hour parking, and only 59 of the one-hour spots allow parking during daytime hours.

Using data previously collected by the Venice Project Center recording the location of every store in the historic city, we created a heat-map of stores to identify the optimal locations for boat parking spots. We excluded stores primarily targeted to tourists such as souvenir shops, and plotted the current one-hour parking spots on the same map. We determined that the current one-hour spots are not in ideal locations. This can be seen in Figure 1 below.

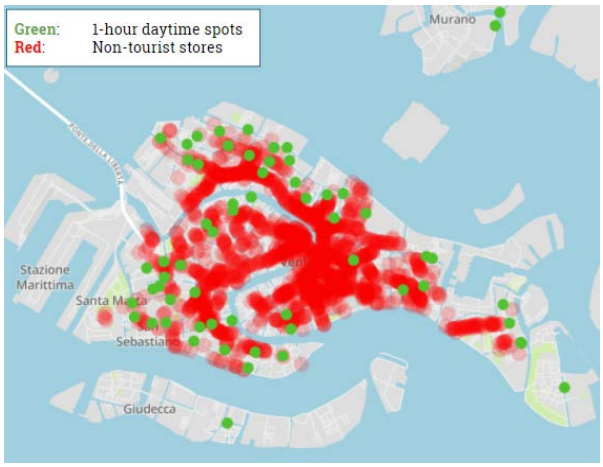

Figure 1. Map of one-hour daytime spots superimposed on a heat map of non-tourist stores.

Based on this analysis, we recommend that the number of temporary boat parking spots be increased. To identify the locations of new parking spots, we applied the following criteria: the spot must have a minimum number of stores nearby and more spots should be located near areas of greater store density. Spots also had to be located in canals with a minimum width of 5 meters to allow parking on both sides of the canal and continued mobility through it. Finally, we implemented a minimum distance between any two spots. We used QGIS to visualize the 31 docks that Vento di Venezia has proposed around Venice, and removed potential parking spots in proximity to these docks. Figure 2 shows the 221 spots that we suggest as ideal for temporary boat parking. The tool we created can be customized to modify the criteria and analyze changes.

Figure 2. Map of our proposed temporary boat parking spots

We examined the current system for regulating boat parking in the current temporary parking spots. We found that boat owners are exceeding the one-hour maximum time limit at the spots, certain spots are missing signs, and no observed boats displayed the required disco orario (a self time-meter).

We proposed a new online tool for reserving and regulating boat parking. This system could be a web-based application suitable for smartphones or other browsers to allow boat owners to register their boats and to reserve and pay for a boat parking spot in advance. Authorities could use the same application with a separate interface to permit them to view reservations, payments and compliance, including issuing fines. A concept for the view of the application for users or for system administrators can be seen in Figure 3.

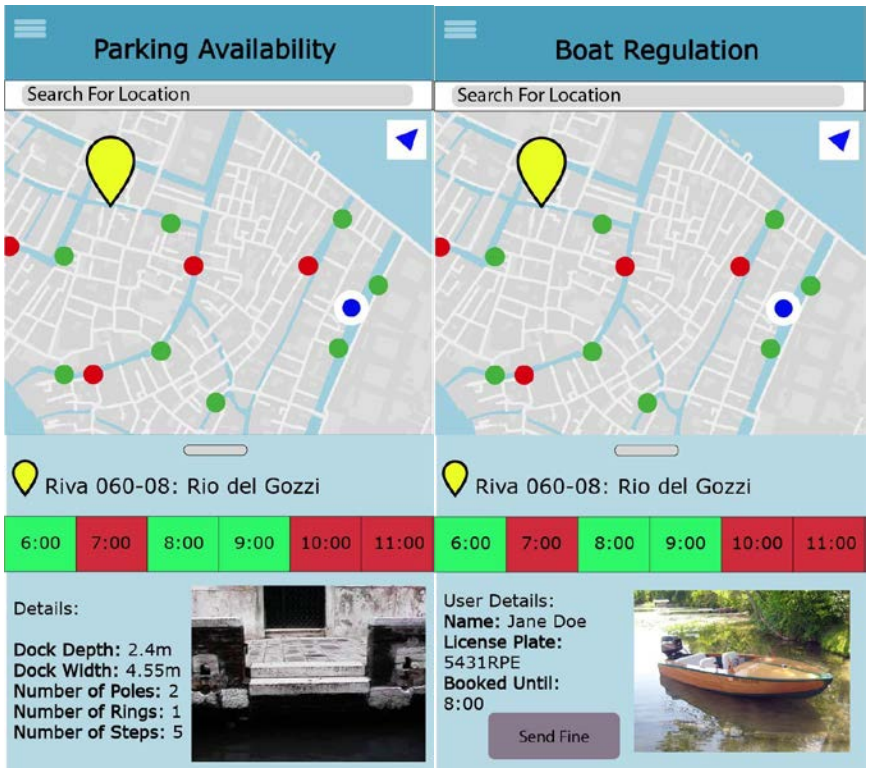

Figure 3. Design for a boat parking app, showing the user view (above left) and the enforcement view (above right)

Car Parking

Next, we examined car parking by gathering data on the number of available parking spots from several online resources and from Google satellite views. We understood the need for car parking based on the number of people entering the historic city via the Ponte della Libertá. We found that there are a total of 5,633 parking spots in Venice, with an additional 1,790 spots immediately across the Ponte della Libertá in Mestre. One possible location for additional parking is converting an existing surface lot on Tronchetto into a five-tier lot. We also performed a cost benefit analysis on this proposed lot and found that this lot would cost €21.99 million to construct and result in 1,207 additional parking spaces. Because creating additional parking in Venice could increase traffic on the Ponte della Libertá, we do not recommend such investments in additional car parking in the historic city.

Current Transportation Systems: Water Bus Lines

Congested water bus lines with frequent stops result in longer travel times. Express boat lines could decrease these travel times. One express line that we examined was line 6, which serves as an express line for lines 5.1 and 5.2 on the southern end of the historic city between Lido and Piazzale Roma. In the summer, the line skips four stops made by lines 5.1 and 5.2, allowing it to travel faster. However, in the winter the line runs less frequently and only skips one of these stops.

While line 6 travels faster along the southern portion of the historic city, it does not reach the railway station Ferrovia as lines 5.1 and 5.2 do, resulting in there being no express connection between Lido and Ferrovia. We concluded that traveling from Lido to Ferrovia could take 9 fewer minutes if the southern portion of lines 5.1 and 5.2 made the same stops as line 6. The change to lines 5.1 and 5.2 can be seen below in Figure 4, in which the lines skip the stops San Zaccaria, Santo Spirito, Santa Marta, and San Basilio. Figure 5 shows the route that line 6 would take if it made the stops that lines 5.1 and 5.2 currently make between Lido and Piazzale Roma.

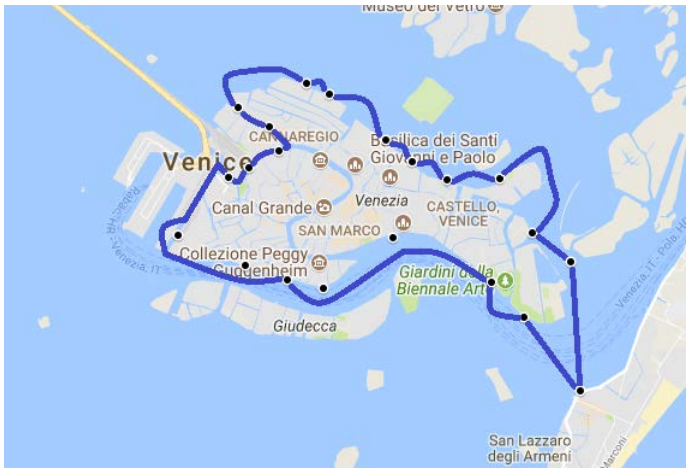

Figure 4. Suggested express service to replace ACTV Lines 5.1 and 5.2

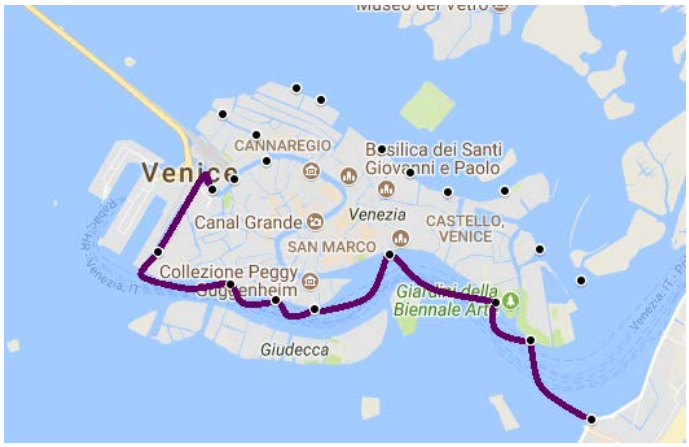

Figure 5. Suggested local service to replace ACTV Line 6

By using isochrones, a tool to visualize all the areas that can be accessed from a specific location within a certain amount of time, we can establish the limits of mobility within the historic city. For example, Figure 6 shows a 15 minute isochrone from Lido, created with an isochrone generator that we produced, which includes walking and public transportation. The blocks become lighter in color as the time it takes to get to the point increases.

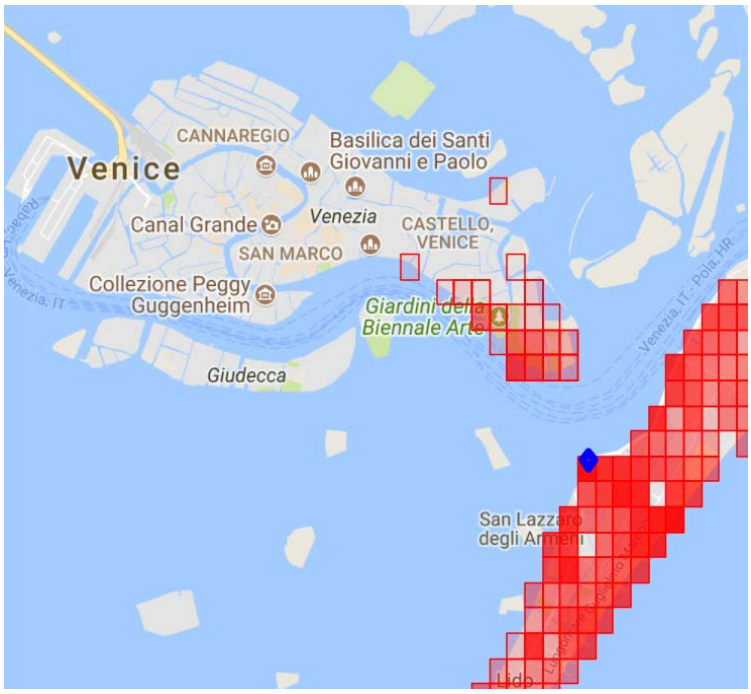

Figure 6. 15-minute isochrone from Lido Santa Maria Elisabetta (S.M.E.) water bus station..

Innovative Transportation Systems: Venice Subway

Next we examined a large scale change to the transportation system in the historic city: a subway system. Subway systems have been proposed for Venice in the past, and a 2005 proposal was funded but never constructed. In Venice, a subway could be built under the lagoon or canals to avoid existing structures, and only passages to subway stations would affect the fabric of the historic city. Our study shows that a subway would substantially reduce travel times compared to any of the possible improvements to the existing transportation systems.

We examined the travel times from Lido, a major population center in Venice and a possible terminus of the subway system. The potential subway system we analyzed included stops in Lido, in the canal next to San Zaccaria (for access to San Marco), a stop in the Giudecca canal with a pedestrian tunnel between Zattere in Dorsoduro and Palanca in Giudecca, and a major station between Venice's two main transportation hubs, Piazzale Roma (for buses and trams) and Ferrovia (intercity trains). This route segment, shown below in Figure 7, was the primary route for analysis and part of two possible subway extensions to the mainland, one to the center of Mestre, shown in Figure 8 below, and the other to Marco Polo Airport, the fourth-busiest airport in Italy and the busiest airport in Italy not connected to rail transportation, shown in Figure 9 below.

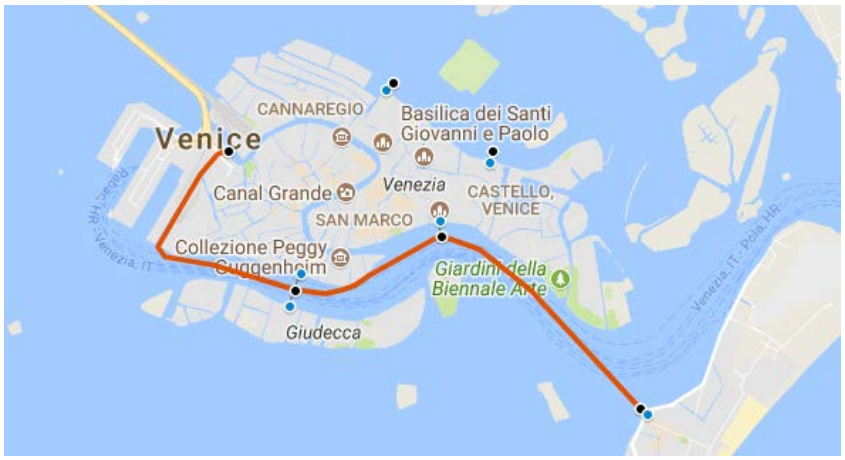

Figure 7. Route map from Lido to Piazzale Roma

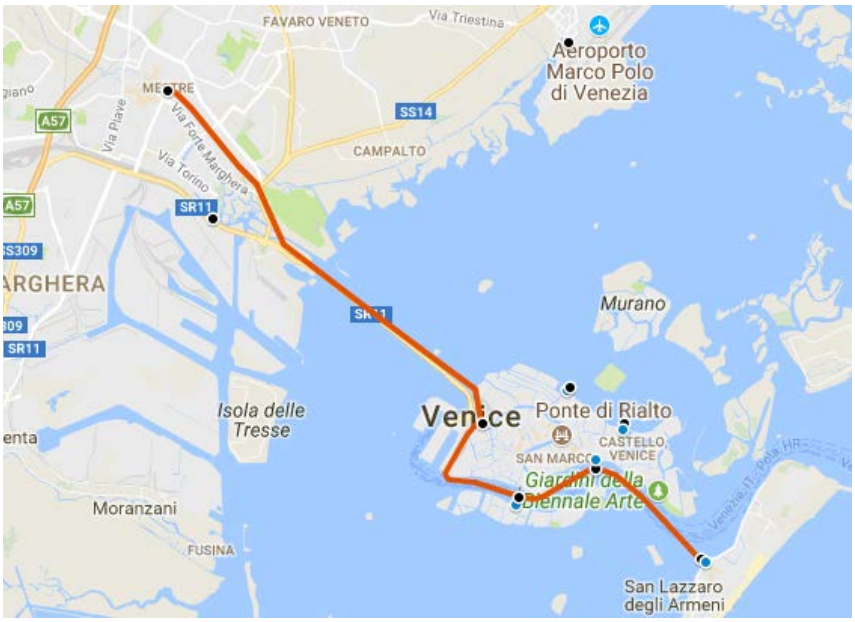

Figure 8. Possible extension of the Lido - Piazzale Roma subway to Mestre

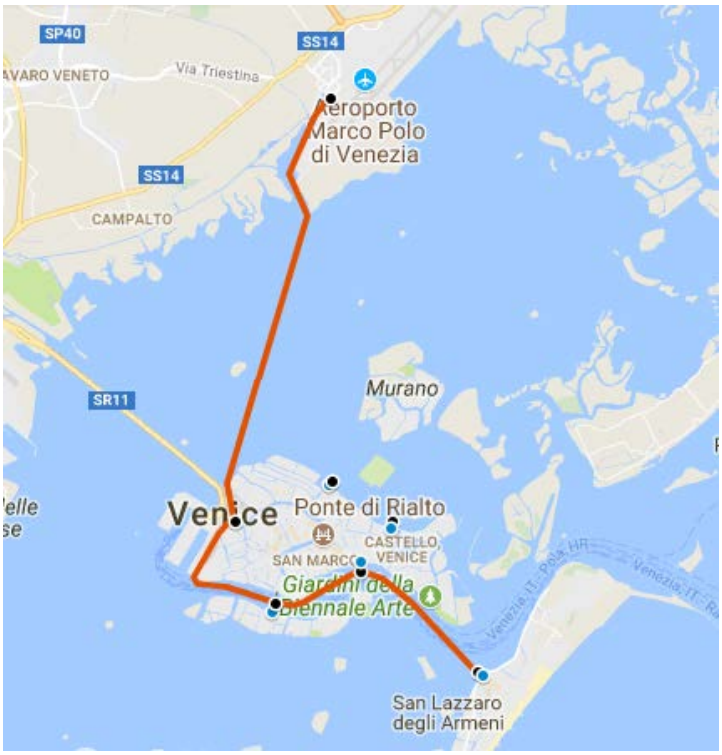

Figure 9. Possible extension of the Lido - Piazzale Roma subway to Marco Polo Airport

We calculated travel times and used isochrones to visualize subway routes with faster mobility. Travel from Lido to Central Mestre decreased from 60 minutes to 15.8 minutes, and from Lido to Marco Polo Airport from 66 minutes to 16.5 minutes. Our isochrone generator could calculate travel times beyond subway stations as if the subway was already a part of Venice's public transportation system. Also, another tool that we created, a subway route simulator, allows us to visualize how a specific route would change if a subway system was implemented. Figure 10 shows the current route and duration of travel, while Figure 11 shows how the route and duration would change if the above subway system was implemented.

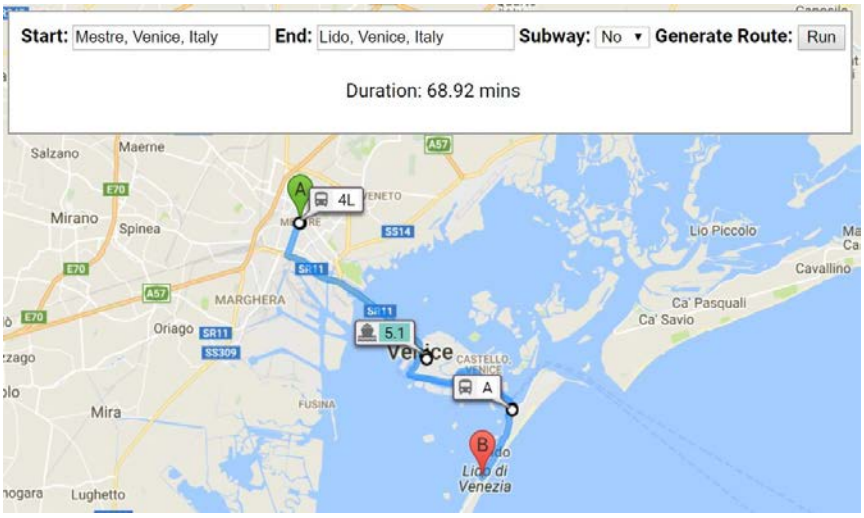

Figure 10. Subway route simulator using current system

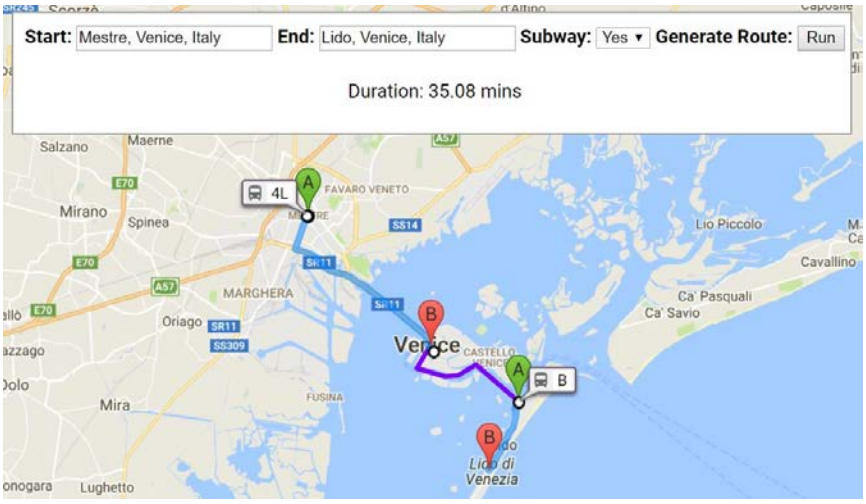

Figure 11. Subway route simulator using proposed subway line

We concluded that a subway system in Venice would cost about €201 million per kilometer. Based on this unit cost, we determined that the line from Lido to Piazzale Roma would cost €1.4 billion to construct, the extension from Piazzale Roma to Mestre would cost €1.7 billion, and the extension from Piazzale Roma to Marco Polo Airport would cost €1.5 billion.

Previous subway proposals have not been without controversy. Opponents of the 2005 subway which proposed to connect Marco Polo Airport to Arsenale were concerned that the system would lead to real estate speculation, increase the cost of living, bring more tourists, exacerbate congestion, and fuel a tourism-driven economy. These concerns should be taken seriously, but we believe that reducing travel times for residents also has benefits that should not be underestimated. Decreasing travel times may bring non-tourism business into the city, increase the quality of life for residents, spread the economic vitality across the larger Commune of Venice in Mestre and Lido, and create a 21st-century transportation infrastructure to enable Venice to thrive in the new economy.

Conclusions

Our study compared the benefits of modest changes to existing water bus systems to a new transportation system. For example, traveling between Lido and the railway station takes 43 minutes with the current water bus system using lines 5.1 or 5.2 during the summer. An express water bus service would take 34 minutes to travel between these points. A subway would take 11 minutes for the same journey. The subway system could also improve access to Mestre and Marco Polo Airport, reducing travel times for each destination from Lido by about 75%, but also costing the city up to €4.53 billion. We concluded that while car parking is limited, possible expansions would most likely result in more congestion on the Ponte della Libertá. We were also able to conclude that Venice's current system for boat parking is being exploited, and we proposed a new system to regulate it that would revolve around a smartphone application. Lastly,

we were able to determine suggestions for possible alternative boat parking spots for the historic city.

Through our work on parking and transportation systems within Venice, we have laid the groundwork for several projects. We completed an analysis of car parking, boat parking, express boat lines, and a potential subway system. While our analyses both explored and resulted in many recommendations, our work can be used as a framework for future innovative projects involving the parking and transportation systems in Venice. Our boat parking spot generator, various cost analysis, and isochrone generator are vital tools that we foresee being used when entering the implementation stages of alternate boat parking spots or alternative transportation systems for Venice.

Acknowledgements

Our team would like to thank the following individuals/organizations for their assistance throughout our project:

Fabio Carrera: For providing continuous support and guidance towards meeting our goals and objectives.

Peter Hansen: For supplying us with constant edits, suggestions, and feedback on our work while guiding us towards our goals.

Paolo Corposanto: For providing a tremendous amount of data pertaining to the history and current state of the transportation systems in Venice.

Nicola Musolino: For educating us on several online resources that were used for data analysis within our project.

Piero Toffolo: For acting as a liaison between us and ACTV as well as educating us on QGIS software.

Alberto Sonino with Vento di Venezia: For acting as our liaison throughout this project and supplying us with innovative ideas for exploration.

Authorship

While every member contributed to every section through minor contributions and editing, the following members primarily contributed to the below sections.

John Bonina: Contributed to Introduction, Background, Methodology, Car Parking, Express Boat Lines, Subway System Cost Analysis

Sean Cody: Contributed to Introduction, Background, Methodology, Boat Parking

Michael Panicci: Contributed to Introduction, Background, Methodology, Boat Parking, Express Boat Lines, Subway System Benefit Analysis

Katherine Smith: Contributed to Introduction, Background, Methodology, Boat Parking, Express Boat Lines, Subway System Benefit Analysis

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1. Introduction

From the opening of the Venice Railway Bridge in 1846, to the first steamer line in 1881, and the opening of the Ponte della Libertá and Rio Novo in 1933, the historic city of Venice has previously been at the forefront of transportation innovation in Italy. However, in the past 80 years the historic city has made very few updates to its transportation and parking systems. As tourism in Venice increases, the outdated systems are unequipped to efficiently handle both the needs of tourists and Venetians. The resulting congestion contributes to many problems, including overcrowding, a tourist driven economy, and rising housing costs, which have driven many locals to leave the area in search of a better quality of life.

Any person traveling into or within the historic city of Venice is impacted by lengthy travel times and limited parking. For example, the average commutes to work of a Venetian and United States citizen take roughly the same amount of time, however the average Venetian travels only about one-eighth the distance[1]. This lengthy commute is partially due to the large number of stops the water busses must make combined with the slow speeds that the water busses are allowed to travel through the canals. A separate issue is the lack of boat and car parking within the historic city, which prevents boat owners from using their boats for common errands such as grocery shopping, and forces car owners to leave their vehicles on the mainland and then use another form of transportation such as a bus, tramway, or train.

In response to these problems, several proposals have been made to improve the current system or introduce a more modern system to Venice. One of the more noteworthy proposals was made in 2005 for a subway to travel from the Marco Polo airport, underneath the Venetian lagoon, to the shipyards on the eastern side of Venice in only 14 minutes.[2] This proposal received the necessary approval and funding, but construction never began, and the money was used for other projects. Another proposal on a smaller scale was a dock proposal made by Vento di Venezia. This proposal would introduce several docks around Venice and the surrounding area, improving boat parking availability.[3] This proposal has yet to receive the proper approval and funding in order to proceed.

Based on these proposals and others, it's clear that there's a strong desire for improvement in the historic city of Venice. However, in order for the city to approve of and implement these proposals, the impacts outlined by the proposals need to be understood. Therefore, any suggestion examined regarding the future of Venice will be fully analyzed, including their costs and benefits.

The goal of our project was to investigate current transportation systems in Venice, explore potential improvements, and compile the information which we gather, in order to assist

[1] Brafford et al., 2013.
[2] Sylvers, 2005.
[3] Vento di Venezia, 2012.

the community in addressing the creation of a transportation system that is efficient and accessible. We organized data from previous research on transportation and proposals to determine their costs and benefits. With the help of our advisors, liaisons, and especially Paolo Corposanto, we also proposed several improvements and additions to Venice's transportation and parking systems.

2. Background

The current transportation transportation infrastructure of Venice is strongly influenced by the city's unique geography and topography. The current transportation and parking systems are pushed to their maximum capabilities due to the tremendous amount of tourists visiting Venice throughout the year.

With tourism congestion, constant impacts to the foundation of Venice due to wakes in the water, and a decrease in the population of the historic city, the need for an upgrade to the current transportation system becomes progressively more pressing. There are several forms of transportation that exist in other parts of the world that could possibly be implemented in Venice. There are also designs for car and boat parking used elsewhere that could also be implemented in Venice. Furthermore, current technological advancements have led to a growth in the development of futuristic means of transportation and parking.

As transportation systems become increasingly complex and intertwined, technology has made assessing transportation options in Venice easier. Currently there are several resources for navigating Venice. While route times can be be calculated, it is difficult to determine which routes are the fastest. The present limitations of technological transit accessibility in Venice must be established. These limitations must be exploited and thoroughly understood before one can propose or develop an alternative.

2.1 History of Mobility in Venice

Although the railway bridge into Venice opened in 1846, people hoping to travel within the city could only do so by walking, rowing, or sailing until 1881, when the first steamer line was introduced in Venice. Its route, which ran along the Grand Canal and connected the Piazzale Roma to Lido, is still in use today as Line 1 of Venice's ACTV service.[4]

Venice saw two major transportation innovations in the year 1933. First, the road bridge from Mestre to Venice (now known as the Ponte della Libertá) was opened, along with a bus terminal in Venice. The Rio Novo, intended as a more direct connection between St. Mark's Square and the Piazzale Roma, was also opened in this year. However, the Piazzale Roma became prone to congestion starting in the 1960s and 1970s. The Rio Novo, meanwhile, became obsolete over time and was closed to water bus traffic in the early 1990s. It remains open to water taxis, and the area along it is considered one of the worst places to live in Venice because of the noise pollution from the engines of these water taxis.[5]

Since 1933, Venice's transportation infrastructure has changed very little. Service to several outlying islands was discontinued, and a dedicated night network was added to the ACTV service, but the major aspects of Venice's transportation system have remained the same.

[4] Paolo Corposanto (Personal Communication)
[5] Paolo Corposanto (Personal Communication)

Even the speed at which boats travel through Venice's waters has not changed since they were introduced.[6]

2.2 Tourism Impacts Venice

The number of tourists who visit Venice has increased over the past few years, with the total number of overnight tourists alone rising from 4.1 million to 4.5 million between 2011 and 2015.[7] The disposition of these tourists to visit the city at certain times of year, especially during the months of July, August, and September, and to frequent certain major destinations, results in overcrowding in popular areas of Venice.

2.2.1 Tourist Hot Spots

Tourists who visit Venice favor a number of locations, including St. Mark's Basilica, which receives an average of 379,208 visitors annually[8] and is ranked as the top tourist destination in the city by several tourism websites.[9] Another Venetian landmark, the *Palazzo Ducale* (Doge's Palace), received an average of 1,329,906 visitors annually between 2011 and 2015.[10] With a wait time of 150 minutes, the Doge's Palace is tied with the London Eye and the Anne Frank House for the honor of the European tourist attraction with the longest wait time.[11] Additional tourist hotspots in the historic city include the Grand Canal; the Galleria dell'Accademia, which receives 305,302 visitors annually;[12] and the Piazza San Marco, located directly outside of St. Mark's Basilica. Because such high numbers of tourists visit these locations, the locations themselves and the areas around these locations are highly congested, and as a result are not favorable to pedestrian mobility.

2.2.2 Tourism Trends

Tourism in Venice has increased over the years, and is only predicted to continue to increase rapidly. In 2012, over 60,000 tourists visited the city every day, which is slightly more than the population of the historic city;[13] in comparison, the city's tourism capacity has been estimated to be 11,240 overnight tourists and 10,857 day trippers.[14] For a city equipped to handle large numbers of tourists, this can be good, as there are typically economic benefits from tourists spending money on amenities such as hotels, transportation around the city, and restaurants. However, for Venice, tourism is crippling the local population.

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[6] Paolo Corposanto (Personal Communication)
[7] City of Venice, 2015
[8] City of Venice, 2015
[9] Renzulli, n.d.
[10] City of Venice, 2015
[11] Daily Mail, n.d.
[12] City of Venice, 2015
[13] Mack, 2012.
[14] Canestrelli and Costa, 1990

The number of tourists in Venice varies at different times throughout the year, as most of the people visiting do so during holidays or during the the warmer seasons. The peak month is typically July, followed by August and September which is later in the year than previous years' trends indicate.[15] This shows that the time of year that tourists will visit is expanding as opposed to staying in a more limited peak time frame. Celebrations in Venice such as Carnevale also cause a large influx in tourism. When the city experiences these influxes in tourism it only puts further stress on the transportation and parking systems.

2.3 Accessibility of Venice

There are several ways to arrive in the historic city of Venice. Options include cars, busses, boats, and airplanes. Depending on the traveler, a certain system can be more beneficial than another. Understanding these factors allows for the introduction of possible improvements to Venice's transportation infrastructure.

2.3.1 Cars

Nearly 70,000 individuals enter Venice along the Ponte della Libertá every business day, nearly 20,000 of whom arrive by car.[16] Since this bridge is the only way to enter Venice by car, congestion along the bridge can become extreme in the event of high traffic caused by a holiday or other large event. In order to preserve Venice's historic character, once cars arrive from the Ponte della Libertá they are not allowed in any location in the historic city besides the parking area located at Piazzale Roma. Should parking be unavailable in the historic city, the cars have no option but to turn around, which creates further frustration and congestion at the entrance to the historic city, and limits the car capacity of the Ponte della Libertá to approximately 30,000 travelers per day.[17] The congestion caused by this infrastructure is unsustainable. To visualize the limits of parking, a map has been included with all the major parking areas after crossing the Ponte della Libertá (Figure 12).

[15] City of Venice, 2015
[16] Pedrocco, 2000
[17] Da Mosto, Morel, Gibin, Tonin, Fracchia, et al., 2009

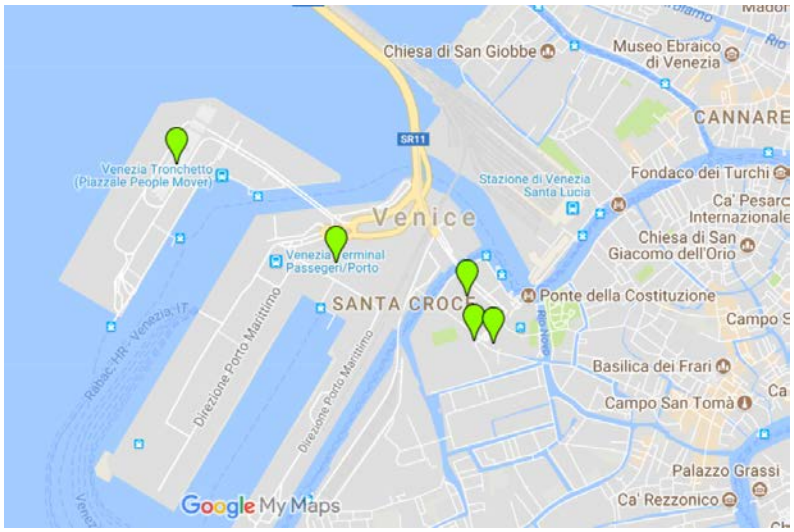

Figure 12. Parking options after crossing Ponte della Libertá

2.3.2 Long Haul Busses

When visiting Italy and attempting to travel from one region to another, including Venice, trains and cars are not your only option. Various bus companies have interregional routes. For instance, SENA Autoline has routes throughout 17 of the 20 regions of Italy. These long haul busses can be a good option for tourists, but are impractical for anyone attempting to conduct business or work in the city.[18]

Tourists hoping to take a bus from Marco Polo airport into the historic city have two options at their disposal. They can either take the private ATVO bus, or they can take the Linea 5 "Aerobus" run by the ACTV, Venice's public transportation system. The ACTV aerobus typically takes 20-25 minutes to travel from the airport to the Piazzale Roma, and both lines cost 8 euros for a one-way trip.

Currently the ACTV owns approximately 620 land busses. These busses reduce the amount of individual vehicles that would be necessary without them; however they still largely contribute to the congestion of the single roadway into the historic city.[19]

2.3.3 Trains

The main train station in Venice, the Venezia Santa Lucia station, receives an average of 82,000 passengers and 450 trains every day.[20] In comparison, the Venetian population is slightly below 60,000, and the city's tourism capacity has been estimated to be 11,240 overnight tourists and 10,857 day trippers.[21] Four rail lines serve this station--Le Frecce, Italo, Thello, and the City

[18] Imboden, n.d.,a
[19] ACTV, n.d.
[20] Grandi Stazioni, n.d.
[21] Canestrelli and Costa, 1990

Night Line--and the cities most commonly traveled to from this station include Italian cities such as Rome and Florence, as well as international cities such as Paris, Vienna, and Zurich.[22]

2.3.4 Airplanes

Venice has two airports at which international travelers can arrive. The larger of the two is the Marco Polo Airport, located on the mainland about 8 kilometers away from the historic city. It is Italy's fifth-busiest airport, receiving 8.4 million passengers in 2013. As a result of the number of passengers that Marco Polo airport receives, one of its terminals, which was opened in 2002, is already at full capacity.[23]

Venice is also served by the Treviso airport, located in Treviso, Italy. However, this airport is located 40 km away from Venice, primarily offers local and cross-continental flights from discount airlines, and is much smaller than Marco Polo Airport.[24]

2.3.5 Cruise Ships

Venice is a popular destination for tourists to travel to by means of cruise ships. These cruise ships hold on average approximately 3,000 passengers, and enter through the lagoon. There are three major ports where cruise ships can dock: the Marittima, the San Basilio, and the Riva dei Sette Martiri, as can be seen below in Figure 13. Due to its large ship capacity and proximity to tourist hot spots, the Marittima is the most popular port among travelers. Over 600 ships come to Venice yearly, bringing about 30,000 passengers daily in peak season.[25] When these cruise ships dock and passengers deboard this can create severe congestion in and around the area of the port. In addition, the cruise ships are negatively impacting the Venice Lagoon itself as they create substantial wakes which suspend 1.2×10^6 metric tons of sediment annually.[26] Finally, these cruise ships cause tremendous congestion in the Venetian canals. To visualize the congestion, Figure 14 shows multiple cruise ships taking up a large amount of space in the canals. Public protest can also be seen, as the pedestrians in the photograph have jumped in the canal to protest the cruise ships.

[22] Grandi Stazioni, n.d.
[23] Airport-Venice.com, 2017
[24] Venice Airport.it, n.d.
[25] Bellingham, Davis, O'Brien, & Saari, 2010
[26] Rapaglia, J., Zaggia, L., Parnell, K., Lorenzetti, G., & Vafeidis, 2015

Figure 13. Cruise Ship Docking Procedures

Figure 14. Venetians protest the encroachment of multiple cruise ships on the harbor of their city

2.3.6 Cargo Ships

In addition to passenger ships, cargo ships are very prevalent throughout Venice. Cargo ships are the primary delivery system of goods to the historic city; ships arrive at port daily

bringing supplies to restock the city. Similar to cruise ships, cargo ships also cause congestion in the waterways, and there have been past proposals to attempt to control the flow of cargo. Students from the University of Venice proposed that cargo ships be charged for the size of their boats per unit length to force suppliers to be more efficient in storage.[27] A past Worcester Polytechnic Institute student team at the Venice Project Center proposed that cargo ships would deliver their supplies to a warehouse on the port, which would then organize and distribute the cargo. This system would allow cargo ships to complete their trips in a more timely fashion.[28]

2.4 Navigating the Venetian Canals

Upon arriving in Venice, people can either travel within the city on foot or along its waterways. If they choose to do the latter, they can travel by water busses or more expensive water taxis. All of these boats produce wakes (*moto ondoso*) that are damaging the foundations of the city.

2.4.1 Water Busses

The most common type of public transportation throughout Venice is water busses, which are operated by the ACTV, the city's primary public transportation company. The ACTV owns approximately 160 boats and carries more than 190 million passengers annually. With the ACTV, people can travel by water bus either with the Vaporetto, such as the one shown in Figure 15, or the Motoscafo, which are two different types of boats.[29]

Vaporetti are the most widely used type of water bus in Venice, and are used to transport both people and their luggage. Each *vaporetto* is 21 meters long and can hold up to 220 passengers at a time. Due to the size of these water buses and the congestion of the canals, crashes between other boats and water busses are not uncommon, and have resulted in death.[30]

[27] Libardo, Nocera, & Trabucco, 2005
[28] Amilcar, Bourgeois, Setalsingh, & Tassinari, 2010
[29] ACTV, n.d.
[30] ACTV, n.d.

Figure 15. A vaporetto

Motoscafi are very similar to *vaporetti* but smaller, as they are 20.7 meters long and less wide, and can hold up to 160 passengers at a time.[31] They were introduced after the Rio Novo was opened in 1933, in order to allow for the ACTV system to run through canals other than the Grand Canal.[32] Although the Rio Novo is no longer open to water buses, the *motoscafi* continue to be in use.

2.4.2 Water Taxis

The water taxis of Venice provide a more upscale means of traveling around the historic city. These water taxis, one of which is shown in Figure 16, can hold up to ten people, and feature private captains, upholstered seats, and open-air seating in the rear of the boat. They are also fairly expensive, with trips between Marco Polo Airport and central Venice costing upwards of €110, and trips within the historic city costing between €40 and €70.[33]

Most water taxis in Venice operate under the Consorzio Motoscafi Venezia, which was formed through the union of several of the leading independent taxi companies at the time. The Consorzio operates a fleet that consists of over 100 water taxis that operate 24 hours a day. Each water taxi is connected to an operation center using an advanced GPS system, which allows for the coordination of the fleet of taxis and reduces customers' waiting times.[34] Though the water taxis are typically faster and more convenient than water busses, their exorbitant prices make them unusable for the typical Venetian on the daily commute.

[31] ACTV, n.d.
[32] Paolo Corposanto (Personal Communication)
[33] Imboden, n.d.,b
[34] Consorzio Motoscafi Venezia, n.d.

Figure 16. A water taxi parked on the side of a canal in Venice

2.4.3 Moto Ondoso

An unfortunate side effect of the waterborne transportation systems discussed up to this point is *moto ondoso* (translated to wave movement), the wakes generated by the motorboats in Venice's waterways, which damage the foundations of the city. This damage is expensive to repair: in 2006, the Venice government set aside 35 million euros to continue scheduled maintenance of canals' retaining walls.[35]

The problems caused by *moto ondoso* are worsened by the fact that only 3% of boats in Venice's canals follow the speed limits for those canals, and only 13% travel within 2 km/h of these speed limits.[36] Increasing the speed of the boats in Venice's waterways from 5 km/h, the speed limit in most of Venice's minor canals, to 7 km/h leads to anywhere from a 36% increase for personal boats with high payloads to a 336% increase for small cargo boats, regardless of payload, in the energy with which the waves impact the walls of the canals.[37] Since 87% of boats in Venice's waterways travel more than 2 km/h above the posted speed limits, the waves from these boats' wakes impact the city's foundations with even more energy.

A previous Venice Interactive Qualifying Project completed through Worcester Polytechnic Institute proposed a five-year plan for reducing *moto ondoso* in Venice's waterways. During the first year of this plan, speed limits in the canals would be more thoroughly enforced, which the group estimated would lead to a 13% reduction in *moto ondoso*. A taxi-sharing app, to be finalized during the first year, would then be introduced in the second year, contributing to a 35% reduction in *moto ondoso*. The third year would involve the implementation of new hulls on

[35] Black, Migdal, Morin, Rene, & Vitello, 2008
[36] Nodine, Jagannath, & Chiu, 2002
[37] Nodine et al., 2002

taxi and cargo boats, the fourth year would see the introduction of new *Alilaguna* boat hulls, and the fifth year would involve evaluating the plan's effectiveness. The proponents of this plan expect it to reduce the severity of *moto ondoso* by 77%.[38] This plan has served merely as a concept up to this point. With enough funding and support, this can become a reality.

[38] Gonclaves, Jasinski, Pauwels, & Tedesco, 2016

3. Methodology

The goal of this project was to investigate current transportation systems in Venice, explore potential improvements, and compile the information which would assist the Venice Project Center and Vento di Venezia in recommending an alternative transportation system that is efficient and accessible. The objectives of this project were to:

1. Assess current transportation and parking systems within Venice.
2. Explore improvements to the current systems.
3. Research innovative transportation and parking options as well as their impacts.

We analyzed the costs and benefits of several possible subway lines, as well as express water bus services. In order to assess the benefits of several subway systems, we created an isochrone generator and a subway route generator. We examined current car parking availability and proposed new temporary parking spots in ideal locations, as well as a system to regulate these spots.

This project's field of inquiry was limited to transportation and parking systems within Venice. These systems include public systems that are owned and maintained by the local or state government. The term innovative transportation system refers to methods of transport either still in development or invented in the last 50 years, as well as transportation methods that do not currently exist in Venice in any form but are in use in other locations.

When assessing the current transportation systems, the spatial scope was limited to the historic city of Venice, as well as the mainland city of Mestre. In terms of evaluating current systems, we were only interested in what already exists in the historic city and in Mestre, so the scope is limited. Our project also attempted to evaluate innovative systems not currently implemented. When analyzing the feasibility of implementing a transportation system in Venice, the scope was also limited to Venice, since all of the transportation systems that we analyzed would run either within the historic city, or between the historic city and points on the mainland such as Mestre and Marco Polo Airport.

Data collected by the VPC and other information sites was collected in previous years for all times of the year. The proposed transportation systems that we evaluated would be active at any time of day and at any point of the year. In terms of data being collected, the team was in Venice between October and December 2017. Data collected from Venice by the team was collected during this time span.

The following chapters contain detailed methodology, results, and analysis for each of our main objectives.

4. Parking Systems and Potential Improvements

Whether a person is traveling into the historic city by car or attempting to visit a store within it by boat, parking can be difficult. There are very few parking options for arriving cars and the temporary parking near Venetian storefronts for boats is extremely limited.

4.1 Car Parking and Potential Improvements

Due to the layout of Venice, cars can either park at Piazzale Roma, the square at the end of the Ponte della Libertá, or at Tronchetto on the edge of the historic city. If all of the lots in the historic city are full, one would have no further options but to return to the mainland in Mestre, and from there travel into and later out of the historic city by other means.

4.1.1 Methodology - Examining Car Parking Availability and Potential Improvements

In order to examine potential improvements to car parking, we first had to evaluate the current car parking availability in Venice. To estimate the availability of car parking in the historic city of Venice and on the mainland in Mestre, we first found the locations of parking services in these areas by finding the locations classified by Google Maps as “Parking”. We then created a list of the locations that were either within the historic city of Venice, or on the shoreline of Mestre near the Ponte della Libertá.

With the exception of Green Park, a private lot in Mestre, every parking lot shown in the Google Maps list contained a link to that parking lot’s website. All but one of these websites contained information about the lots’ capacities. However, since no web site exists for Green Park, and the web site for Venice City Park, another private lot in Mestre, did not display the parking lot’s capacity, we had to estimate the capacities of these parking lots using different methods.

To find the capacity of Green Park we took a screenshot of the parking lot from Google Map’s aerial view and opened the screenshot in AutoCAD. In the AutoCAD file, we created rectangular blocks with the dimensions of a typical car, including buffer room between cars, and placed them over each car and over empty parking spaces, making sure to place the blocks as close to each other as possible without overlapping them. When we had covered the entire parking lot with these blocks in the AutoCAD file, we counted the total number of blocks using AutoCAD’s data extraction command. This quantity was recorded as the capacity of the parking lot.

Venice City Park had few cars visible in the aerial image available for it on Google Maps. We estimated its capacity by finding the total area reserved for parking using Google My Maps (shown in Figure A of Appendix A), and dividing that by the average area of a parking space. To find the average area of a parking space, we drew blocks around groups of five cars parked adjacent to each other and found the areas of these blocks. In order to ensure that our

results were accurate, we drew three of these blocks, so that we could compute the average area of 15 parking spaces.

After establishing the current limitations of the car parking system, we evaluated the possibility of replacing a parking lot in the northwest corner of Tronchetto (shown in Figure 17 below) with a five-story parking garage, the typical garage height given by Means CostWorks.[39]

Figure 17. Location of our proposed parking garage

In order to estimate the cost of such a parking garage, we found the average cost of a parking garage per parking space in the United States in 2015, and used Equation 1 to adjust this value for inflation and differences in construction costs.

$$C_p = C_j(1+f)^{p-j} \cdot \frac{S_p}{S_j} \cdot \frac{L_p}{L_j} \quad \textbf{(1)}$$

In Equation 1, C_p refers to the estimated cost of any parking system being proposed for Venice, C_j refers to the cost of the facility being used as a comparison, f refers to the average inflation rate between times p (the date of new facility's construction) and j (the year of the original facility's construction), S_p and S_j refer to the size of the new facility and the old facility, respectively, and L_p and L_j refer to the country cost indices for the new facility and the original facility. For the purposes of calculating the cost of a parking garage, the Big Mac Indexes of Italy and the United States, which give the average price of a Big Mac at McDonalds in the two

[39] Fixr, n.d.

countries and indicate the purchasing power of their currencies, were used as L_p and L_j, respectively. Since Equation 1 is only used for preliminary cost analysis, the actual cost might be as low as half of the estimated cost and as high as twice the estimated cost.

4.1.2 Results - Evaluation of Current Car Parking and Potential Improvements

Using our methodology, we found there to be a total of 5,633 parking spaces in the historic city of Venice, with another 1,790 spaces directly across the lagoon in Mestre. In the areas of Mestre close to the Ponte della Libertá, public parking is more easily available than private parking, with 1,242 of the 1,790 parking spaces in Mestre owned by government agencies. In the historic city, however, the number of privately-owned parking spaces far exceeds the number of publicly-owned spaces, with 4,900 privately-owned parking spaces and only 733 publicly-owned ones. As shown in Table B, this discrepancy is due to the large parking capacity of the Tronchetto, which can accommodate approximately 4,000 cars.

Table 1: Summary of Parking Availability in the Historic City and Mestre

Location (Ownership)	**Sum of Car Capacity**
Mestre	**1790**
Private	*548*
Public	*1242*
The Historic City	**5633**
Private	*4900*
Public	*733*
Grand Total	**7423**

When we estimated the capacity of Venice City Park, we found the area of the parking lot reserved for parking spaces to be 0.369 hectares, and calculated the area of fifteen cars to be 0.017 hectares. Based on these values, we estimated the capacity of Venice City Park to be 326

cars (see Table 14 and Figure 44). The capacity of Green Park was found to be 222 cars (see Figure 45).

Table 2: Cost Calculations for an Additional Parking Garage on Tronchetto

US Parking Garage Cost / ft^2	$55.66
Average Inflation from 2015-2017	1.49%
Elapsed Time (Years)	2
Italy Big Mac Index	4.8
US Big Mac Index	5.3
Base Square Footage of New Facility ($ft.^2$)	97843.94569
# of Stories in New Facility	5
Unit Size of Original Facility ($ft.^2$)	1
Tronchetto Parking Garage Cost	*$25,401,480.92*
Tronchetto Parking Garage Cost (euros)	***€21,337,000.00***

Table 3: Calculations for the Capacity of an Additional Parking Lot on Tronchetto

Cost per Parking Space (2015 USD)	$18,599.00
Cost per Square Foot (2015 USD)	$55.66
Square Feet / Space	334.2
Base Square Footage of New Facility (ft.^2)	97843.9
# of Stories in New Facility	4
Capacity of New Facility	1509
Capacity of Existing Lot	302
Capacity Added	**1207**

Due to spatial constraints, it would be difficult to add parking spaces within the historic city. However, some possibilities exist for additional parking. Replacing a 97,844-square foot parking lot in the northwest corner of Tronchetto with a five-story parking garage would cost €21,994,000.00 and add 1,207 new parking spaces to Venice (accounting for the spots that would be removed to make way for the garage), increasing the historic city's car capacity by 21.4%.

4.1.3 Analysis - Potential Car Parking Improvements

Unlike most bridges, where cars can continue to travel in both directions after crossing the bridge, the only option for cars traveling into the historic city is to park immediately after exiting the Ponte della Libertá, or to immediately return to Mestre. As a result, the number of cars already parked in the historic city and the number of cars leaving the historic city determine the number of cars that can enter. Specifically, the cumulative number of cars that have entered the historic city can be no more than 5,633 cars greater than the cumulative number of cars that have exited the historic city.

The 1,207 spaces added by the five-story parking garage would make it easier for daily commuters and people traveling to the city for business purposes to access the city. However, due to the high cost of constructing the garage, the construction costs would be difficult to recover, while the costs of staffing and maintaining the garage would only add to its overall cost, so this project would likely not pay for itself over time. The addition of parking spaces in the historic city could also entice more people to arrive by car and increase congestion on the Ponte della Libertá. While the benefits of replacing a parking lot on Tronchetto with a parking garage would be substantial, the addition of a new garage would have many negative effects that may require additional action.

4.2 Boat Parking and Potential Improvements

Parking a boat in the historic city of Venice is an issue faced by boat owners. Those who own boats in the historic city can either park them in private boat parking lots or keep them at Marinas. Tourists can be impacted by this as well, because as canal congestion increases due to parking constraints, canal traffic can increase as the limited space impedes mobility. With the exception of the Canal Grande, the space in the canals is extremely limited,[40] and with boats parked throughout smaller canals, boats have little room to move within the canals.

4.2.1 Current One-Hour Parking System

Although a majority of rive parking spaces are limited to 15 minutes and used primarily for supply delivery and trash pickup, Venice has its own system of boat parking spots reserved for temporary parking by boat owners. These spots are limited to one hour, and are labeled with special signs. An example of one of the signs can be seen in Figure 18 below.

[40] Bukowski, n.d.

Figure 18. Temporary parking signage

In addition, boat owners parking in these spots must display the disco orario, a special parking decal acting as a self timer that allows authorities to see how long a boat has been in a space, which can be seen in Figure 19 below.

Figure 19. Disco Orario

The current temporary boat parking spots can be seen in Figure 20 below.

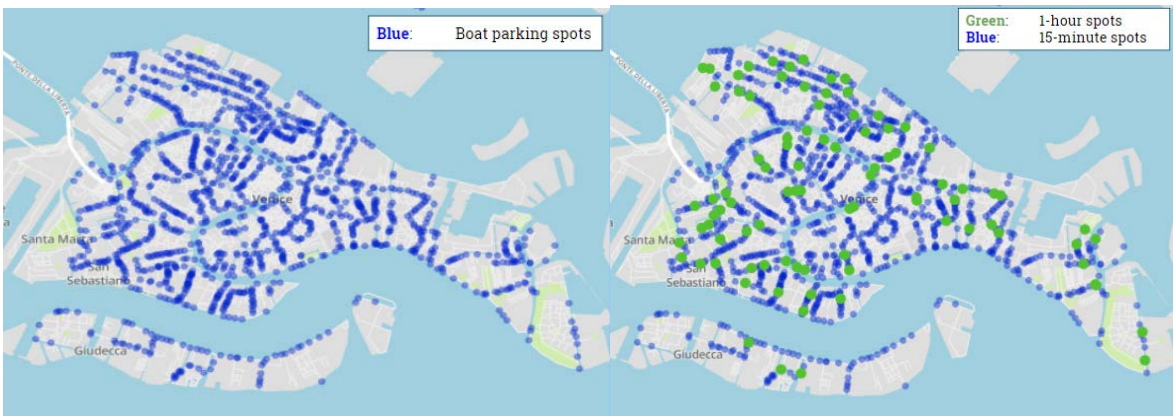

Figure 20. All boat parking spots (left) and parking spots divided by time limit (right)

In order to assess the effectiveness and usage of this parking system, we collected data of some of these spots. The team visited 9 of the 52 riva parking spots without time availability restrictions every half hour for 5 hours, noting if the spot was in use, if the spots and boats had the proper signs and decals, and taking photos of each boat observed.

Based on the data collected, summarized in Table 4 below, the team found that of the 9 spots, only six were used within the 5 hour period. Of the 9 boats observed, 2 exceeded the 1 hour parking limit. In addition, some spots were missing the required signs, and none of the observed boats displayed the required disco orario.

We can suggest that, based on the collected data, the system is being exploited. People are violating the guidelines and it has not been observed that authorities are implementing the regulations. Additionally, we can suggest that one hour may not be enough time for temporary boat parking spots seeing as 50% of the boats that remained parked for at least 15 minutes exceeded the one hour time limit. We evaluated this number using boats that were parked for at least 15 minutes because that suggests that the boat owners were using the temporary parking for activities other than things such as loading and unloading.

Table 4: Summary of Boat Parking Data

		A	B	C = B - A
Riva #	*Boat #*	*Time First Spotted*	*Time Last Spotted*	*Minimum Hrs. Spent*
064-07	1	12:02	13:13	1.18
062-04	1	12:09	12:47	0.63
062-04	2	15:59	15:59	0.00
060-07	1	14:09	14:47	0.63
060-07	2	15:48	15:48	0.00
096-02	1	12:10	14:37	2.45
067-04	1	12:12	12:12	0.00
074-09	1	12:22	12:22	0.00
074-09	2	15:16	15:16	0.00
095-06	NONE			
013-03	NONE			
005-04	NONE			

4.2.2 Vento di Venezia Docks

A major factor that we considered when evaluating potential new temporary boat parking was a proposal by Vento di Venezia. They proposed the addition of 31 docks spread throughout Venice and the surrounding area. The proposal included photoshop renderings of each dock, with detailed information including the number of boats that could park at it and estimated cost. However, these spots were spread out and the coordinates listed to locate each spot did not correspond to the locations shown in the photoshop rendering. In order to assess their feasibility and impact as potential improvements, we visualized all the proposed docks on a single QGIS layer. We used Google Maps to find the precise coordinates and used QGIS to sketch a polygon of each dock. Figure 21 below shows an example of one of the docks visualized in QGIS, and Figure 22 below shows a plot of the locations of each of the docks.

Figure 21. QGIS rendering of one of Vento di Venezia's proposed docks

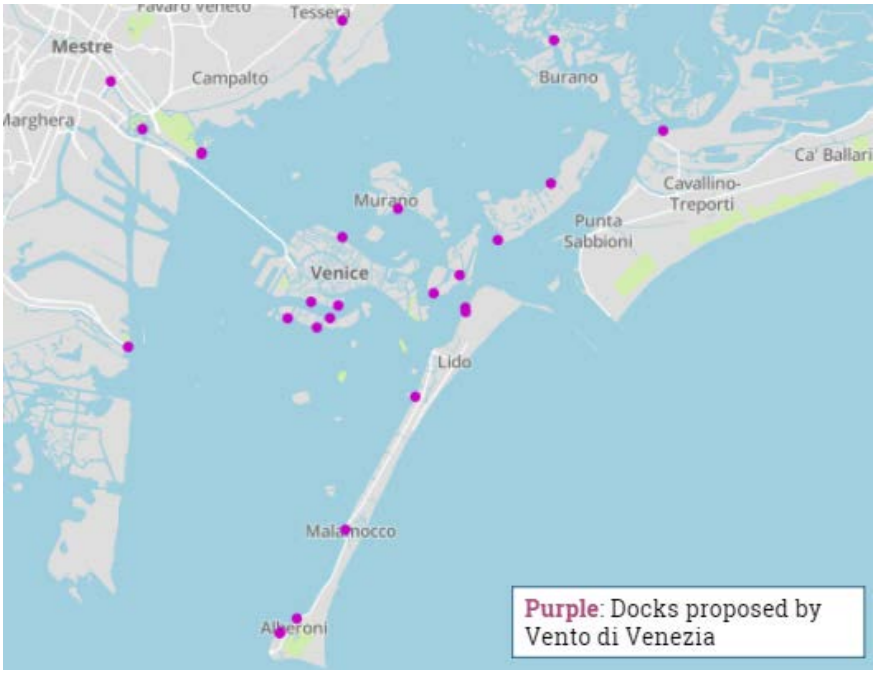

Figure 22. Map of docks proposed by Vento di Venezia

4.2.3 Methodology - Examining Boat Parking

In order to evaluate the usefulness of temporary boat parking we considered the 91 current available one-hour boat parking spots, potential new dock locations suggested by Vento di Venezia, and stores within the historic city. Temporary boat parking would be primarily used

for activities such as shopping at stores and having meals. To evaluate this, we needed to visualize the boat parking locations compared to store data from the Venice Project Center. We narrowed down the store data available of the historic city to only include categories of stores that we believe would be used by Venetians. This essentially eliminated categories such as hotels, souvenir shops, travel agencies, etc. We then visualized the current 91 one-hour spots over a heatmap of these stores, as seen in Figure 23 (left). For these temporary boat parking spots to be useable for stores they need to be available during store hours. About one third of the 91 spots in the current one-hour boat parking system can only be used from 20:00 to 04:00, so we then removed these from our visualization, leaving us with 59 spots as seen in Figure 23 (right).

Figure 23. Current 1-hour spots and 1-hour daytime spots

We were able to conclude that the current system does not provide spots in the most strategic locations if Venetians wanted to take their boat out and visit stores. We came to our conclusions by visualizing the current spots with daytime availability against a heatmap of stores throughout the historic city. The heatmap of stores does not include categories of stores relating to tourism activities, as described previously. The heatmap of stores with the daytime parking spots can be seen below in Figure 24.

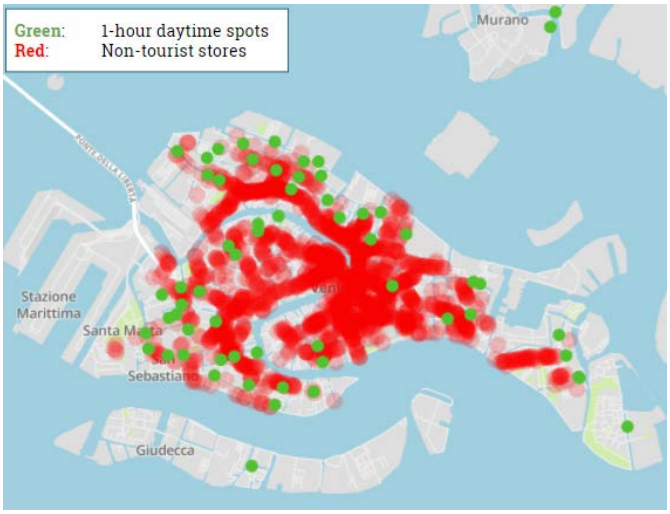

Figure 24. Current Daytime 1-Hour Boat Parking and Stores Heatmap

In order to suggest better temporary parking spots, we designed a computer program that would run through all of the current rive spots. To identify the locations of new parking spots, we applied the following criteria: the spot must have a minimum number of stores nearby and more spots should be located near areas of greater store density. Spots also had to be located in canals with a minimum width of 5 meters to allow parking on both sides of the canal and continued mobility through it. Then, we implemented a minimum distance between any two spots. We used QGIS to visualize the 31 docks that Vento di Venezia has proposed around Venice, and removed potential parking spots in proximity to these docks.

We then examined the maximum times for which boats should be allowed to park. For the current temporary boat parking system the maximum time is one hour, however, based on our data collection of 9 spots, we found that 25% of the boats observed that remained parked for at least 15 minutes exceeded the one hour time limit. We then considered the amount of time that it takes to dine and shop, two leisure activities that temporary boat parking spots might be used for. In Europe, the average amount of time spent at a restaurant is 77.3 minutes.[41] For shopping, we wanted to account for the total amount of time spent shopping at multiple stores, so even though the historic city does not have shopping malls we found the average length of a trip to a shopping mall in America, 84 minutes,[42] and assumed that it is similar to the full time one might spend shopping in the historic city. The amounts of time spent on both of these activities exceed one hour. Finally, we considered the practicality of two-hour parking spots as opposed to one-hour parking spots. Doubling the maximum time that a boat owner can spend parking halves the number of people who can park in a spot throughout the day, should all boat owners stay for the maximum time. This could potentially have a negative effect on store owners because it means that less customers are able to come in. Thus, to account for both the needs of boat owners and the economic impact on stores, only a limited number of temporary boat parking spots should be two-hours.

4.2.4 Results - Suggesting Boat Parking Spots

We believe that the spots seen in Figure 25 below would be ideal for possible temporary parking. These spots fit our mentioned criteria and could improve accessibility to stores.

[41] Kimes, Wirtz, & Noone, 2002.
[42] JCDeaux, n.d.

Figure 25. Suggested temporary boat parking spots

While these 221 spots can be considered viable candidates for increased temporary parking, we have also left behind code that would allow for the alteration of our our criteria. Based on new criteria, different suggested spots could be generated.

4.2.4 Analysis - Assessing Suggested Spots

When examining a specific location with high store density, such as the area surrounding the Rialto Bridge, the current systems provides no daytime spots. By assigning spots based on store density, additional spots were created around the Rialto Bridge in our proposal. When comparing the current spots to the newly proposed spots, the accessibility of stores has drastically increased with our proposal.

4.3 Designing a System for Regulating Boat Parking

In order for temporary parking spots to be accessible and regulated, we have designed a platform that will allow both boat owners to find and book temporary parking and authorities to regulate the spots. We have created designs in Adobe Illustrator that can act as a foundation to the development of an actual application available for smartphones. When designing this application, we considered:

- Enforcement and user side
- Boat registration
- Payments and fines
- Searching for locations
- Booking within a limited timeframe

4.3.1 Results - A Smarter System

Figure 26 shows our application design, beginning with the login screen (top left). Depending on your login credentials, you will have access to either the user view (bottom left) or the authority view (bottom right). When registering, a user is brought to the registration screen (top middle and top right) where they must provide their personal information, boat information, and payment information. This allows them to be easily identified by enforcement. On the user view, users are able to enter the desired location to which they are traveling and view current availability of spots in that area. When the user selects a spot, they can then see the future availability of that spot for the next 6 hours. From there, they can then book and pay. On the enforcer view, enforcers are able to select a spot to see if it should be currently occupied, and if so, by whom. If the user who booked the spot remains parked past the time limit then they can be issued a fine through the app, and if a boat is parked in a spot that is unregistered with the system, a ticket will be issued.

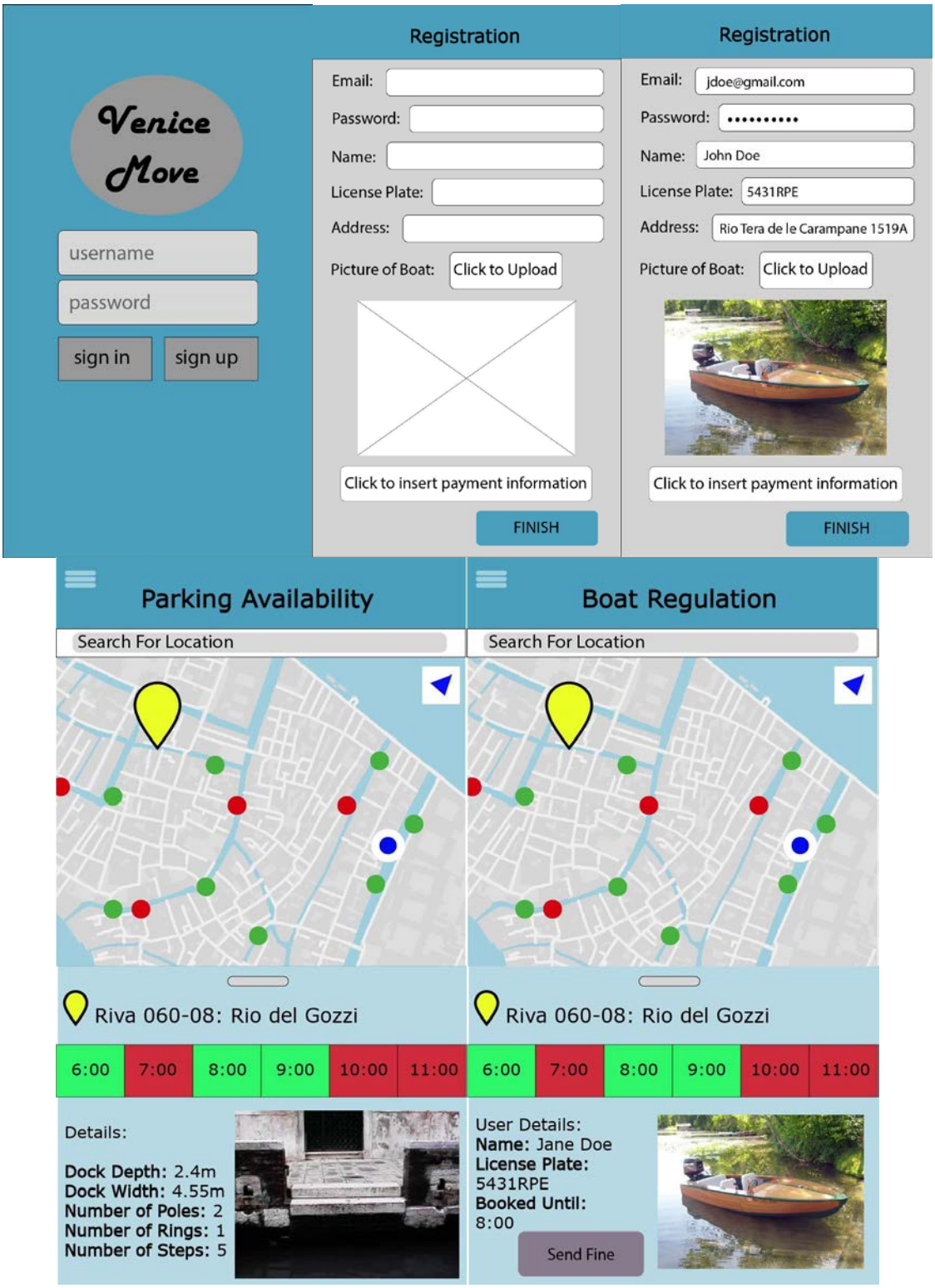

Figure 26. Parking app

4.3.2 Analysis - Assessing a Digital Regulation System

When a new regulation system of any type is created, the public will often want the old system to also remain. If the current system of using the disco orario to mark the time arrived at a spot were to be used in addition to the proposed smartphone application, the feature of booking in advance would have to be eliminated. It is not possible to have a boat owner's booked spot be valid if a boat owner using the current system were to park in that spot before they arrived. To use the smartphone application, users would have to arrive at an open spot and then book the spot. Additionally, it would be impossible to implement a payment system through the smartphone application as the current system is free to use. In the attempt at suggesting an efficient system, a system combining the old system and newly proposed system would not be ideal.

The new system will have to be standalone in order to be efficient. This means that everyone using the system will have to possess a smartphone. If a boat owner does not have a smartphone or does not register with the application they cannot use the potentially implemented parking spots. Based on data collected, we do not foresee this as a problem. The amount of smartphone users in 2014 was 1.57 billion and the predicted amount for 2020 is 2.87 billion.[43] Of Italy's population of about 59,798,000, 39,323,000 (65.8%) use a smartphone.[44] Technology is becoming more innovative and people are continuously adapting to a changing environment. If implemented, we believe people will be able to adapt to this newly proposed system.

4.4 Conclusions

Car parking in Venice is fairly limited, with a total of 5,633 spots in the historic city and another 1,790 spots immediately across the Ponte della Libertá in Mestre. Since cars arriving in the historic city have to either park or turn around, the number of parking spots in the historic city limits the number of cars that can travel over the Ponte della Libertá, leading to congestion on the bridge. Due to the spatial constraints in the historic city, we considered the possibility of converting a current parking lot in Tronchetto into a five-tier parking garage. This lot would increase the car capacity of the historic city by 15.6%, but would cost nearly €22 million to construct and increase traffic on the Ponte della Libertá because additional parking incentivizes more people to drive into the historic city. As a result, we do not recommend the construction of such a garage.

We observed two major flaws in the historic city's boat parking system: a lack of one-hour spots close to non-tourist stores, and a lack of enforcement of parking regulations. Of the nearly 1,600 rive in Venice, only 91 are available for one-hour parking, and only 59 of these one-hour spots are available during the day. Based on the Venice Project Center's data on the locations of stores, these one-hour parking spots are not in optimal locations for shopping at

[43] Statista, n.d.
[44] Newzoo, 2017.

these stores. Using this store data, information on the widths of Venice's canals, and the locations of docks proposed by Vento di Venezia, we were able to suggest spots that we recommend that the city convert to one-hour spots.

From field work, we witnessed faults in the current one-hour parking system, especially a lack of signs on many of the parking spots. We also found that this system was being exploited, with boat owners often exceeding the maximum time limit and not displaying required information, and found it appropriate to suggest a new system for regulation. We believe that it is time for the boat parking in Venice to align with the current available technology. We designed the layout of a smartphone application that could be used to book (on the user side) and to regulate (on the authority side) our suggested parking spots. Since we do not believe that this system could be used alongside the current system for boat parking regulation, we recommend phasing the current system out and replacing it with the smartphone application that we designed.

5. Potential Improvements to Water Bus Systems

We considered two small scale improvements to Venice's infrastructure, both of which involved changes to the ACTV water bus service. First, we investigated the possibility of replacing the southern part ACTV lines 5.1 and 5.2 with line 6 that runs express between Lido and Piazzale Roma, while line 6 would make all of the stops that lines 5.1 and 5.2 would skip. We evaluated the benefits associated with this system in terms of the time that it would save on the trip from Lido to the Ferrovia.

We also investigated the possibility of reopening the Rio de'l Arsenal and the Canale delle Galeazze, two connected canals on the eastern end of the historic city, to water bus service. We found the additional cost of adding water bus service through the canals, and estimated the amount of time that it would take boats to travel through the canals in order to determine the time savings associated with this additional service.

5.1 Express Boat Service

The ACTV waterbus system currently includes express lines that skip various stops in order to reach certain points of interest more quickly. One example is line 6, which acts as a *de facto* express line for lines 5.1 and 5.2 during the summer. During the summer, as shown in Figure 27, this line makes five stops over the course of its route: it begins its route at Lido S.M.E. and makes stops at Sant' Elena, Giardini, and Zattere before terminating at Piazzale Roma; in comparison, lines 5.1 and 5.2 (shown in Figure 29) make nine stops along the south end of the historic city between Lido and Piazzale Roma. During the winter, as shown in Figure 28, line 6 makes additional stops at San Marta, San Basilio, and Spirito Santo on the western and southern ends of the historic city. This increases the amount of time that it takes to travel between Lido and Piazzale Roma.

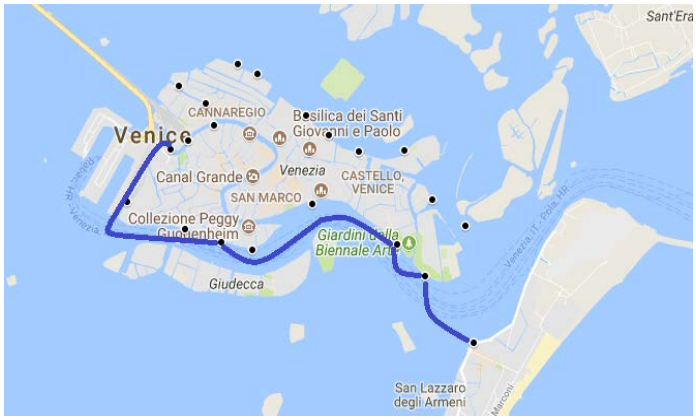

Figure 27. ACTV line 6 summer service

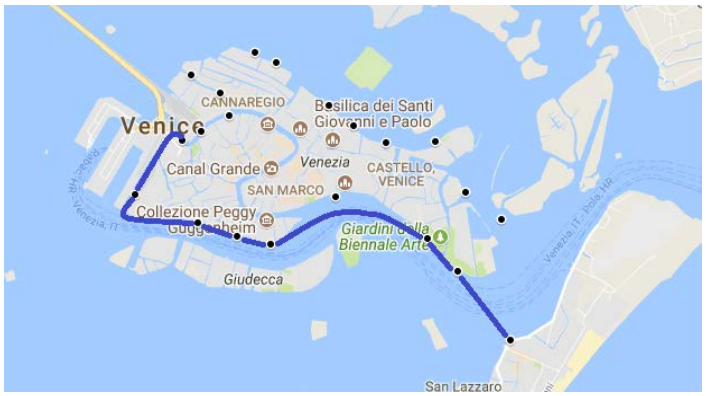

Figure 28. ACTV line 6 winter service

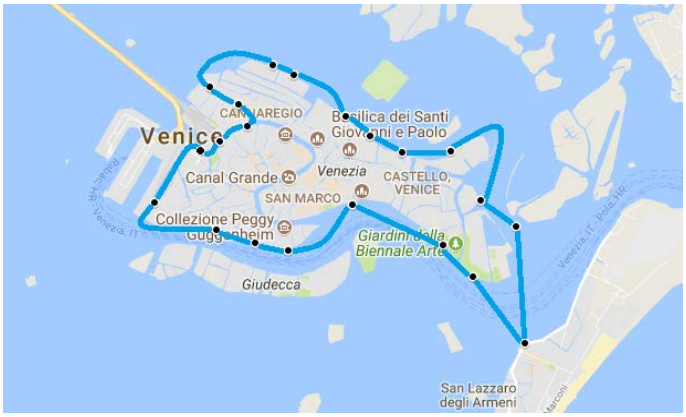

Figure 29. Map showing service for ACTV line 5.1

However, whereas Lines 5.1 and 5.2 continue their routes on the north end of the historic city, line 6 terminates at Piazzale Roma. As a result, it does not provide service to the Ferrovia and the northwest corner of the historic city. One of the goals of our project was to investigate the possibility of extending the express service that line 6 offers during the summer north of the Piazzale Roma.

5.1.1 Methodology

We investigated the possibility of changing the route of Lines 5.1 and 5.2, so that both lines make only the stops that line 6 currently makes between Lido and Piazzale Roma. Under this system, line 6 would serve as a local line along the south end of the historic city, making all of the stops that lines 5.1 and 5.2 currently make between Lido and Piazzale Roma. We examined the time savings that this would afford in terms of the travel times from Lido to Ferrovia with the existing summertime service and with express service along the south end of the historic city. We used this past summer's timetables for line 5.1 in order to find the amount of time that it takes to travel from Ferrovia to Lido. In order to estimate the amount of time that it would take an express version of line 5.1 to travel between these two points, we found the amount of time that it takes line 5.1 to travel from Ferrovia to Piazzale Roma and added it to the

amount of time that it takes line 6 to travel from Piazzale Roma to Lido during the summertime, based on the timetables for that line.

Figure 30. Proposed express line to replace Lines 5.1 and 5.2.

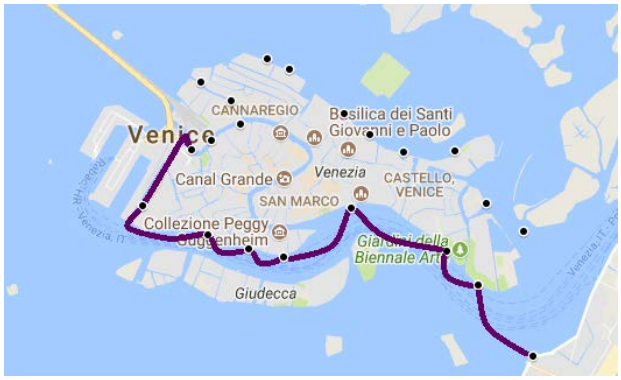

Figure 31. Proposed local line for the south end of Venice.

5.1.2 Results

If Lines 5.1 and 5.2 were replaced with the express service shown in Figure 30, it would take 34 minutes to travel from Ferrovia to Lido. This travel time is based on the fact that it takes four minutes to travel from Ferrovia to Piazzale Roma on line 5.1, and 30 minutes to travel from Piazzale Roma to Lido on line 6 during the summertime. Currently, it takes 43 minutes to travel between the two points in the summertime using line 5.1.

5.1.3 Analysis

The time savings associated with replacing Lines 5.1 and 5.2 with an express line along the south end of the historic city are small. However, since the lines currently run with the same frequency, and would presumably continue to run with the same frequency when their routes are changed, this change in service would not result in any additional cost. In addition, replacing the south ends of Lines 5.1 and 5.2 with express service would improve access not only to the Ferrovia, but to the Guglie and Tre Archi stops in the Cannaregio Canal as well. This change in ACTV service would not require that any existing pontoons be replaced, since Lines 5.1 and 5.2 use the same type of boat as line 6.

The main disadvantage of modifying Lines 5.1, 5.2, and 6 is that the new Lines 5.1 and 5.2 (which would run express along the south end of the historic city), would skip the San Zaccaria stop, while the new line 6, which would stop at San Zaccaria, would not reach the train station. If this service were implemented, the number of lines connecting San Zaccaria to the Ferrovia through the Giudecca Canal would be reduced by half, with Lines 4.1 and 4.2 continuing to travel along this route. While other lines, such as Lines 1 and 2, travel between San Zaccaria and the Ferrovia, they do so along the Grand Canal, and as a result take much longer to complete the journey.

This reduction in service could be addressed by joining the new line 6 with Line 3 at Piazzale Roma, so that the local line along the south end of the historic city could then run to Murano. Since line 6 runs every 20 minutes, while Line 3 runs every 30 minutes during the winter, this would require Line 3 to run with an increased frequency, raising the ACTV's operating costs. However, since Line 3 uses the same boats as Lines 5.1, 5.2, and 6, connecting Line 3 with the slow line along the south end of the historic city would not require any stations to be replaced. As a result, the only additional costs associated with connecting the two lines would be the operating costs associated with the increased frequency of service from the Piazzale Roma to Murano.

5.2 Reopening the Rio de'l Arsenal

Prior to 1999, ACTV boats ran through the Arsenal along the Rio de'l Arsenal and the Canale delle Galeazze, which offered a shortcut for water busses which would otherwise have to travel around the eastern end of the historic city. In 1999, however, the Canale delle Galeazze was closed for repairs and never reopened[45]; in order to travel between the south and north ends of the historic city along its east side, boats now had to travel around the eastern end of the city. We examined the possibility of running ACTV service through the Rio del' Arsenal and the Canale delle Galeazze (collectively referred to as the Rio de'l Arsenal in this section) in order to reduce travel times between the southern and northern ends of the historic city.

5.2.1 Methodology

Since the Rio de'l Arsenal is already wide enough that it does not need to be widened in order to allow water busses to run through it, and reopening it would not require the ACTV to expand its fleet, there are no capital costs associated with reopening the Rio de'l Arsenal to water bus service. In order to calculate the operational expenses associated with additional ACTV service through the Rio de'l Arsenal, we found the 1998 ACTV operating expenses, the final year in which the use of the Rio de'l Arsenal was still factored into the ACTV's budget , and adjusted for inflation. We then used the current ACTV timetables to find the total number of hours per

[45] Paolo Corposanto (Personal Communication)

day that all boats spend in revenue service, and divided the ACTV operating costs by this number in order to find the cost of running a boat for an hour per day every day of the year.

Next, we found the total number of hours per day that boats would spend running through the Rio de'l Arsenal. To do this, we found the time that boats would require to go through the canal by dividing the length of the canal by the average speed at which ACTV boats travel. Since the service through the Rio de'l Arsenal would be an express service for an existing line (ACTV lines 4.1 and 4.2), we assumed that boats would travel through the canal once every 30 minutes--once per hour in each direction--and divided the time required to travel through the canal by this amount. We then multiplied the resulting quotient by 18 hours, since Line 4.1, to which the service through the canal would be an addition, runs from 6am to midnight.[46] Finally, we multiplied the resulting value by the cost of running a boat for an hour per day every day of the year in order to find the cost of service.

In order to assess the benefits of opening the Rio de'l Arsenal to ACTV service, we found the amount of time that boats would take to travel from Arsenale to Celestia by dividing the distance between the two stops along the Rio de'l Arsenal by the average speed of ACTV boats.[47] We also found the time that it currently takes to walk between the two stops by tracing the shortest route in Google My Maps, finding the length of the route, and dividing the length by 1.42 m/s, the average human walking speed.[48] Finally, we found the amount of time currently required to travel between the two fermata using the timetables for ACTV Lines 4.1 and 4.2.

5.2.2 Results

The total annual operating expenses for the ACTV were estimated to be €103,000,000 based on 1998 ACTV operating expenses and adjusting for inflation. Since ACTV boats are in revenue service for 1172.15 hours per day[49], we estimated that it cost €88,000 to run a single line for an hour per day, every day of the year.

As shown in Table 1, we estimated the cost of service through the Rio de'l Arsenal by assuming that the line would be in service for 18 hours a day and that there would be two crossings of the Rio de'l Arsenal per hour (one in each direction). Based on these assumptions, we determined that adding boat service through the Rio de'l Arsenal would cost an additional €580,000/year.

Table 5: Cost Analysis of Additional ACTV Service Through the Rio de'l Arsenal

A	**1998 ACTV expenses (lire)**	1.44E+11
B	**1998 ACTV expenses (euros)**	€74,395,114.39

[46] ACTV, n.d.
[47] Nodine et al., 2002.
[48] Browning, Baker, Herron, and Kram, 2006.
[49] ACTV, 2017.

C	**1998-2017 inflation**	38.93%
D = B x (1+C)	**1998 ACTV expenses (2017 euros)**	€103,357,132.43
E	**Boat-hours of service/day**	1172.15
F = D / E	**Cost/boat-hour x 365 days**	€88,177.39
G	**Hours/day in service**	18
H	**Avg. Time Between Boats (minutes)**	30
I	**Time to go through Canal (minutes)**	11
J = G x I / H	**Boat-hours/day**	6.58
K = F x J	**Annual Cost of Service**	€580,000.00

As shown in Table 2, boats traveling through the Rio de'l Arsenal at the typical water bus speed of 5.8 km/hr[50] would take approximately 11 minutes to travel between the Arsenale and Celestia *fermata*, the ACTV stations at each end of the canal. In comparison, boats currently take between 25 and 26 minutes to travel between the two stations, based on timetables for ACTV Lines 4.1 and 4.2.

Table 6: Estimated Travel Time of Boats Through the Rio de'l Arsenal

Potential Ferry Line		
Distance	1.06	km
Speed	5.8	km/hr
Time	10.97	minutes

5.2.3 Analysis

The benefits of reopening the Rio de'l Arsenal can be determined in terms of how much time an ACTV line through the canal would save compared to the current means of traveling between the Celestia and Arsenale *fermata* (boat stops). Table 7 and Table 8 show the current travel times between Arsenale and Celestia by walking and taking an ACTV boat, respectively.

[50] Nodine et al., 2002.

Table 7: Calculations for Time Required to Walk From Arsenale to Celestia

Distance	1.08	km
Speed	1.42[51]	m/s
Time	760.56	s
Time	*12.7*	*minutes*

Table 8: Current Ferry Travel Times Between Celestia and Arsenale

Celestia-Arsenale	25	minutes
Arsenale-Celestia	26	minutes

Compared to walking along the canal, the time savings afforded by running an ACTV line through the Rio de'l Arsenal are small, with less than two minutes of time saved per person. However, the walking speed used in Table 3 apply to the average human being; some groups, such as elderly or disabled individuals, walk at a slower pace. These individuals might also not be able to walk the 1.08 km between the two stations, and might find it easier to remain on the boat as it travels around the eastern end of the island. Reopening the Rio de'l Arsenal to ACTV service would benefit these people especially.

Replacing some of the existing service along Lines 4.1 and 4.2 with service through the Rio de'l Arsenal would help reduce costs, but would also make it harder to access the eastern end of the city and the island of Certosa, and would make it more difficult for people in these places to access the rest of the city. However, all of the spots that would be skipped by a line running through the Rio de'l Arsenal are also served by Lines 5.1 and 5.2. Since both of these lines terminate at Lido, however, somebody hoping to travel from the south end of the historic city to the north end of the historic city (or vice-versa) would have to take a boat to Lido and wait for another boat back to the historic city. There would be no other way to reach Certosa.

5.3 Conclusions

The current water bus routes were examined with the purpose of finding possible small-scale improvements. Express lines currently exist within the water bus system, but we proposed an alteration. Since there is no express line connecting Lido and the train station, we investigated the possibility of replacing the southern portion of lines 5.1 and 5.2 with an express line that makes only the stops that line 6 makes during the summer. We estimate that this express service can reduce travel times between Lido and the train station by 9 minutes. Since lines 5.1, 5.2, and 6 run with the same frequency, and would likely run with the same frequency even if their routes were reconfigured, we assumed that the added costs of reconfiguring their routes would be

[51] Browning et al., 2006.

negligible. Because reconfiguring lines 5.1, 5.2, and 6 would decrease the travel times to the train station and the northwest end of the historic city at little to no additional cost, we recommend that authorities consider this possibility.

We then examined reopening the Rio de'l Arsenal, which was closed in 1999 to water bus service. We determined that doing so would reduce travel times from Arsenale to Celestia by fourteen minutes for those taking the water bus between these points, but that an hourly service between these points would cost €580,000 per year. While some water buses on lines 4.1 and 4.2 could run express through the Rio de'l Arsenal, this would require them to bypass the entire east end of the historic city and the island of Certosa, reducing service to these areas. Because of the implications of reduced service to the east end of the historic city, we recommend reopening the Rio de'l Arsenal to water bus service only if service through it is added as an extra route and does not affect existing ACTV service.

6. A Subway System for Venice

Subways are currently being used in cities all over the world, and provide quick, inexpensive transportation for commuters and tourists alike. Subways have the advantage of operating underground, and therefore are unaffected by weather conditions or traffic above them. Subways also create the convenience of directly connecting major travel destinations within a city.

6.1 Venice Subway System Past Proposal

A proposal for a subway system in Venice was made in 2005 by the mayor of Venice at the time, Paolo Costa. This subway was proposed to travel from the mainland starting at Marco Polo Airport, making 5 stops throughout Venice before ending near Arsenale in the historic city. Travel time from start to end was estimated to be 14 minutes. The Venetian government agreed to pay 56% of the 343 million euro estimated cost. The rest would have to come from private investors. Supporters for the subway claimed it would increase mobility and make it easier for businesses and workers to access the historic city. This proposal ultimately was never implemented, partially due to public opposition, with critics claiming that the subway system would only bring in more tourists.[52] Additionally, while the project received enough contributions from private investors to meet the total cost, the money contributed by these investors was allocated elsewhere.[53]

6.2 Isochrone Generator

Isochrones are ways to visualize the area around an origin point that can be reached within a set amount of time. In order to assess the current limits of mobility compared to the limits of mobility if a potential subway system were to be implemented, we used a tool referred to as an Isochrone Generator. This tool we have constructed produces isochrones for analysis. The tool accepts a specific travel time, a latitude, and a longitude as an origin point. The tool then accesses Google Maps Distance Matrix API, returning the duration of travel using walking and available public transportation from the inputted origin to hundreds of points located in a grid format throughout Venice. The outputted result is an infographic that displays red areas where the travel time is less than or equal to the inputted desired travel time. As the travel time approaches the inputted travel time, the boxes' color decrease in opacity. An example of an input and output with this tool can be seen in Figure 32. Additional isochrones visualizing the current systems can be found in Appendix B.

[52] Sylvers, 2005.
[53] Fabio Carrera (Personal Communication)

Input:
startingPoint = '45.438043,12.335956' (coordinates of rialto bridge)
travelTime = 15 (minutes)

Output:

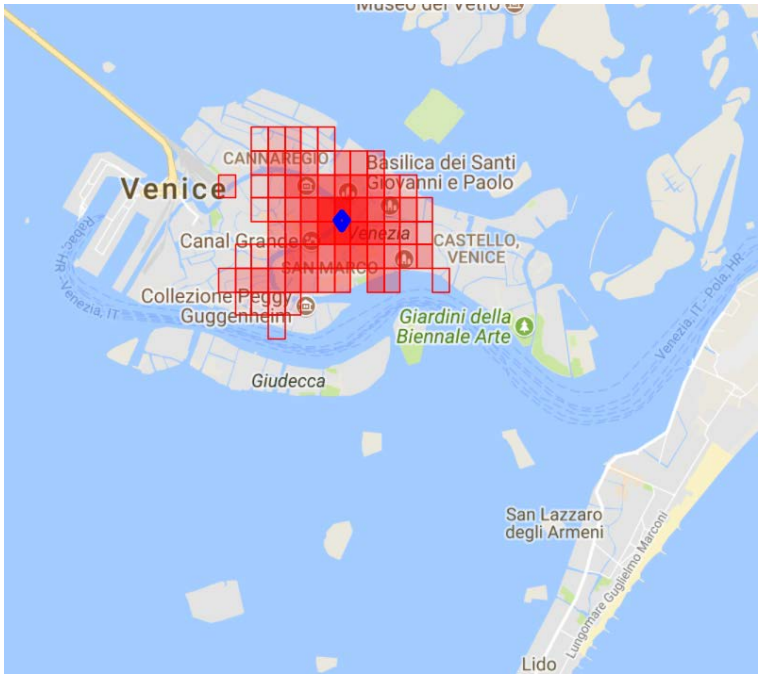

Figure 32. 15 minute isochrone from Rialto bridge

6.3 Subway Route Simulator

With the isochrone generator, it is possible to visualize many places that can be accessed from a starting point. However, what if you want to see how a specific route would change with the implementation of a subway system. Using a tool that we created, the subway route simulator, this analysis is now possible. As an example, in Figure 33, we can examine with our tool the route and duration of a current trip using public transit and walking from Mestre to Lido. We could also select a potential subway system and view that same route and estimated duration if the selected subway system was created and implemented. The altered route and duration can be seen in Figure 33. This tool will allow us to improve our analysis of suggested systems, as well as provide a way to analyze systems presented in the future. Additional route comparisons can be found in Appendix C and Appendix D.

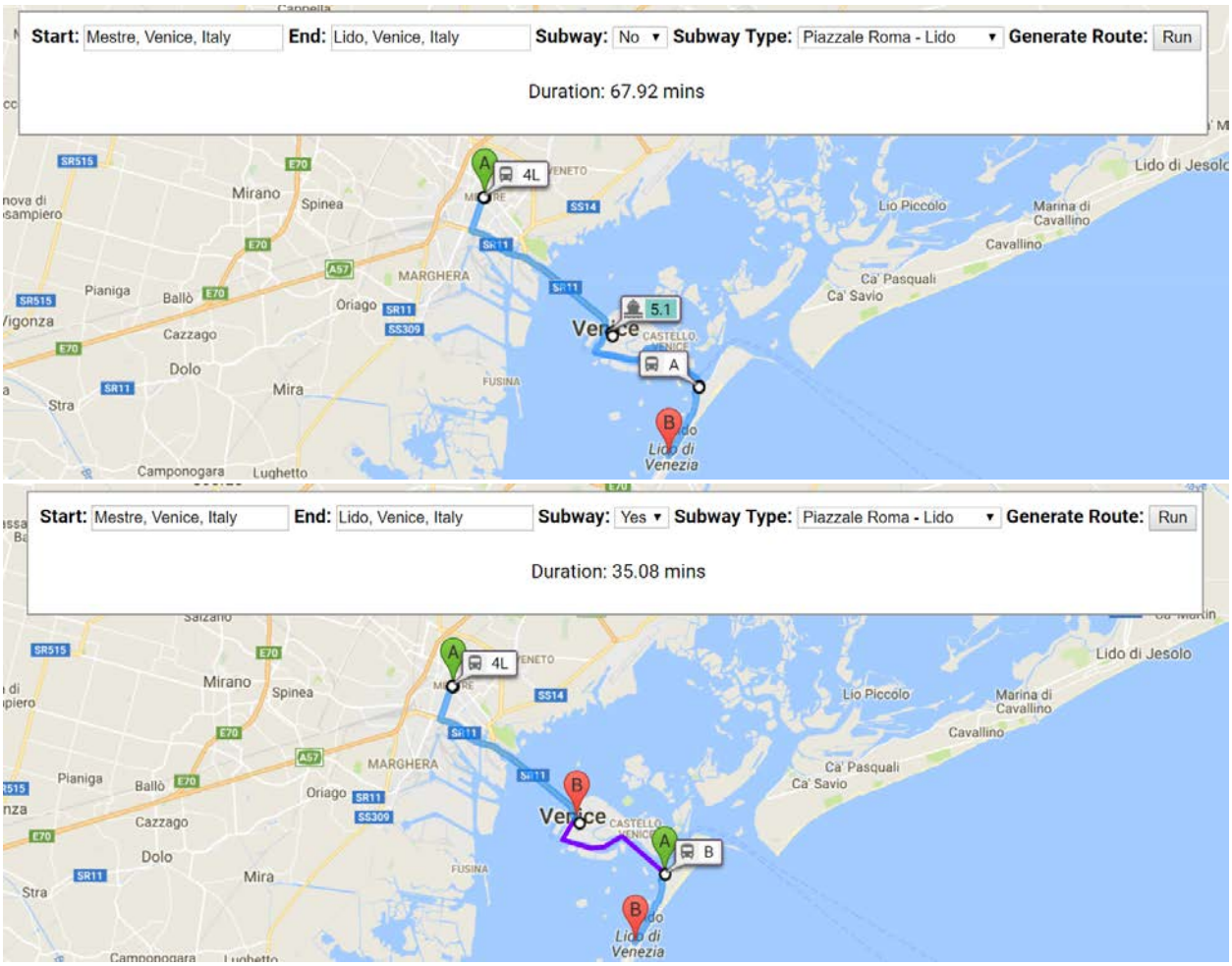

Figure 33. Subway route simulator from Central Mestre to Lido using current system (top) and using suggested subway system (bottom)

6.4 Methodology

We analyzed several possible options for subway lines into and within Venice, including both new routes and those from past proposals. The first option that we analyzed was the line proposed by Paolo Costa in 2005. This line was supposed to have a total length of 8,166 meters and stop at the following locations:

- Marco Polo Airport
- Terminal Tessera, located 615 meters southwest of the Marco Polo Airport
- Murano San Mattia, an island in the northwest of Murano
- The south end of Murano
- The west end of Fondamente Nove, on the historic city's northern end
- The historic city's hospital
- Arsenale Nord, on the north end of the historic city

We analyzed the costs and benefits of this line as described in Section 5.3.2.1 and 5.3.2.2, respectively.

We next analyzed an alternate subway line. Similar to the line proposed by Costa, this line would run underwater in order to avoid construction underneath the historic city. However, unlike the line proposed by Costa, this line would also connect to Lido and Giudecca. The line that we examined would stop at the following locations:

- Lido Santa Maria Elizabeta (S.M.E.), an existing transportation hub on an island of Venice with 16,869 residents.[54]
- San Zaccaria, which is not only close to the Piazza San Marco and the various tourist attractions located in that area, but is already an ACTV transportation hub.
- In the middle of the Giudecca canal, connected by a pedestrian tunnel from which pedestrians could reach Giudecca Palanca and Zattere. Giudecca Palanca is located in the center of Giudecca and is home to 6,151 residents.[55] The station in Zattere is close to many of Venice's universities and to the Ponte dell'Accademia, which provides a link to San Marco.
- Between Ferrovia and Piazzale Roma. This stop would provide riders of the subway with access to inter-city rail and bus transportation.
- Possible extension A of this line would be to Central Mestre, near the central station of its tram system. This stop would provide access to the mainland of Venice, which is home to 70% of the city's population.[56]
- Possible extension B of this line would be to Marco Polo Airport, the fourth-busiest airport in Italy, which received 9.6 million arrivals in 2016.[57]

The line from Lido to Piazzale Roma can be seen below in Figure 34. Possible extension A to Central Mestre can be seen below in Figure 35. Possible extension B to Marco Polo Airport can be seen below in Figure 36.

[54] Venice Project Center, n.d.
[55] Venice Project Center, n.d.
[56] Venipedia, 2015
[57] Assaeroporti, 2017

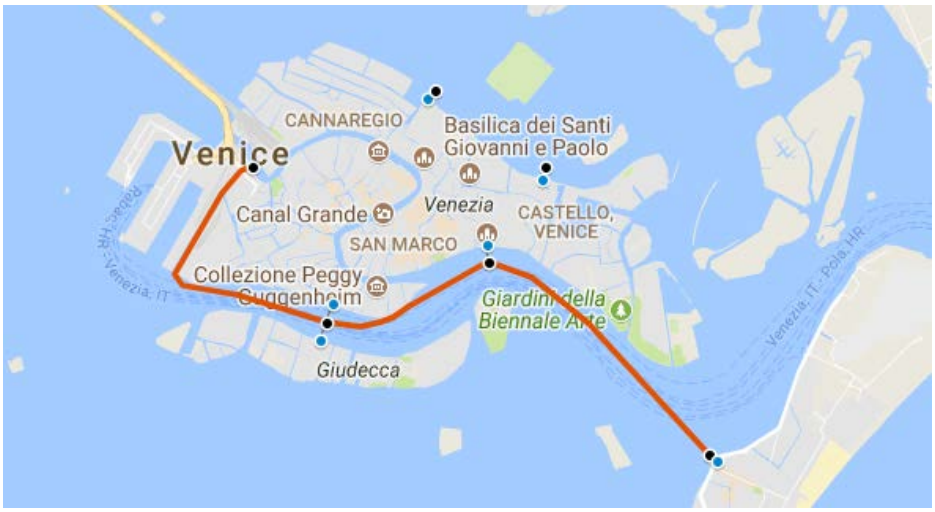

Figure 34. Route map from Lido to Piazzale Roma

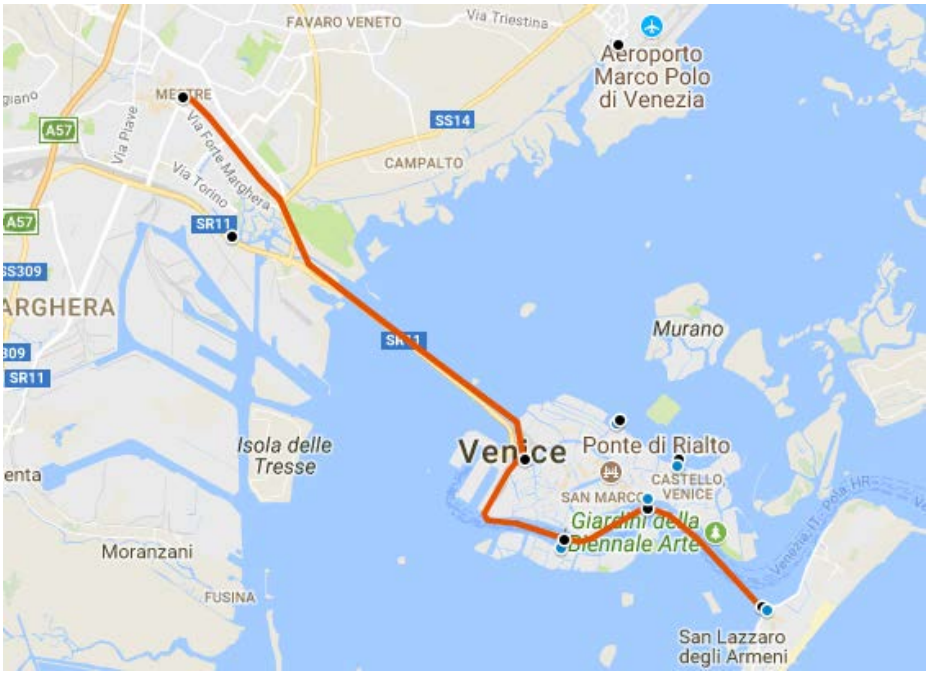

Figure 35. Possible extension of the Lido - Piazzale Roma subway to Mestre

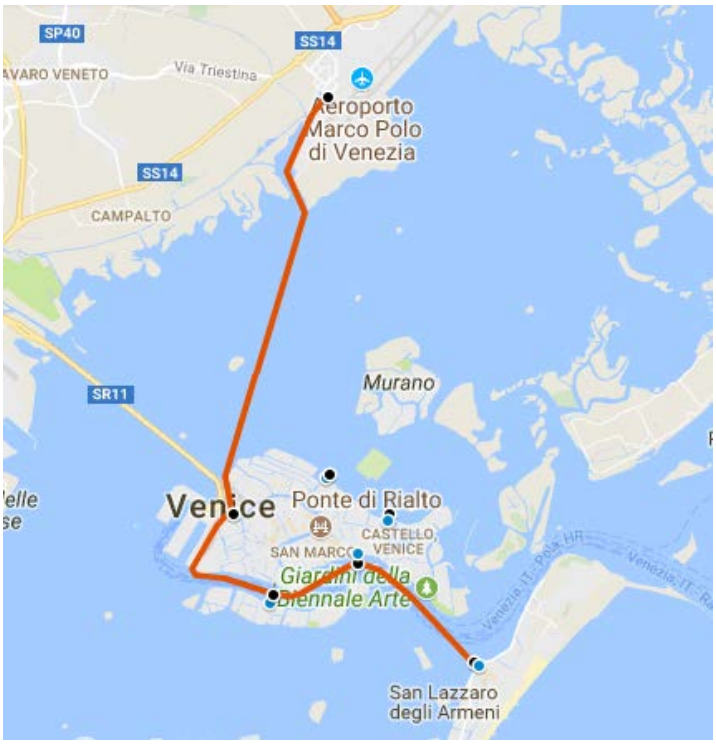

Figure 36. Possible extension of the Lido - Piazzale Roma subway to Marco Polo Airport

We also assessed the possibility of several alternate potential subway routes within Venice:

- A line connecting Murano to Ferrovia and Piazzale Roma.
- A modification of the line proposed by Paolo Costa in 2005, which would extend to Lido. This line would also make fewer stops, stopping only at Marco Polo Airport, Murano, Fondamente Nove, and Lido S.M.E.
- A line running from Marco Polo Airport to Fondamente Nove, Ferrovia, and lastly Piazzale Roma.

For each of these systems, we plotted a potential route in Google My Maps in order to determine the necessary track length for each line. We then found the costs of each line, the expected travel times between each station, and the current travel times between the locations of each station using the methodology described below.

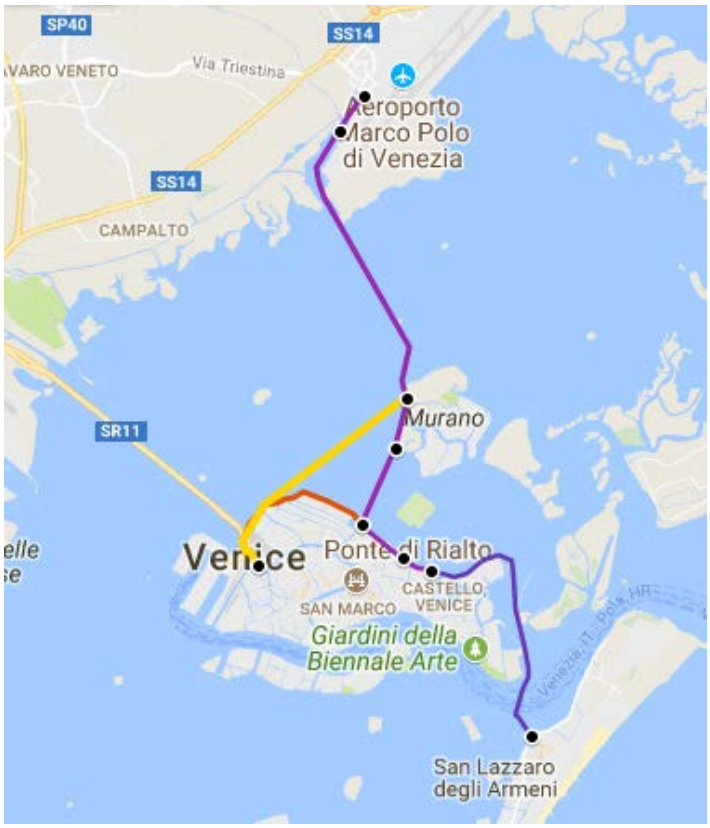

Figure 37. Map of other proposed subway systems

6.4.1 Estimating Subway System Costs

Using the selected subway routes previously determined, we performed cost analysis on these hypothetical implementations. We found the costs of subway construction projects in other cities, and used these costs to estimate the costs of a similar system in Venice using Equation 1:

$$C_p = C_j(1+f)^{p-j} \cdot \frac{S_p}{S_j} \cdot \frac{L_p}{L_j} \quad \textbf{(1)}$$

In Equation 1, C_p refers to the estimated cost of a subway system being constructed in Venice, C_j refers to the cost of the facility being used as a comparison, f refers to the average inflation rate between times p (the date of new facility's construction) and j (the year of the original facility's construction), S_p and S_j refer to the length of the Venice subway system and the original subway system, respectively, and L_p and L_j refer to the city cost indices in Venice and in the city where the subway system being used as a reference was constructed. Since Equation 1 is only used for preliminary cost analysis, the actual cost might be as low as half of the estimated cost and as high as twice the estimated cost.

For each subway system route that we evaluated, we found the costs of several infrastructure projects and compiled a cost estimate based on the individual cost estimates

obtained using Equation 1. These revised cost estimates were based on the minimum estimated cost, the average estimated cost, and the maximum estimated cost, as shown in Equation 2.

$$C_{p,revised} = \frac{C_p(max.) + 4\,C_p(avg.) + C_p(min.)}{6} \quad \textbf{(2)}$$

In addition to estimating the costs of constructing these systems, we estimated the operating costs of these systems using present value analysis. The present value of an expenditure made (or a profit achieved) at some point in the future is calculated using Equation 3, shown below:

$$PV = \frac{P}{(1+r)^n} \quad \textbf{(3)}$$

In Equation 3, *PV* refers to the present value of a sum of money either gained or spent, *P* refers to the amount of money either spent or gained, *n* refers to the amount of time elapsed between the present and the time in which the transaction takes place (typically in years), and *r* refers to the effective interest rate, which is calculated based on the interest rate and inflation rate as shown in Equation 4:

$$r = \frac{1+i}{1+f} - 1 \quad \textbf{(4)}$$

In Equation 4, *i* refers to the interest rate and *f* refers to the inflation rate. Both the average interest rate and the average inflation rate can be calculated based on the inflation rates over a period time using Equation 5:

$$i_{average} = \sqrt[n]{(1+i_1)(1+i_2)(1+i_3)\ldots(1+i_n)} - 1 \quad \textbf{(5)}$$

We estimated the costs of the suggested subway routes using two methods. First we used the Comparison Method, which allowed us to estimate the cost of any subway system proposed for Venice based on its length and the cost of subway systems previously constructed in other cities. For this method, we applied the methodology described above to the following subway construction projects from areas throughout Europe:

- An extension to Berlin's subway system, completed in 2009.[58]

[58] Spiegel Online, 2009.

- A 1.9-km extension to Line 6 of Naples's subway, opened in 2007.[59]
- Amsterdam's North-South Line[60]
- Copenhagen's Circle Line[61]
- Paris's Metro Line 14[62]

We estimated the unit cost per kilometer of these systems if they were constructed in Italy using Equation 1. In order to account for the differences in construction costs (the L_p/L_j term in Equation 1), we found the labor cost indexes of the countries in which these systems were constructed and compared them to Italy's labor cost index.[63] After calculating an estimated unit cost for each of the five systems listed above, we used Equation 2 to estimate a final cost per kilometer for any subway system in Venice.

The second method that we used, the Unit Cost Method, accounted for both the length of the subway system being constructed and the number of stations that it contained. For this method, we obtained a separate unit cost per kilometer of one-track underground railway (the type of railway proposed for Venice in 2005)[64] and a unit cost per underground station from Don H. Pickrell's 1985 paper "Estimates of Rail Transit Construction Costs," which analyzed the costs of various rapid transportation systems in the United States and created equations to predict the cost of railway lines based on their length and number of stations.[65] We adjusted both unit costs for inflation, converted from dollars to euros, and estimated differences in the two countries' labor costs using the countries' Big Mac Indexes, which give the average price of a Big Mac in a given country and indicate that country's purchasing power. We also adjusted the unit cost for the railway by converting from miles to kilometers. Our calculations for these revised unit costs can be found in Table 12 in Appendix C.

After we had calculated the unit costs per kilometer of rail and per station, we estimated the costs of the various subway lines we were evaluating for Venice using Equation 6:

$$C_{total} = a_1 * L + a_2 * L \quad \textbf{(6)}$$

In Equation 6, a_1 represents the cost of construction per kilometer of one-track underground railway, L represents the length of railway in kilometers, a_2 represents the cost of construction per station, and N represents the number of stations.

In order to find the maintenance and operating costs for each subway system, we applied the Comparison Method methodology as described previously to the following rail transportation systems:

[59] Railway Gazette, 2007.
[60] Levy, 2017.
[61] Railway Gazette, 2010.
[62] Levy, 2017.
[63] YCharts, n.d.
[64] Sylvers, 2005.
[65] Pickrell, 1985.

- Port Authority Trans-Hudson (PATH) system
- Los Angeles Metro Rail
- Boston "T"
- New York City Subway
- Miami Metrorail
- Washington, D.C. Metro
- Madrid Metro
- Philadelphia SEPTA subway
- Atlanta MARTA
- Berlin U-Bahn
- Paris Metro and RER
- London Underground
- Bay Area Rapid Transportation (BART) system
- Chicago "L"[66]

We then estimated the unit cost per car-mile of these systems if they were constructed in Italy using Equation 1. In order to account for the differences in construction costs (the L_p/L_j term in Equation 1), we found the Big Mac Indexes of the countries in which these systems were constructed and compared them to Italy's Big Mac index.[67] After calculating an estimated unit cost for each of the 14 systems listed above, we used Equation 2 to estimate a final cost per car-mile for any subway system in Venice. After we had found a maintenance cost per car-mile, we divided this by the number of passengers that a subway car could accommodate and multiplied the quotient by the length of the subway system in order to find the maintenance cost per passenger, assuming that each passenger rode the route for its entire length.

Next, we needed to find the potential ridership for each subway line being evaluated in order to find the total operating cost by passenger use. In order to find the ridership of the line from Lido to Piazzale Roma, we found the number of overnight stays in the historic city by tourists each year from 2004-2015 and projected the number of overnight stays from 2018-2080, by which point a financially sound subway system should have generated enough revenue to pay off its construction costs and interest on those costs, using linear regression. We estimated the number of trips taken by tourists by assuming that, on average, each tourist used the subway once for every day that they spent in the historic city, and that half of all day trippers, which we calculated from the number of day trippers entering the city in 2013[68] and assuming the number increased in proportion to the number of overnight arrivals, used the subway system once. Using these assumptions, the total number of tourist trips was equal to the sum of the number of nights spent by tourists in the historic city, the number of arrivals in the historic city, and half of the number of day trippers visiting the city. We also estimated local ridership of the subway by

[66] Levy, 2017.
[67] YCharts, n.d.
[68] Blanco, D'Ambrosio, La Manna, Martin, 2014.

obtaining the combined population of the historic city, Giudecca, and Lido, which would each be connected to the subway route, in 2011 and 2017. Based on these numbers, we projected the combined population of these islands forward through 2080 and multiplied the population for each year by 260 in order to predict ridership, based on the assumption that half of the residents of these islands used the subway once per day, every day of the year. For each year from 2018-2080, we added the expected tourist ridership and the expected local ridership and multiplied this value by the operating cost per passenger.

We estimated the maintenance costs for the extension into Mestre based on the estimated number of people using the extension. In order to find the ridership for the proposed extension to Mestre, we found the number of people arriving in the historic city along the Ponte della Libertá by bus on a typical weekday in 1986 and 1997 and divided the numbers obtained by two, based on the assumption that half of the people arriving by bus would switch to taking the subway if such a system existed. We used linear regression to estimate the number of people who would use the subway on typical weekdays from 2018 through 2080, and multiplied these values by 520 to predict annual ridership, assuming those accessing the historic city by subway rode it every weekday and also used it to return to Mestre. We then multiplied these values by the operating cost that we had calculated for the extension to Mestre.

In order to find the ridership for the proposed extension to the airport, we found the number of people who arrived at and departed from Marco Polo Airport each year from 2007-2016. We then estimated the number of locals and tourists who arrived at the Airport during each of these years, based on the number of tourists who arrived in 2007. We predicted the number of locals and tourists arriving at Marco Polo Airport through 2080 using linear regression, and estimated the number of people using the subway system by multiplying the number of locals by 15%, half of the percentage of Venice's residents who live in the historic city, and the number of tourists by 50%. We found the maintenance costs for each year by multiplying the total number of people using the system by the maintenance cost per person that we had calculated for the system.

We then calculated the present value of the total costs of construction and operation of each system through 2080 using Equation 3. For this present value analysis, we assumed that 0.98 km of each system proposed could be constructed in one year, but that all of the capital costs of construction would be committed at the start of 2018. This value is based on the construction times and lengths of the Berlin subway system extension, the Naples line 6 extension, and Paris's Metro Line 14.

We also found the interest accrued on each branch of the subway system over time, using an average interest rate of 2.06% in the Eurozone from 1998-2017.[69] For our calculations of interest, we assumed that all construction costs would be committed and begin to accrue interest at the start of 2018.

[69] Trading Economics, n.d.

6.4.2 Estimating Subway System Benefits

We quantified the benefits of innovative transportation systems by estimating the time saved by using these transportation systems and the number of people using these systems. We also considered less quantifiable benefits of these subway lines, such as a more pleasant trip to the airport or the alternative to the Ponte della Libertá offered by a subway system into Mestre.

In order to estimate the travel time saved, we first established the current travel times for individuals traveling along the subway routes with the current public transportation systems using the Directions feature in Google Maps. In order to ensure that our results reflected typical travel times, we found the travel times at 12:00 pm on weekdays, when public transportation would most likely be running frequently, and recorded both the difference between the arrival time and 12:00 pm, and the difference between the arrival time and the recommended departure time. Finding both of these gave us both the minimum amount of time that it takes to travel between the two points, and the amount of time that traveling between the two points might be expected to take if one had to wait for transportation to arrive. We did this for all of the subway routes we are evaluating.

Next, we estimated the revenue benefits through ticket sales. For the subway system proposed in 2005 by Paolo Costa, found the number of people who arrived at Marco Polo Airport each year from 2007-2016. We then estimated the number of locals and tourists who arrived at the Airport during each of these years, based on the number of tourists who arrived in 2007. We predicted the number of locals and tourists arriving at Marco Polo Airport through 2080 using linear regression, and estimated the number of people using the subway system by multiplying the number of locals by 15% and the number of tourists by 50%. We then found the revenue generated by the subway system by multiplying the number of locals using the transportation each year by €2.00, the proposed fare for locals, and by multiplying the number of tourists using the transportation by €6.00, the proposed fare for tourists.[70] Then, using the ridership found for the Piazzale Roma to Lido route, as well as the possible extensions to Mestre and to Marco Polo Airport as described above, we estimated the revenue benefits for these routes using the same proposed ticket fares as in the 2005 proposal.

For the branch of the subway system running from Lido to Piazzale Roma, we found the number of trips taken by tourists each year from 2018-2080 using the methodology described in Section 5.3.2.1 and multiplied these numbers by €6.00, the proposed fare for tourists.[71] We also found the number of trips taken by locals using the methodology described in that section and multiplied the values obtained by €2.00.

We estimated the total revenue generated by the extension to Mestre based on ridership of that extension. In order to find the ridership for the proposed extension to Mestre, we found the number of people arriving in the historic city along the Ponte della Libertá by bus on a

[70] Sylvers, 2005.
[71] Sylvers, 2005.

typical weekday in 1986 and 1997 and divided the numbers obtained by two, based on the assumption that half of the people arriving by bus were arriving from Mestre and the other half were arriving from more distant locations. We used linear regression to estimate the number of people who would use the subway on typical weekdays from 2018 through 2080, and multiplied these values by 520 to predict annual ridership, assuming those accessing the historic city by subway rode it every weekday and also used it to return to Mestre.

For the potential extension to Marco Polo Airport, we estimated the number of locals and tourists who arrived at the Airport during each of these years, based on the number of tourists who arrived in 2007. We predicted the number of locals and tourists arriving at Marco Polo Airport through 2080 using linear regression, and estimated the number of people using the subway system by multiplying the number of locals by 15% and the number of tourists by 50%. We found the total revenue generated by the system by multiplying the number of locals using the system by €2.00, and multiplied the number of tourists using the system by €6.00.

We also investigated the possibility of using the subway system to ship cargo into the historic city as a means of subsidizing the system. We found the weight of cargo that arrived in Marco Polo Airport each year from 2013-2016, and estimated the weight of incoming cargo through 2047 using linear regression. We then created a data table with different percentages of cargo entering the historic city and different rates charged per ton of cargo transported on the subway. This data table showed the percentage of the present value of the subway's expected revenue through 2047 compared to the present value of the subway's costs through 2047, as a function of these two parameters.

For the subway routes which we investigated, we found the travel times between stations using Equation 7, shown below:

$$t = \sqrt{\frac{d}{0.09a}} \quad \textbf{(7)}$$

In Equation 7, *t* represents the travel time between stations, *d* represents the distance between these stations, and *a* represents the train's acceleration and deceleration. This equation was derived from the assumption that the trains would spend the first 10% of their travel time between stations accelerating at a constant rate, travel at a constant speed for the middle 80% of their trip, and spend the final 10% of their journey decelerating at a constant rate. The calculations that led to the derivation of this equation can be found in Figure 19. Entering the distances between stations on the 2005 proposed Airport-Arsenale line and using the "Goal Seek" function, which allows the user to find the value of an input necessary to produce a specified output, to ensure that it took 14 minutes for the train to run between the two termini resulted in an acceleration of 0.787 m/s^2.

6.5 Results

We determined that the main branch of the potential subway system that we evaluated, from Lido to Piazzale Roma, would require seven years and €1.373 billion to construct, and would open in 2025. We determined that the extension to Mestre would take nine years and €1.702 billion to construct, while the extension to Marco Polo Airport would take eight years and an additional €1.455 billion to construct. Assuming that these extensions are constructed at the same time as the line from Lido to Piazzale Roma, the extension from Piazzale Roma to Mestre would open in 2027 and the extension from Piazzale Roma to Marco Polo Airport would open in 2026.

6.5.1 Proposed Subway System Costs

Using the Comparison Method, the subway lines being proposed for Venice were estimated to cost €201 million per two-track kilometer, or €100.5 million per one-track kilometer. Alternatively, using the Unit Cost Method, these lines were estimated to cost roughly €106 million per kilometer of two-track rail and €66 million per station. These figures were based on a 1985 report that analyzed the costs of various rail transportation systems in the United States and gave unit costs of $103 million (USD in 1983) for each two-track mile of underground rail and $40 million million for each underground station for rapid transit.[72] The values given in that report were adjusted for inflation and differences between purchasing power in the United States and Italy, and were converted from cost per two-track mile to cost per two-track kilometer.

As shown in Table 9 and Figure 38, the route from Lido to Piazzale Roma is expected to be the most profitable segment of the subway. It is expected to take seven years and cost €1.373 billion to construct. However, assuming the subway were to be in operation by 2025, it would generate enough revenue from ridership to pay off all of interest accrued on construction costs and previous maintenance costs by 2034, and would be financially self-sufficient after that year.

Table 9: Construction Costs for the Lido - P.le Roma Route Using the Comparison Method

	Track and Stations	Access Tunnels	*Total*
Avg.	€1,287,899,243.43	€53,637,863.95	*€1,341,537,107.38*
Min.	€424,629,680.21	€17,684,791.05	*€442,314,471.26*
Max.	€2,332,517,856.08	€97,143,682.68	*€2,429,661,538.76*
Value to use	*€1,318,000,000.00*	*€55,000,000.00*	***€1,373,000,000.00***

[72] Pickrell, 1985.

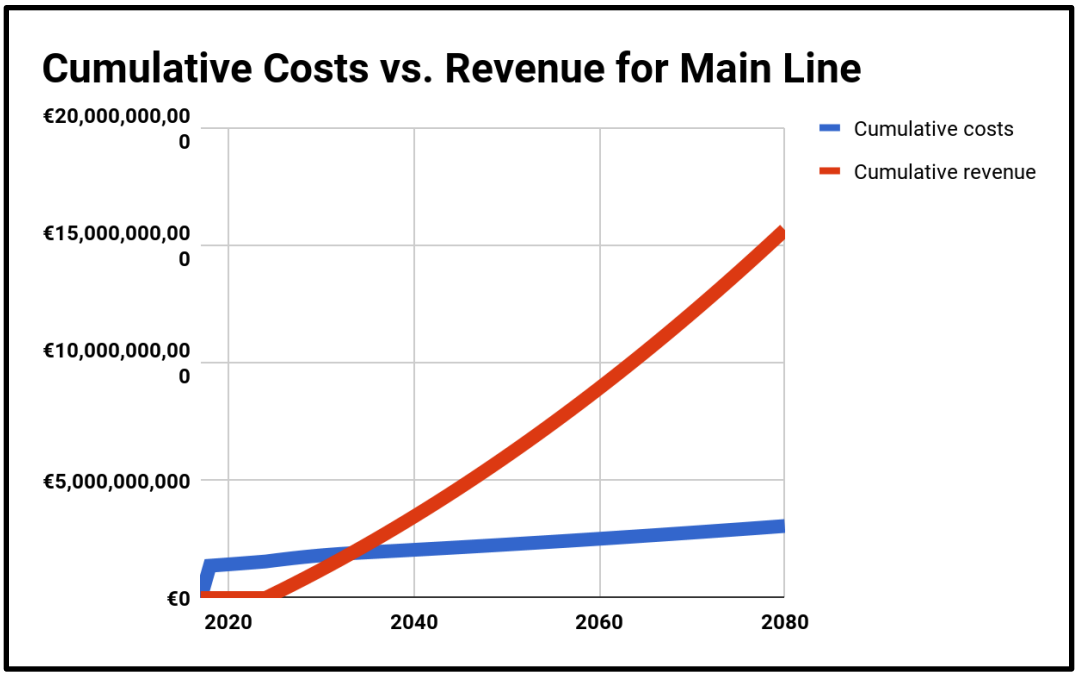

Figure 38. Graph of Cumulative Costs vs. Revenue for Lido - Piazzale Roma Route

Extending service to Mestre would cost an additional €1.702 billion, raising the total cost of the system to €3.075 billion. While the extension to Mestre alone would not generate enough revenue to pay off the interest on the costs of constructing the extension, the full line from Lido to Mestre would generate enough revenue to pay off all construction costs, in addition to all prior operating costs and interest, by 2044, as seen in Figure 39.

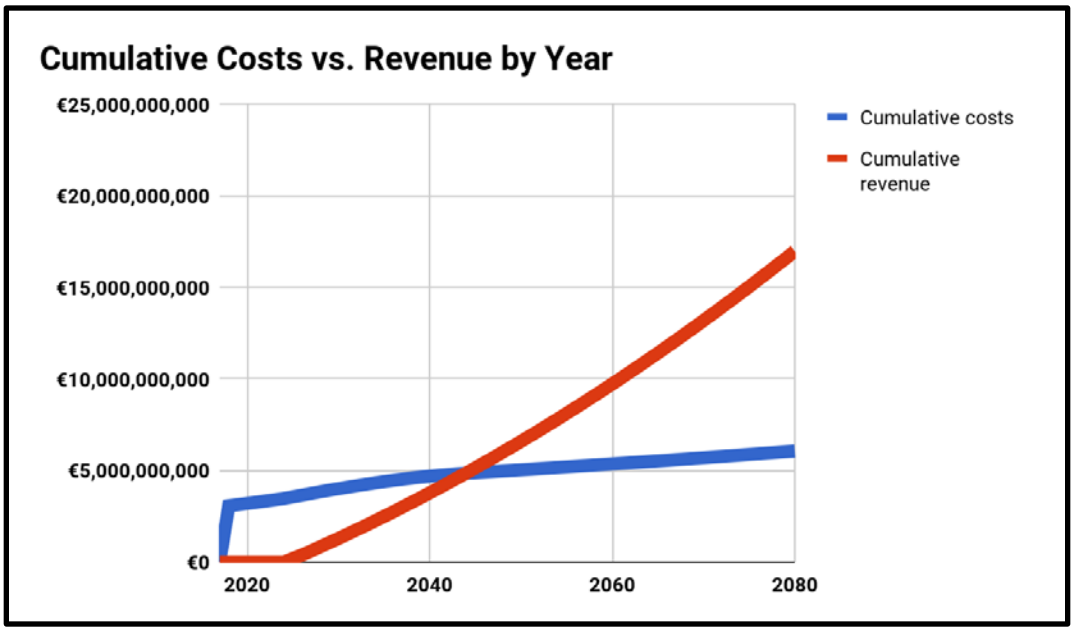

Figure 39. Graph of Cumulative Costs vs. Revenue for the full line from Lido to Mestre

Extending the subway line to Marco Polo Airport would add €1.455 billion to the cost of the subway system, increasing the total cost of the system of Lido to Marco Polo Airport to €2.828 billion. As is the case with the extension to Mestre, the extension to the Airport alone would not be financially self-sufficient, and the interest for its construction and maintenance costs would cause the total cost to increase over time. The complete line from Lido to Marco Polo Airport would generate enough revenue to recover all construction costs, prior operating costs, and interest by 2043.

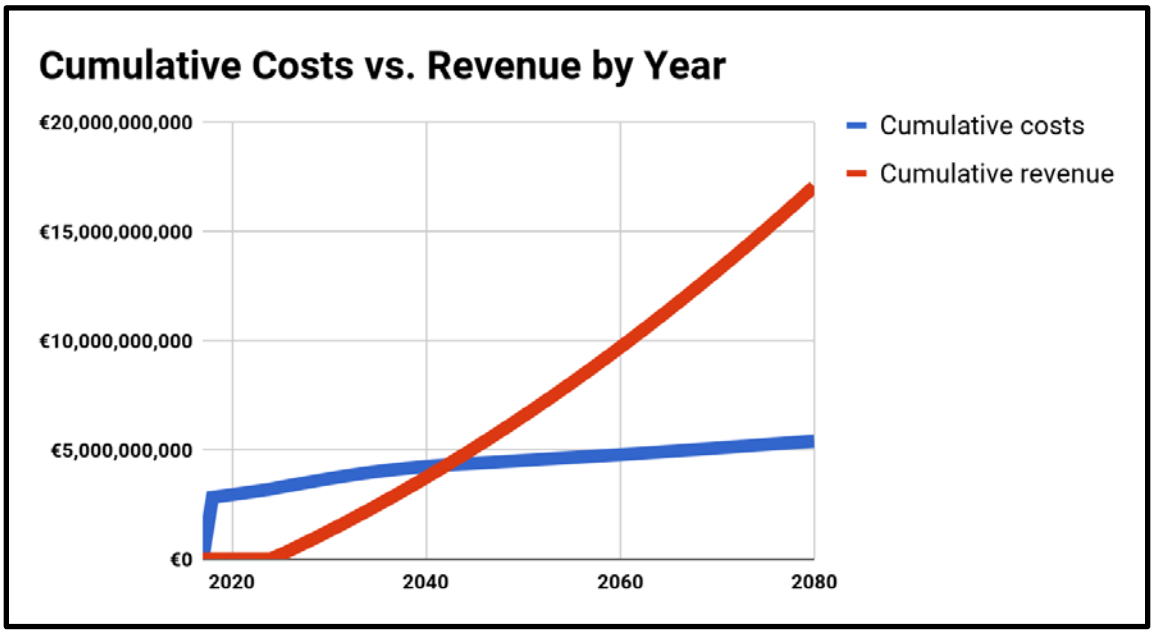

Figure 40. Graph of Cumulative Costs vs. Revenue for the full line from Lido to Marco Polo Airport

As shown in Table 10, the 2005 proposed subway line from the Airport to Arsenale is expected to have a capital (construction) cost of €1.645 billion. The 8,166 km route would take nine years to construct; in comparison, when then-Mayor Paolo Costa proposed the system in 2005, it was expected to open in 2009.[73] It would begin to operate in 2026 and generate €17.7 million dollars in revenue that year, an amount that is predicted to increase over time as more people travel to Marco Polo Airport. However, the revenue generated by the subway system would not be sufficient to pay back any of the interest accrued on its construction costs, regardless of the amount of cargo that it shipped. Figure 42 shows the cumulative cost and revenue of the subway system over time if 50% of cargo arriving at Marco Polo Airport were shipped along the subway system at a cost of €100/ton.

[73] Sylvers, 2005.

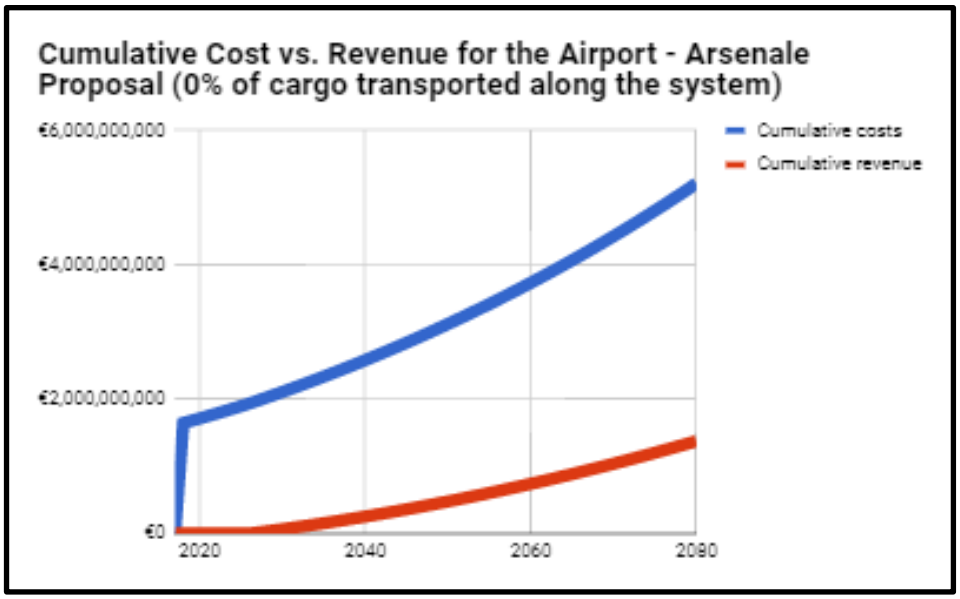

Figure 41. Cumulative cost and revenue for the 2005 proposal, assuming none of the incoming cargo is shipped along the system

Figure 42. Cumulative cost and revenue for the 2005 proposal, assuming 50% of incoming cargo is shipped along the system at a price of €100/ton

Table 10 contains a summary of the construction costs of the remaining subway lines that we evaluated, shown in Figure 37. Calculations for the cost of construction for each subway line can be found in Appendix C.

Table 10: List of Construction Costs for Each Potential Subway Line

Route	Length of Track (km)	Number of Stations	Estimated Cost Using Comparison Method	Estimated Cost Using Unit Cost Method
Airport - Arsenale (2005 Proposal)	8.166	7	€1,645,000,000.00	€1,326,000,000.00
Murano – Piazzale Roma	3.6	2	€725,000,000.00	€513,000,000.00
Airport - Lido	12.05	4	€2,428,000,000.00	€1,538,000,000.00
Airport - F.te Nove - Piazzale Roma	9.54	6	€1,922,000,000.00	€1,405,000,000.0

6.5.2 Proposed Subway System Benefits

The 2005 proposed subway line from Marco Polo Airport to Arsenale Nord was expected to take 14 minutes to complete the 8.166-km journey. During this time, it would make seven stops, including the two terminals.[74] Assuming that it spends 16.6 seconds at each train station, the average stopping time observed at a sampling of New York City subway stations[75], and spends the first tenth of its journey between stations accelerating at a constant rate, the proposed subway system would accelerate at 0.787 m/s^2. Based on this acceleration, projected travel times for the Lido - Piazzale Roma route are shown below. Travel times for the other routes can be found in Appendix D.

In Table 11, the travel times between subway stations are displayed for the Lido to Piazzale Roma route, including the possible extensions from Piazzale Roma to Mestre and Marco Polo Airport respectively. This table includes both the time that it takes to access the platform from the point of entry, and the travel times between each station. These components of the travel times can be found in Appendix D. In Table 12 which displays travel times with the current transportation system, the first value in each cell refers to the difference between 12:00pm and the earliest arrival time for someone departing at 12:00pm; the value in parentheses is the difference between the earliest arrival time and the corresponding departure time, which in some cases was later than 12:00pm.

Since they would share the same track along the southern edge of the historic city, the Lido-Piazzale Roma line would take 11.8 minutes to reach the Ferrovia and the Piazzale Roma from Lido, and 8.8 minutes to reach those locations from the Piazza San Marco. In comparison, it currently takes 42 minutes to travel from Lido to Piazzale Roma[76] and 23 minutes to travel

[74] Bottazzo, 2006.
[75] Teruashvili and Chan, 2005.
[76] Google Maps, 2017.

from the Piazza San Marco to Piazzale Roma[77], not including the time spent waiting for transportation to arrive. The amount of time that the extensions to Mestre and the Airport would save compared to the current systems is also substantial with approximately 75% travel time savings for each. It currently takes 74 minutes to travel from the Airport to Lido, but would take 15.8 minutes using the subway system

Table 11: Travel Times in Minutes for Lido-Piazzale Roma Route With Extensions to Mestre and the Airport

To (below) / From (right)	Lido S.M.E.	San Marco / San Zaccaria	Zattere	Giudecca Palanca	Piazzale Roma	Mestre	Airport
Lido S.M.E.	0.0	5.7	8.9	8.9	10.4	16.5	15.8
San Marco / San Zaccaria	5.7	0.0	6.0	6.1	7.6	13.6	12.9
Zattere	8.9	6.0	0.0	3.8	5.3	11.3	10.6
Giudecca Palanca	8.9	6.1	3.8	0.0	5.3	11.4	10.6
Piazzale Roma	10.4	7.6	5.3	5.3	0.0	6.0	5.3
Mestre	16.5	13.6	11.3	11.4	6.0	0.0	11.4
Airport	15.8	12.9	10.6	10.6	5.3	11.4	0.0

Table 12: Current Travel Times[78] in Minutes for Lido-Piazzale Roma Route With Extensions to Mestre and the Airport

To (below) / From (right)	Lido S.M.E.	San Marco - San Zaccaria	Giudecca Palanca	Zattere	Piazzale Roma	Central Mestre	Airport
Lido S.M.E.		23 (21)	33 (32)	23 (22)	43 (41)	62 (58)	82 (74)
San Marco - San Zaccaria	26 (20)		18 (17)	12 (10)	36 (31)	48 (44)	68 (60)
Giudecca Palanca	32 (32)	22 (16)		8 (4)	31 (19)	52 (38)	69 (61)
Zattere	20 (20)	15 (8)	5 (4)		22 (20)	42 (38)	52 (44)
Piazzale Roma	42 (42)	37 (23)	21 (19)	22 (22)		26 (22)	39 (31)
Central Mestre	61 (59)	51 (47)	41 (39)	41 (41)	29 (27)		36 (23)
Airport	65 (63)	65 (62)	50 (50)	50 (50)	35 (31)	45 (24)	

[77] Google Maps, 2017.
[78] Google Maps, 2017.

In order to determine if these subway routes were the most ideal in regards to travel time, we examined isochrones that showed the current areas that can be reached with the current transportation systems and walking against areas that could potentially be reached with the addition of a subway system. You can see in Figure 43 the difference between the 15 minute isochrone from the Lido (left) with the addition of the subway system extending from Piazzale Roma to Lido (right). With the implementation of this system you could reach farther than Piazzale Roma from Lido in 15 minutes. Additional isochrones showing limits of mobility with this potential subway system are found in Appendix B.

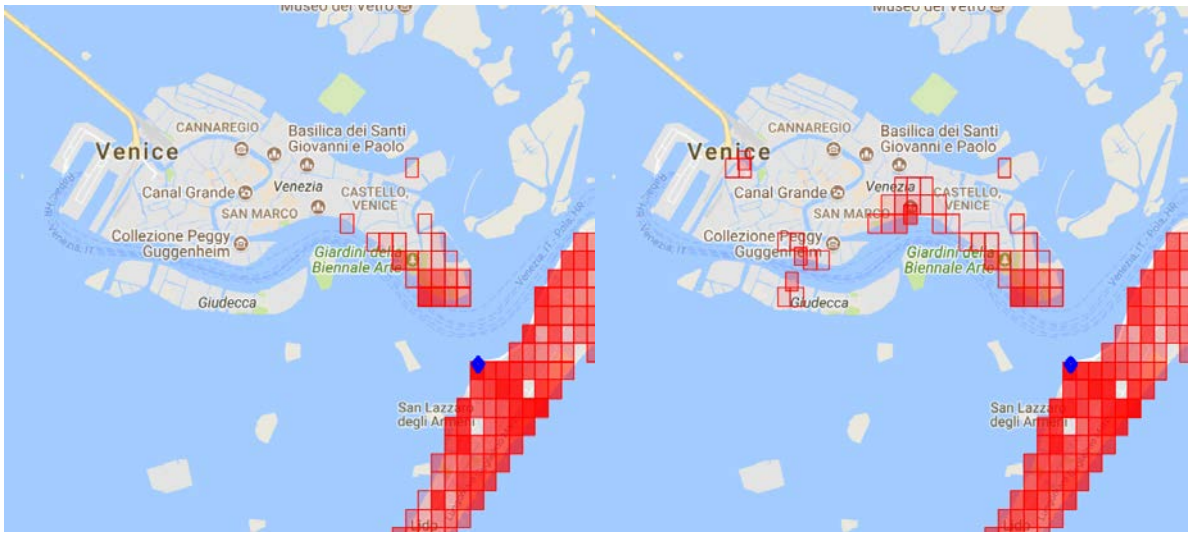

Figure 43. 15-minute isochrone from Lido S.M.E. with the current transportation system (above left) and with a subway system (above right)

6.6 Analysis

Of the various portions of the subway line we evaluated, which would run from Lido to Piazzale Roma, with possible extensions to Mestre and Marco Polo Airport, the portion of the route from Lido to Piazzale Roma is not only the most profitable, but the only portion of the route that can pay back its own construction costs, with interest, at any point in time.

While the extension from Piazzale Roma to Mestre would not be financially self-sufficient on its own, the entire route from Lido to Mestre would be able to recover all costs by 2044. It would also provide other, less tangible benefits. The extension would provide access to the mainland portions of Venice, where 70% of the city's population lives. It would also serve as an alternative to the Ponte della Libertá, which is occasionally closed multiple times a year, and reduce congestion on the bridge when it is not closed by providing alternative transportation option.

In addition to being somewhat more financially beneficial than the extension to Mestre, the extension to Marco Polo Airport also offers a wide range of non-monetary benefits. The connection that it would provide between Marco Polo Airport and Piazzale Roma would make Marco Polo Airport more accessible to those living in nearby cities, such as Padua, Vicenza, and

Verona by providing a connection between the airport and the railway system. A subway route to the airport would make the journey to and from the airport quicker and therefore less stressful, especially for people carrying luggage. Most likely, the subway could run more frequently than the current transportation service to and from the airport, which would result in even greater time savings for those using it.

We determined that Paolo Costa's 2005 proposal for a subway system would not be advisable to implement. Firstly, it would not be financially feasible on its own: while it would be possible to recover a large portion of the cost of construction in the first thirty years of service, it would not be able to recover any of the interest accrued at a 2.06% interest rate, regardless of the amount of cargo that it carried and the rate charged for that cago.

The other shortcoming of the original proposal is that it would not serve any of the major transportation hubs in the historic city besides Fondamente Nove. Since the line would reach neither Ferrovia nor Piazzale Roma, it would not be useful for travelers continuing their journeys to locations outside of the historic city, and would only serve people accessing the north end of the historic city from the Airport. In comparison, the extension of our proposed subway line to the airport would give riders direct access to Ferrovia and Piazzale Roma, as well as to Giudecca, Piazza San Marco, and Lido. The one benefit of the original proposal compared to our proposal is that it includes service to Murano; however, the advantages associated with this are mitigated by the fact that Murano's population of 4,506[79] is smaller than the populations of both Giudecca and Lido, both of which are directly served by our proposed system, and that the island is already served by multiple water bus lines.

6.7 Conclusions

While we analyzed the construction costs and travel times of a number of possible subway systems, we focused primarily on two possible routes. One route was proposed by then-mayor Paolo Costa in 2005. This route would have connected Marco Polo Airport to Murano and the northeast end of the historic city, taking approximately fourteen minutes to travel between its two terminals. We determined that this subway system would cost €1.645 billion to construct, based on a unit cost of €201 million per two-track kilometer. We also determined that, even if the line transported cargo from the airport into the city, it would not generate enough revenue to recover the costs of construction and the interest accrued on those costs until after 2080, and would never recover these costs unless it shipped a large percentage of the cargo arriving at the Airport. Furthermore, the subway line proposed by Costa does not include service to existing transportation hubs such as Piazzale Roma and San Zaccaria, and as a result would only be used by individuals traveling between the Airport and the historic city. Therefore, we do not recommend the implementation of this subway system.

[79] Venice Project Center, n.d.

The other system that we analyzed would start at Piazzale Rome, make stops in Zattere and Giudecca, which would be connected by a pedestrian tunnel, San Zaccaria, and finally the Lido. We were able to assess the cost of this system and determined that it would cost approximately €201 million/km, or €1.373 billion for the entire route from Lido to Piazzale Roma. We determined that this subway system would allow people to travel from Lido to the Piazzale Roma in ten and a half minutes, whereas it currently takes over 40 minutes to make this trip. We also determined that the revenue generated by ridership would be more than enough to pay for the subway system's operating costs, and could pay for all construction costs, interest, and prior operating costs by 2034. With all costs and benefits considered, we recommend that such a system be investigated further and eventually implemented.

We also examined the possibilities of extending the subway line to Mestre and Marco Polo Airport. Extending the subway line to the center of Mestre would provide another link between the historic city and the mainland, where 70% of Venice's residents live.[80] With the extension to Mestre, the subway system would recover all prior costs and interest by 2043 and would allow people to travel from Lido to the center of Mestre in 16 and a half minutes, a journey that currently takes roughly an hour.[81] Alternatively, the subway line could be extended from Piazzale Roma to Marco Polo Airport, Italy's fourth-busiest airport and the busiest one without an existing rail connection.[82] With this extension, the entire line would recover all construction and operating costs by 2043 and allow people to travel from Lido to Marco Polo Airport in 16 minutes, whereas it currently takes over an hour to complete this journey.[83] With all costs and benefits considered, we recommend the implementation of such a system.

[80] Venipedia, n.d.
[81] Google Maps, 2017.
[82] Fabio Carrera (Personal Communication)
[83] Google Maps, 2017.

7. Conclusions & Recommendations

Efficient parking and transportation systems in the historic city of Venice are essential for Venetians and tourists to reach and to move within the city. We have examined alterations and additions to these systems. For each category, we examined what currently exists and what could possibly change in order to result in a more efficient and useful system. We specifically examined car parking, boat parking, the water bus system, and a potential subway system. Within each examined topic, we formulated and analyzed results in order to propose recommendations.

Car parking is available in Mestre near the Ponte della Libertá and in the historic city. We were able to quantify the exact amount of car parking currently available. Taking into account parking lots before and after the Ponte della Libertá, there are currently 7,423 parking spaces useful for people traveling to the historic city. Understanding spatial constraints, we determined that expanding upward was a possibility. We assessed the cost of changing a current parking lot in Tronchetto into a five-tier parking garage. We determined that such an expansion could drastically increase the accessibility of Venice by car by increasing the car capacity of the historic city by 15.6%. However, we also determined that it would not be advisable to implement, as it would cost nearly €22 million and increase congestion on the Ponte della Libertá by increasing incentive to drive into the historic city. As a result, **we do not recommend** the construction of such a garage.

We were also able to assess the current temporary **boat parking** system throughout the historic city. Of about 1,600 rive, only 91 are available for one-hour parking. We concluded that the current system could be more efficient with modification. From field work, we witnessed faults in the current one-hour parking system. We also determined that the current one-hour spots are not in optimal locations. Using store data, canal width, and new dock proposal data, we were able to suggest new spots that could be used. **We recommend** that the city convert these spots to temporary parking spots.

We also witnessed the current system being exploited, with boat owners often exceeding the maximum time limit and not displaying required information, and found it appropriate to suggest a new system for regulation. We believe that it is time for the boat parking in Venice to align with the current available technology. We designed the layout of a smartphone application that could be used to book (on the user side) and to regulate (on the authority side) our suggested parking spots. However, we do not believe that this system could be used alongside the current system for boat parking regulation. As a result, **we recommend** phasing the current system out and replacing it with the smartphone application that we designed.

The current **water bus routes** were examined with the purpose of finding possible small-scale improvements. Express lines currently exist within the water bus system, but we proposed an alteration. Currently there is no express line connecting Lido and the train station. Replacing the southern portion of line 5.2, which connects Lido and the train station but is not express, with an express service making the stops that line 6 does during the summer could result in a time

savings of 9 minutes from Lido to the train station. Line 6 would run the route of the current line 5.2, so service to those stops would not be lost. Because reconfiguring lines 5.1, 5.2, and 6 would decrease the travel times to the train station and the northwest end of the historic city at little to no additional cost, **we recommend** that this possibility be implemented.

We then examined **reopening the Rio de'l Arsenal**, which was closed in 1999 to water bus service and determined it would reduce travel times from Arsenale to Celestia by fourteen minutes for those taking the water bus between these points. Based on our analysis of the costs and benefits of reopening this canal, **we recommend** reopening the Rio de'l Arsenal to water bus service only if service through it does not affect existing ACTV service.

Finally, we assessed the implementation of a **subway system**. The system we analyzed would make stops in Zattere and Giudecca, which would be connected by a pedestrian tunnel, San Zaccaria, and finally the Lido. We were able to assess the cost of this system and determined that it would cost approximately €201 million/km, or €1.373 billion for the entire route from Lido to Piazzale Roma. We were also able to visualize the increase in the amount of locations you can reach due to the implementation of this system through our isochrone generator. We were also able to visualize how certain routes can be improved if a subway system was implemented using our subway route simulator. We determined that the revenue generated by ridership would be more than enough to pay for the subway system's operating costs, and could pay for all construction costs, interest, and prior operating costs by 2034. Extending the subway line to the center of Mestre would provide another link between the historic city and the mainland, where 70% of Venice's residents live.[84] With the extension to Mestre, the subway system would recover all prior costs and interest by 2043 and would allow people to travel from Lido to the center of Mestre in 16 and a half minutes, a journey that currently takes roughly an hour. Alternatively, the subway line could be extended from Piazzale Roma to Marco Polo Airport, Italy's fourth-busiest airport and the busiest one without an existing rail connection.[85] With this extension, the entire line would recover all construction and operating costs by 2043 and allow people to travel from Lido to Marco Polo Airport in 16 minutes, whereas it currently takes over an hour to complete this journey. With all costs and benefits considered, **we recommend** the implementation of such a system.

We do not recommend the implementation of the subway line proposed in 2005, from Marco Polo Airport to the northeast end of Venice. This line would cost €1.645 billion to construct, would not generate enough revenue to recover the costs of construction and the interest accrued on those costs until after 2080, regardless of how much cargo it transported, and would not include service to points of interest such as the Piazzale Roma and St. Mark's Square.

The parking and transportation systems within Venice are complex and have many factors influencing them. After assessing these, we explored improvements and additions to the systems, and were able to find results and analyze these findings. By analyzing these, we were

[84] Venipedia, n.d.

[85] Fabio Carrera (Personal Communication)

able to make educated recommendations that could be considered when making changes to the current systems.

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Appendix A: Availability of Car Parking in the Historic City and Mestre

Table 13: List of Parking Lots by Location, Ownership, and Capacity

Name	Location	Ownership	Car Capacity
Park Costa	Mestre	Public	302
Piazzale Candiani	Mestre	Public	105
Da Verrazzano	Mestre	Public	102
SM of the Battui	Mestre	Public	105
Einaudi	Mestre	Public	126
Ex Umberto I	Mestre	Public	320
Forte Marghera	Mestre	Public	89
Piazzale L. DaVinci	Mestre	Public	93
S. Andrea car park	Historic City	Public	100
San Giuliano	Historic City	Public	633
Garage San Marco Venice	Historic City	Private	900
Venezia Tronchetto Parking	Historic City	Private	4000
Venice City Park	Mestre	Private	326
Green Park	Mestre	Private	222
Total			**7423**

Table 14: Parking Area Sizes, Car Area Sizes, and Estimated Capacity of Venice City Park

Shape on Map	**Area**			**Shape on Map**	**Area**	
Parking Area 1	0.022	ha		5 cars (spacing 1)	0.006	ha
Parking Area 2	0.047	ha		5 cars (spacing 2)	0.005	ha
Parking Area 3	0.075	ha		5 cars (spacing 3)	0.006	ha
Parking Area 4	0.03	ha		*Total Area*	*0.017*	*ha*
Parking Area 5	0.11	ha		*# of Cars in Area*	*15*	
Parking Area 6	0.017	ha				
Parking Area 7	0.068	ha				
Total Parking Area	*0.369*	*ha*		**# of Parking Spots**	**326**	

Figure 44. Screenshot of the Google My Maps file used to estimate the car capacity of Venice City Park in Mestre.

In this image, the areas used to estimate the total parking area are shown in green and labeled with red numbers, and the areas used to estimate the area of an individual car are shown in black and labeled with white numbers.

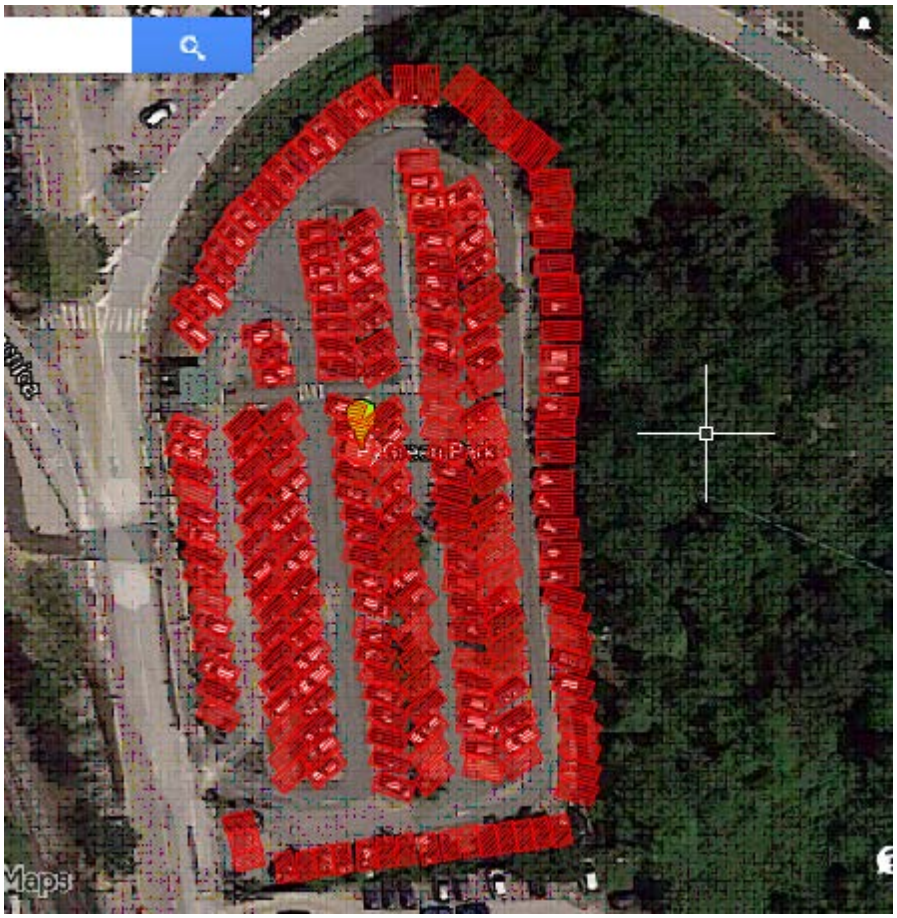

Figure 45. Screenshot of the AutoCAD file used to estimate the number of parking spaces in Green Park

In Figure 45, the red quadrilaterals, each of which represents a parking space, were drawn so that they were approximately the size of one car each.

Appendix B: Isochrone Generator and Subway Route Simulator Outputs, Including Hand-Drawn Isochrones

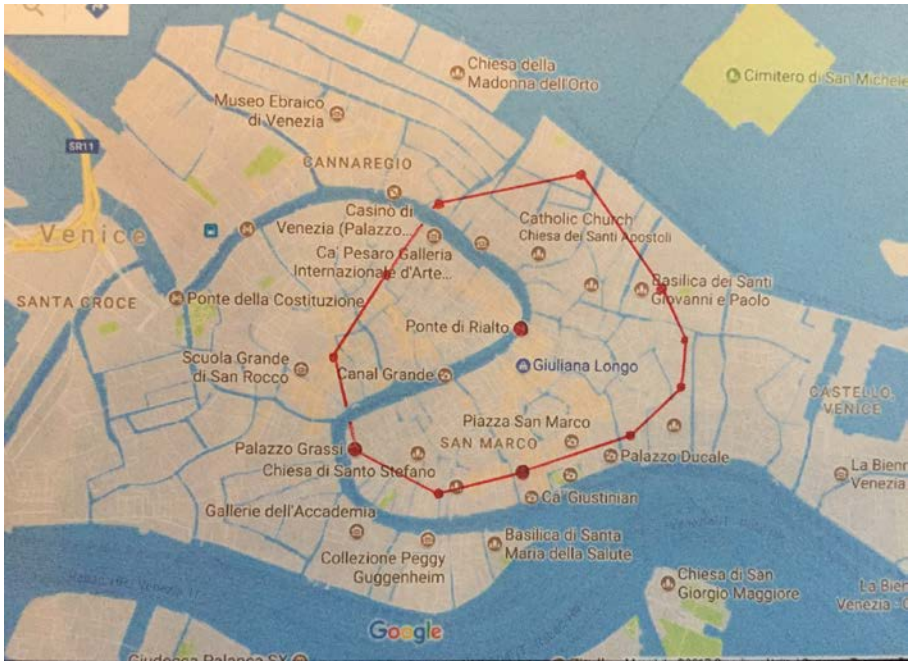

Figure 46. 10-minute walking isochrone for the Rialto Bridge

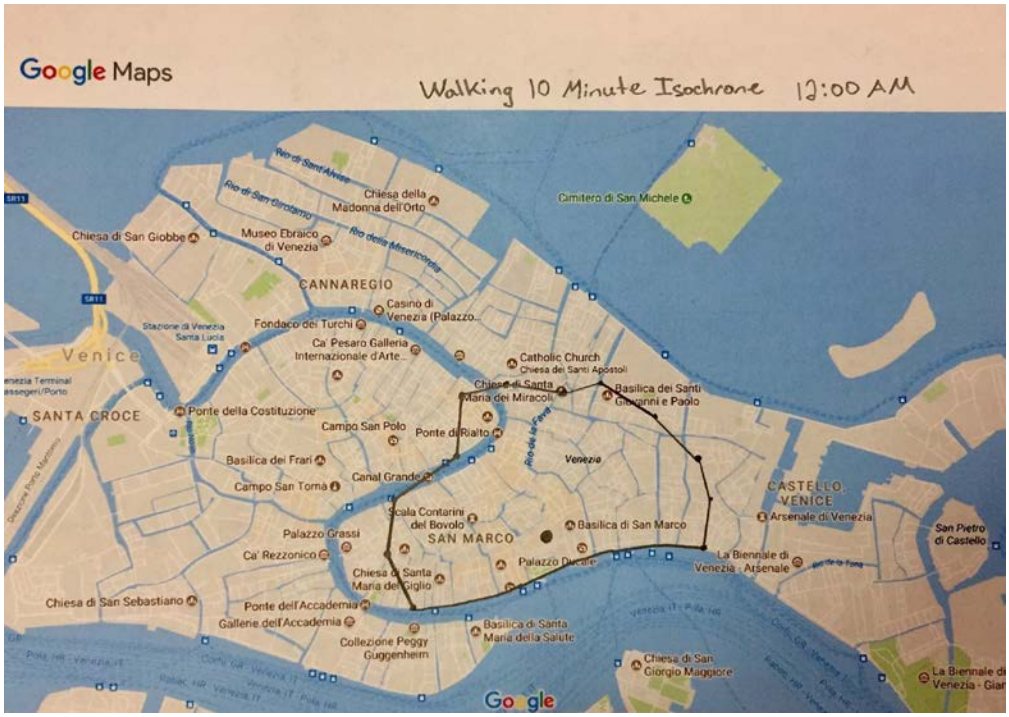

Figure 47. 10-minute walking isochrone for the Piazza San Marco at 12:00am

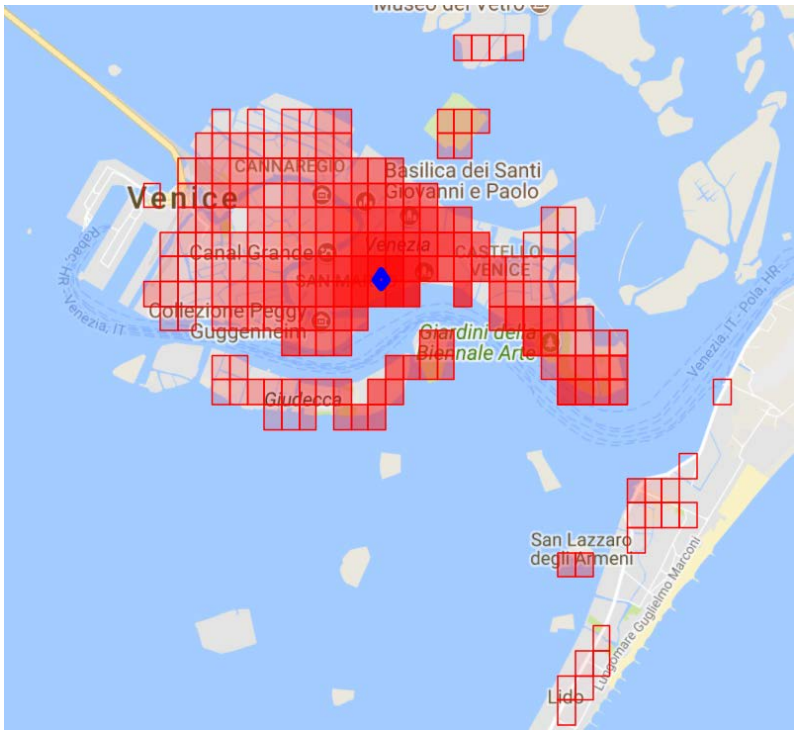

Figure 48. 30 Minute Isochrone from Piazza San Marco

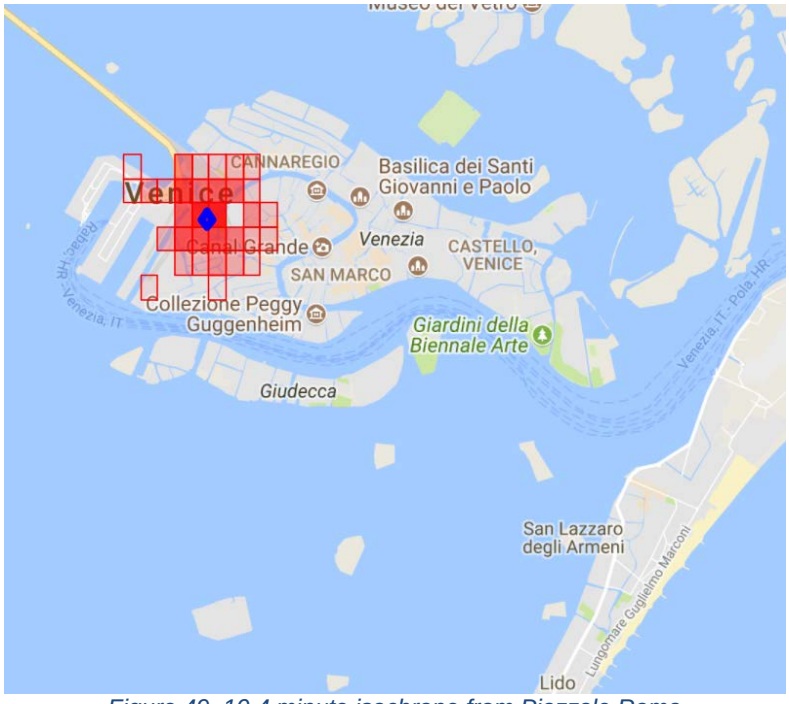

Figure 49. 10.4 minute isochrone from Piazzale Roma

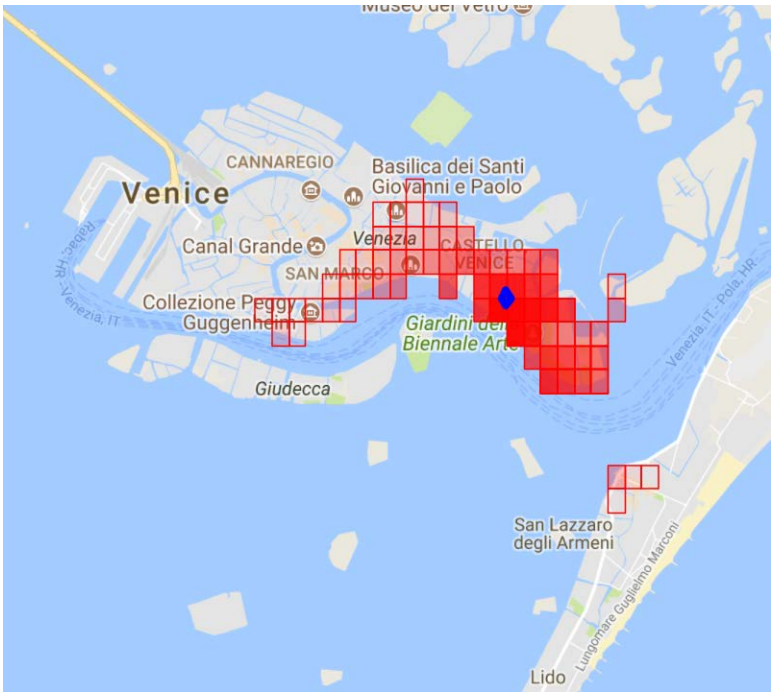

Figure 50. 20 Minute Isochrone from Giuseppe Garibaldi Monument

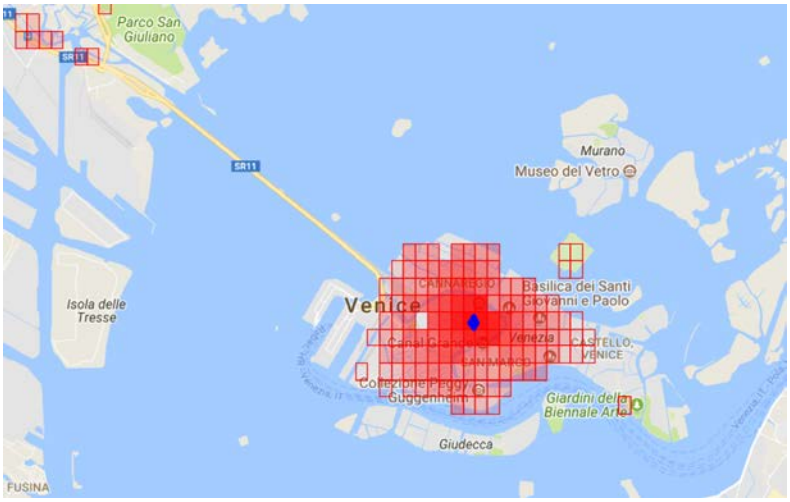

Figure 51. 25 Minute Isochrone from Venice Project Center

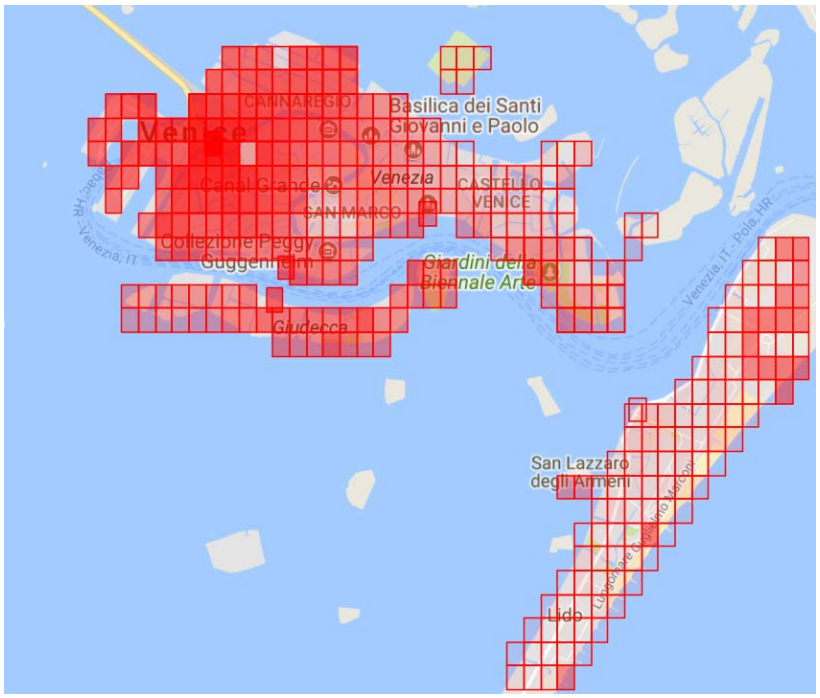

Figure 52. 45 Minute Isochrone from Marco Polo Airport with Subway from Airport to Lido

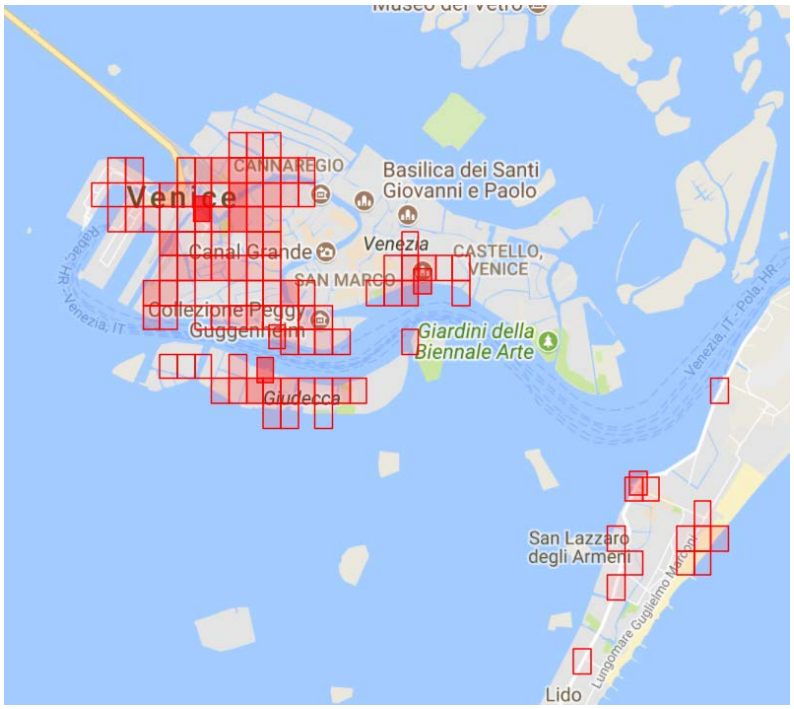

Figure 53. 20 Minute Isochrone from Mestre with Subway from Mestre to Lido

The following outputs were produced with the input at the top of each figure:

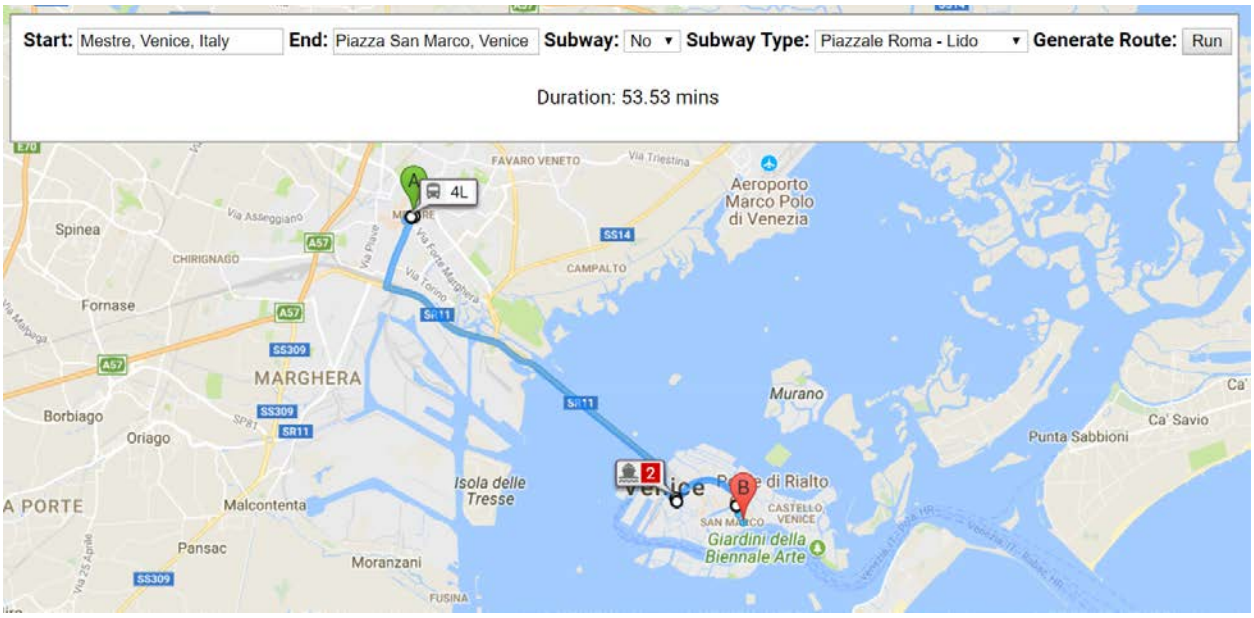

Figure 54

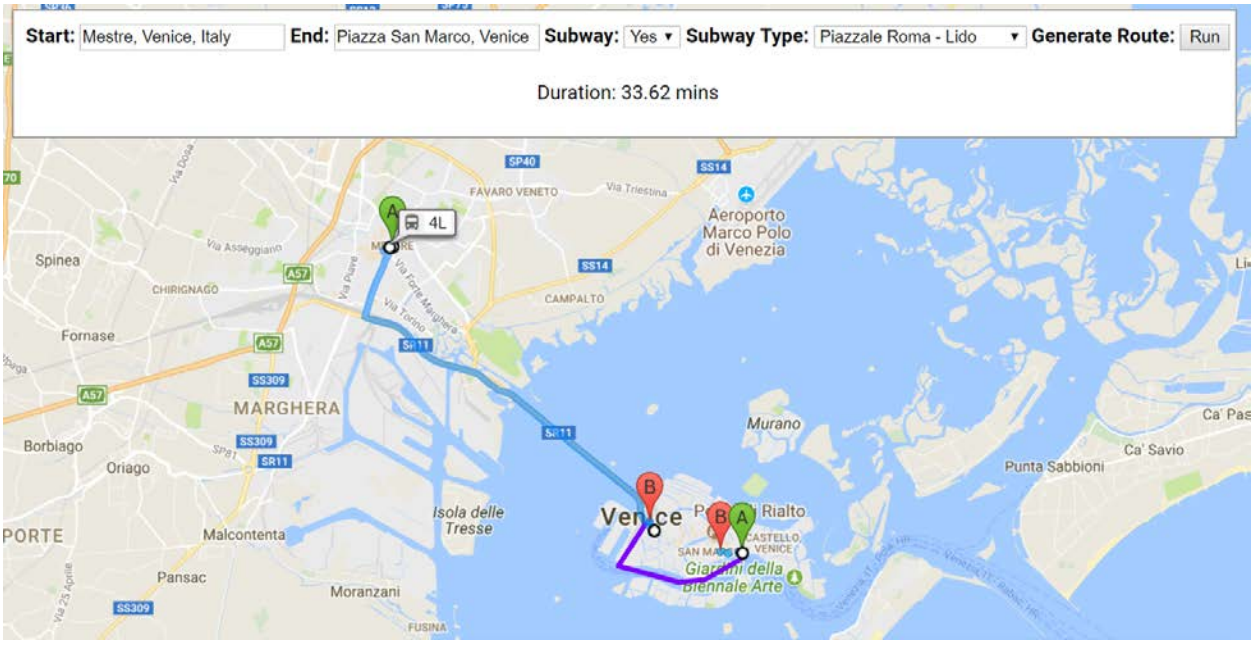

Figure 55

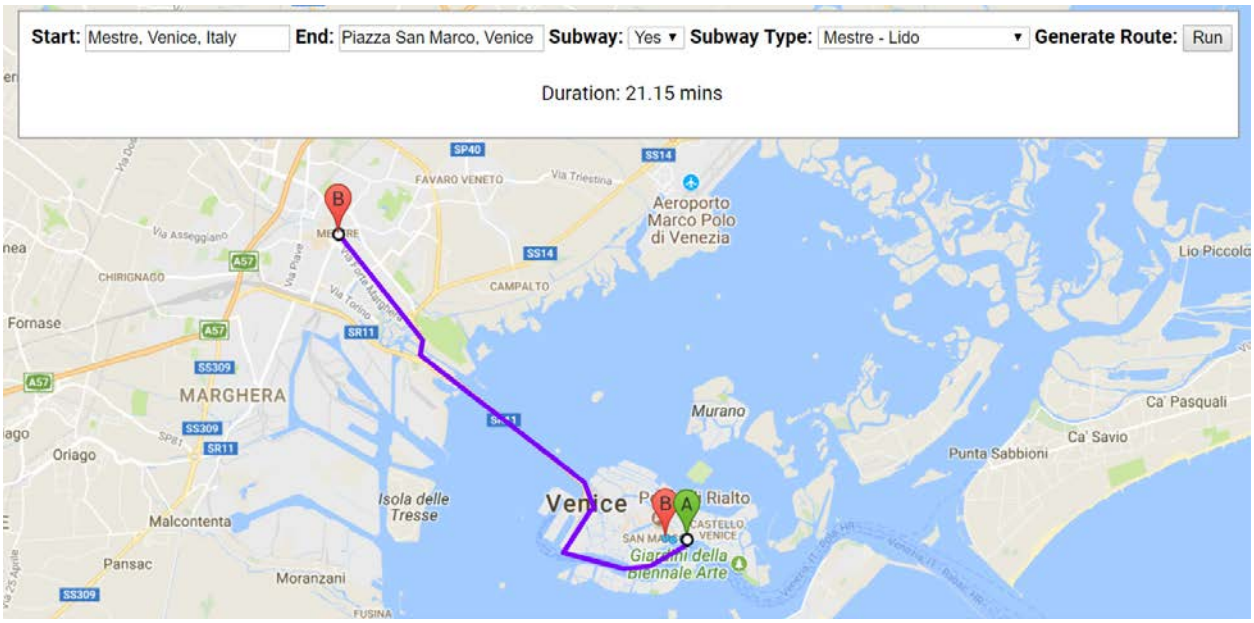

Figure 56

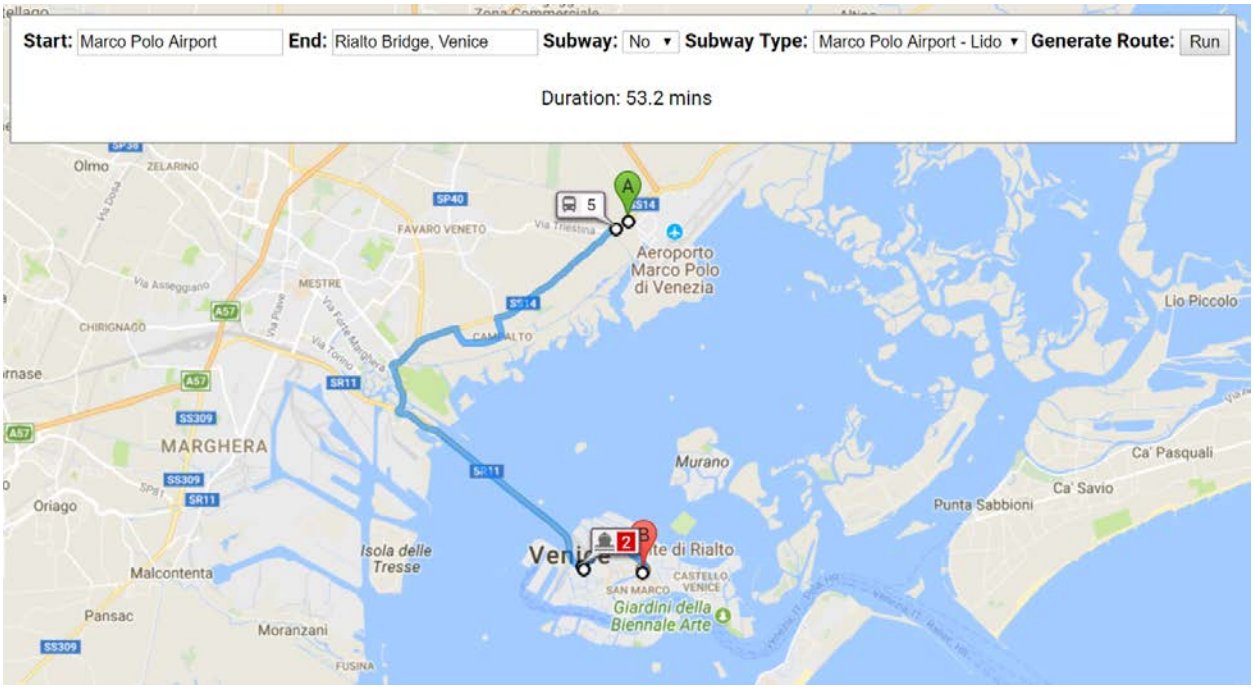

Figure 57

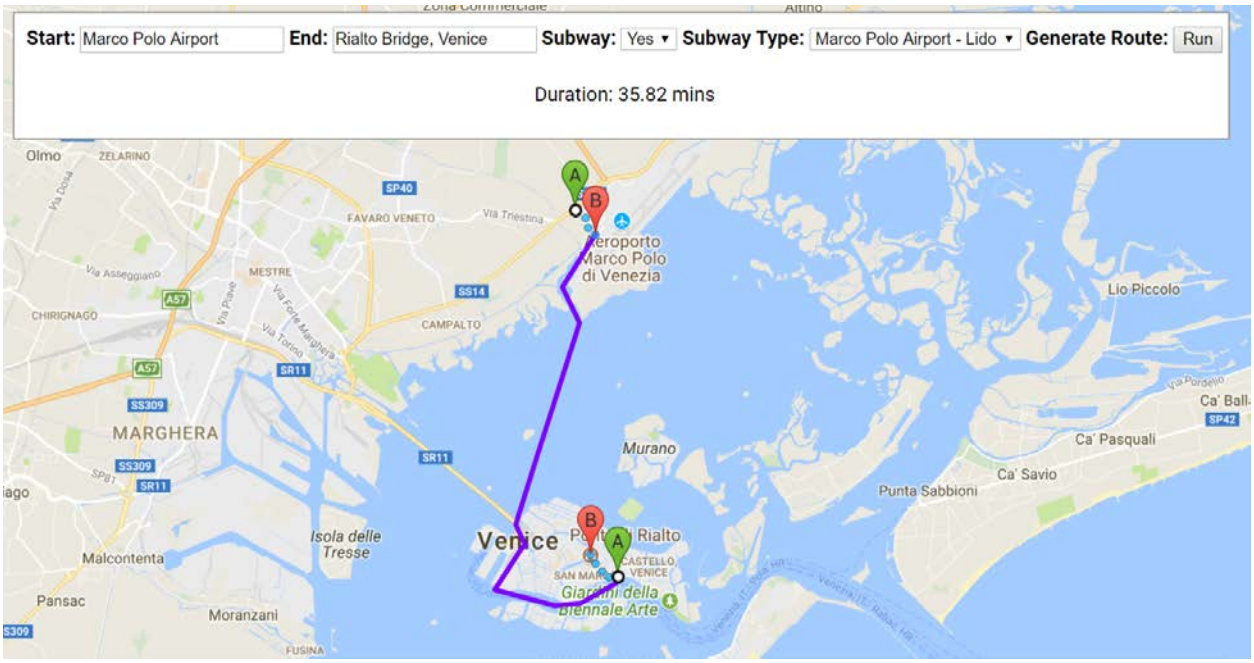
Start: Marco Polo Airport
End: Rialto Bridge, Venice
Subway: Yes
Subway Type: Marco Polo Airport - Lido
Generate Route: Run
Duration: 35.82 mins
Olmo
ZELARINO
FAVARO VENETO
Via Trieste
Via Asseggiano
MESTRE
CHIRIGNAGO
CAMPALTO
Aeroporto Marco Polo di Venezia
Lio Piccolo
MARGHERA
Murano
Ca' Pasquali
Ca' Savio
Punta Sabbioni
Isola delle Tresse
Venice
Rialto
Malcontenta
Pansac
Moranzani
FUSINA
Giardini della Biennale Arte
A
B
SP40
SS14
A57
SR11
SS309
SP42

Figure 58

Appendix C: Cost Calculations for Potential Subway Routes

Table 15: Unit Cost Estimate for a Subway System in Venice Using an Extension to Berlin's Subway System

	Berlin Subway System Extension	
C_j	€320,000,000.00	euro
1+f	1.0133	
p-j	8	years
L_p	102.8	
L_j	110.3	
S_p	1	km
S_j	1.8	km
C_p	*€184,180,485.54*	*euro*

Table 16: Unit Cost Estimate for a Subway System in Venice Using an Extension to Naples's Subway System

	Naples Line 6 Extension	
C_j	€107,000,000.00	euro
1+f	1.014285752	
p-j	10	years
L_p	102.8	
L_j	102.8	
S_p	1	km
S_j	1.9	km
C_p	*€64,898,315.79*	*euro*

Table 17: Unit Cost Estimate for a Subway System in Venice Using Amsterdam's North-South Line

	Amsterdam North-South Line	
C_j	€3,100,000,000.00	euro
1+f	1.0133	
p-j	8	years
L_p	102.8	
L_j	104.6	
S_p	1	km
S_j	9.5	km
C_p	*€356,490,578.65*	*euro*

Table 18: Unit Cost Estimate for a Subway System in Venice Using Copenhagen's Circle Line

	Copenhagen Circle Line	
C_j	€3,100,000,000.00	euro
1+f	1.012903873	
p-j	7	years
L_p	102.8	
L_j	108.3	
S_p	1	km
S_j	15.5	km
C_p	*€207,669,289.01*	*euro*

Table 19: Unit Cost Estimate for a Subway System in Venice Using Paris's Metro Line 14

	Paris Metro Line 14	
C_j	€1,130,000,000.00	euro
1+f	1.013794276	
p-j	24	years
L_p	102.8	
L_j	104.9	
S_p	1	km
S_j	9	km
C_p	*€170,942,320.94*	*euro*

Table 20: Determination of the Unit Cost for the Comparison Method (see Table 15-Table 19)

Average Cost	€196,836,197.99	/km
Minimum Cost	€64,898,315.79	/km
Maximum Cost	€356,490,578.65	/km
Unit Cost to Use	**€201,000,000.00**	**/km**

Table 21: Rapid Transit Systems Analyzed by Pickrell (1985)

City	Project	Two-Track Miles/Number of Stations		
		Tunnel	**Surface**	**Elevated**
Cleveland	Initial Line Airport Extension	- 0.3/0	14.9/15 3.8/3	- -
Philadelphia	Lindenwold Line Snyder-Pattison Extension	- 1.2/1	14.5/13 -	- -
San Francisco	BART System	20.0/14	27.0/7	24.0/13
Washington, D.C.	Metrorail: Phases 1-IVA Phases V-VI	 22.4/28 12.5/9	 13.3/11 10.7/8	 1.5/2 1.0/2
Atlanta	Rail Phase A	5.5/8	5.8/7	2.4/2
Baltimore	Metro Phase 1	4.5/6	-	3.2/3
Boston	Red Line South Red Line Northwest Orange Line North	- 3.2/4 1.0/2	9.5/5 - 4.4/5	- - -
Miami	Metrorail N-S Line	-	1.7/0	19.3/20
New York	63rd Street Tunnel 2nd Avenue Tunnel	12.0/0 7.2/0	- -	- -
Chicago	Dan Ryan Line Milwaukee Extension O'Hare Airport Extension	- 1.2/2 0.6/1	9.4/9 3.9/4 6.6/3	1.1/0 - -

Source: Pickrell, D.H. (1985). Estimates of Rail Transit Construction Costs. Transportation Research Record, 1006. Retrieved from http://onlinepubs.trb.org/Onlinepubs/trr/1985/1006/1006-008.pdf.

Table 22: Determination of Railway and Station Unit Costs for the Unit Cost Method

	One mile of two-track rail	One subway station
Unit Costs (1983 USD)	$103,000,000.00	$40,000,000.00
1983-2017 Inflation	114.77%	114.77%
Unit Costs (2017 USD)	*$221,213,100.00*	*$85,908,000.00*
Conversion Rate (euros/dollar)	0.849311	0.849311
Unit Costs (2017 euros)	*€187,878,719.17*	*€72,962,609.39*
Italy Big Mac Index	4.8	4.8
USA Big Mac Index	5.3	5.3
Preliminary Total	*€170,154,311.70*	*€66,079,344.35*
Convert from two-track to one-track	1	N/A
Convert miles to kilometers	0.6213711922	N/A
Final Unit Cost	**€105,728,987.53**	**€66,079,344.35**

Table 23: Cost Calculations for Airport-Arsenale Route (Original Proposal) Using the Unit Cost Method

	Units	Unit Cost	Subtotal
Two-track km	8.166	€105,728,987.53	€863,383,000.00
Stations	7	€66,079,344.35	€462,555,000.00
Total			**€1,326,000,000.0**

Table 24: Cost Calculations for a One-Track Version of the Airport-Arsenale Route (Original Proposal)

	Units	Unit Cost	Subtotal
One-track km	8.166	€52,864,493.76	€431,691,456.08
Stations	7	€66,079,344.35	€462,555,410.46
Total			**€894,000,000.0**

Table 25: Cost Calculations for Murano - Ferrovia Route Using the Unit Cost Method

	Units	Unit Cost	Subtotal
Two-track km	3.6	€105,728,987.53	€380,624,000.00
Stations	2	€66,079,344.35	€132,159,000.00
Total			**€513,000,000.0**

Table 26: Cost Calculations for Airport - Lido Route (Addendum to original proposal) Using the Unit Cost Method

	Units	Unit Cost	Subtotal
Two-track km	12.05	€105,728,987.53	€1,274,034,000.00
Stations	4	€66,079,344.35	€264,317,000.00
Total			**€1,538,000,000.0**

Table 27: Cost Calculations for Airport - F.te Nove - Ferrovia Route Using the Unit Cost Method

	Units	Unit Cost	Subtotal
Two-track km	9.54	€105,728,987.53	€1,008,655,000.00
Stations	6	€66,079,344.35	€396,476,000.00
Total			**€1,405,000,000.0**

Table 28: Estimate of Maintenance Cost per Car-Mile Based on the PATH Transportation System

Subway network	**PATH**
Cost per car-mile	$30.00
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$27.17

Table 29: Estimate of Maintenance Cost per Car-Mile Based on the Los Angeles Metro Rail

Subway network	**Los Angeles Metro Rail**
Cost per car-mile	$19.00
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$17.21

Table 30: Estimate of Maintenance Cost per Car-Mile Based on the Boston "T"

Subway network	**Boston T**
Cost per car-mile	$15.60
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$14.13

Table 31: Estimate of Maintenance Cost per Car-Mile Based on the New York City Subway

Subway network	**New York City Subway**
Cost per car-mile	$15.10
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$13.68

Table 32: Estimate of Maintenance Cost per Car-Mile Based on the Miami Metrorail

Subway network	**Miami Metrorail**
Cost per car-mile	$11.70
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$10.60

Table 33: Estimate of Maintenance Cost per Car-Mile Based on the Washington Metro

Subway network	**Washington Metro**
Cost per car-mile	$11.50
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$10.42

Table 34: Estimate of Maintenance Cost per Car-Mile Based on the Madrid Metro

Subway network	**Madrid Metro**
Cost per car-mile	$11.00
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	4.34
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$12.17

Table 35: Estimate of Maintenance Cost per Car-Mile Based on Philadelphia's SEPTA Subway

Subway network	**Philadelphia SEPTA subway**
Cost per car-mile	$11.00
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$9.96

Table 36: Estimate of Maintenance Cost per Car-Mile Based on the Atlanta MARTA System

Subway network	**Atlanta MARTA**
Cost per car-mile	$9.60
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$8.69

Table 37: Estimate of Maintenance Cost per Car-Mile Based on the Berlin U-Bahn

Subway network	**Berlin U-Bahn**
Cost per car-mile	$9.60
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	4.45
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$10.36

Table 38: Estimate of Maintenance Cost per Car-Mile Based on the Paris Metro

Subway network	**Paris Metro and RER**
Cost per car-mile	$9.60
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	4.68
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$9.85

Table 39: Estimate of Maintenance Cost per Car-Mile Based on the London Underground

Subway network	**London Underground**
Cost per car-mile	$9.30
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	4.11
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$10.86

Table 40: Estimate of Maintenance Cost per Car-Mile Based on the Bay Area Rapid Transportation system

Subway network	**BART**
Cost per car-mile	$8.60
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$7.79

Table 41: Estimate of Maintenance Cost per Car-Mile Based on the Chicago "L"

Subway network	**Chicago L**
Cost per car-mile	$8.00
1+inflation	1
Time since data gathered	0
Italy Big Mac Index	4.8
Big Mac Index of original country	5.3
Unit length of new system	1
Unit length of original system	1
Cost of Venice subway/car-mile	$7.25

Table 42: Estimate of Maintenance Cost per Car-Mile Based on Table 28 - Table 41

Average value obtained	$12.15
Minimum value obtained	$7.25
Maximum value obtained	$27.17
Expected cost of Venice subway	$13.84
Expected cost (euros)	€11.68

Table 43: Cost and Revenue Calculations for the Airport - Arsenale Route (Original Proposal)

Resident Fare		€2.00						
Tourist Fare		€6.00						
% of Tourists Using System		50%						
Locals Using System		15%						
	A	**B**	**C = A * B**	**D = C * 50%**	**E = A - C**	**F = E * 30%**	**G = 0.52 * (E + F)**	**H = 6*D + 2*F**
Year	**# of People Using Airport**	**% Tourists**	**# of Tourist Arrivals**	**# of Tourists Using System**	**# of Local Arrivals**	**# of Locals Using System**	**Operating Cost**	**Total Revenue**
2018	9886185	35.10%	3470448	1735224	6415737	962361	€1,413,597	€12,336,066
2019	10182764	35.10%	3574559	1787280	6608205	991231	€1,456,004	€12,706,142
2020	10479344	35.10%	3678670	1839335	6800674	1020101	€1,498,410	€13,076,212
2021	10775923	35.10%	3782781	1891391	6993142	1048971	€1,540,818	€13,446,288
2022	11072502	35.10%	3886893	1943447	7185609	1077841	€1,583,225	€13,816,364
2023	11369082	35.10%	3991004	1995502	7378078	1106712	€1,625,632	€14,186,436
2024	11665661	35.10%	4095115	2047558	7570546	1135582	€1,668,039	€14,556,512
2025	11962241	35.10%	4199227	2099614	7763014	1164452	€1,710,446	€14,926,588
2026	12258820	35.10%	4303338	2151669	7955482	1193322	€1,752,852	€15,296,658
2027	12555400	35.10%	4407449	2203725	8147951	1222193	€1,795,260	€15,666,736
2028	12851979	35.10%	4511560	2255780	8340419	1251063	€1,837,667	€16,036,806
2029	13148558	35.10%	4615672	2307836	8532886	1279933	€1,880,074	€16,406,882
2030	13445138	35.10%	4719783	2359892	8725355	1308803	€1,922,481	€16,776,958
2031	13741717	35.10%	4823894	2411947	8917823	1337673	€1,964,887	€17,147,028
2032	14038297	35.10%	4928006	2464003	9110291	1366544	€2,007,295	€17,517,106
2033	14334876	35.10%	5032117	2516059	9302759	1395414	€2,049,702	€17,887,182
2034	14631456	35.10%	5136228	2568114	9495228	1424284	€2,092,109	€18,257,252
2035	14928035	35.10%	5240339	2620170	9687696	1453154	€2,134,516	€18,627,328
2036	15224614	35.10%	5344451	2672226	9880163	1482024	€2,176,923	€18,997,404
2037	15521194	35.10%	5448562	2724281	10072632	1510895	€2,219,330	€19,367,476
2038	15817773	35.10%	5552673	2776337	10265100	1539765	€2,261,737	€19,737,552

2039	16114353	35.10%	5656785	2828393	10457568	1568635	€2,304,144	€20,107,628
2040	16410932	35.10%	5760896	2880448	10650036	1597505	€2,346,551	€20,477,698
2041	16707511	35.10%	5865007	2932504	10842504	1626376	€2,388,958	€20,847,776
2042	17004091	35.10%	5969118	2984559	11034973	1655246	€2,431,365	€21,217,846
2043	17300670	35.10%	6073229	3036615	11227441	1684116	€2,473,772	€21,587,922
2044	17597250	35.10%	6177341	3088671	11419909	1712986	€2,516,179	€21,957,998
2045	17893829	35.10%	6281452	3140726	11612377	1741857	€2,558,586	€22,328,070
2046	18190409	35.10%	6385564	3192782	11804845	1770727	€2,600,993	€22,698,146
2047	18486988	35.10%	6489675	3244838	11997313	1799597	€2,643,400	€23,068,222
2048	18783567	35.10%	6593786	3296893	12189781	1828467	€2,685,807	€23,438,292
2049	19080147	35.10%	6697897	3348949	12382250	1857338	€2,728,214	€23,808,370
2050	19376726	35.10%	6802008	3401004	12574718	1886208	€2,770,621	€24,178,440
2051	19673306	35.10%	6906120	3453060	12767186	1915078	€2,813,028	€24,548,516
2052	19969885	35.10%	7010231	3505116	12959654	1943948	€2,855,435	€24,918,592
2053	20266464	35.10%	7114342	3557171	13152122	1972818	€2,897,842	€25,288,662
2054	20563044	35.10%	7218454	3609227	13344590	2001689	€2,940,249	€25,658,740
2055	20859623	35.10%	7322565	3661283	13537058	2030559	€2,982,656	€26,028,816
2056	21156203	35.10%	7426676	3713338	13729527	2059429	€3,025,063	€26,398,886
2057	21452782	35.10%	7530787	3765394	13921995	2088299	€3,067,470	€26,768,962
2058	21749362	35.10%	7634899	3817450	14114463	2117169	€3,109,877	€27,139,038
2059	22045941	35.10%	7739010	3869505	14306931	2146040	€3,152,284	€27,509,110
2060	22342520	35.10%	7843121	3921561	14499399	2174910	€3,194,691	€27,879,186
2061	22639100	35.10%	7947233	3973617	14691867	2203780	€3,237,099	€28,249,262
2062	22935679	35.10%	8051344	4025672	14884335	2232650	€3,279,505	€28,619,332
2063	23232259	35.10%	8155455	4077728	15076804	2261521	€3,321,913	€28,989,410
2064	23528838	35.10%	8259566	4129783	15269272	2290391	€3,364,319	€29,359,480
2065	23825417	35.10%	8363678	4181839	15461739	2319261	€3,406,726	€29,729,556
2066	24121997	35.10%	8467789	4233895	15654208	2348131	€3,449,133	€30,099,632
2067	24418576	35.10%	8571900	4285950	15846676	2377001	€3,491,540	€30,469,702
2068	24715156	35.10%	8676012	4338006	16039144	2405872	€3,533,948	€30,839,780
2069	25011735	35.10%	8780123	4390062	16231612	2434742	€3,576,355	€31,209,856
2070	25308315	35.10%	8884234	4442117	16424081	2463612	€3,618,761	€31,579,926

2071	25604894	35.10%	8988345	4494173	16616549	2492482	€3,661,168	€31,950,002
2072	25901473	35.10%	9092457	4546229	16809016	2521352	€3,703,575	€32,320,078
2073	26198053	35.10%	9196568	4598284	17001485	2550223	€3,745,983	€32,690,150
2074	26494632	35.10%	9300679	4650340	17193953	2579093	€3,788,390	€33,060,226
2075	26791212	35.10%	9404791	4702396	17386421	2607963	€3,830,797	€33,430,302
2076	27087791	35.10%	9508902	4754451	17578889	2636833	€3,873,203	€33,800,372
2077	27384370	35.10%	9613013	4806507	17771357	2665704	€3,915,611	€34,170,450
2078	27680950	35.10%	9717124	4858562	17963826	2694574	€3,958,017	€34,540,520
2079	27977529	35.10%	9821236	4910618	18156293	2723444	€4,000,425	€34,910,596
2080	28274109	35.10%	9925347	4962674	18348762	2752314	€4,042,832	€35,280,672

Table 44: Present Value Analysis for the Airport - Arsenale Route (Original Proposal), Excluding Cargo Transportation

Year	Construction Cost	Maintenance Cost	Present Value of Costs	Ticket Revenue	Cargo Revenue	PV of revenue
2017	€0	€0	€0	€0	€0	€0
2018	€1,645,000,000	€0	€1,633,233,882	€0	€3,051,729	€3,029,901
2019	€0	€0	€0	€0	€3,208,047	€3,162,319
2020	€0	€0	€0	€0	€3,364,366	€3,292,688
2021	€0	€0	€0	€0	€3,520,684	€3,421,031
2022	€0	€0	€0	€0	€3,677,002	€3,547,369
2023	€0	€0	€0	€0	€3,833,321	€3,671,724
2024	€0	€0	€0	€0	€3,989,639	€3,794,119
2025	€0	€0	€0	€0	€4,145,958	€3,914,576
2026	€0	€0	€0	€0	€4,302,276	€4,033,115
2027	€0	€2,930,333	€2,727,355	€18,111,120	€4,458,595	€21,006,362
2028	€0	€2,999,552	€2,771,811	€18,538,932	€4,614,913	€21,395,892
2029	€0	€3,068,771	€2,815,492	€18,966,748	€4,771,231	€21,778,777
2030	€0	€3,137,991	€2,858,406	€19,394,566	€4,927,550	€22,155,093
2031	€0	€3,207,210	€2,900,562	€19,822,376	€5,083,868	€22,524,904
2032	€0	€3,276,429	€2,941,968	€20,250,192	€5,240,187	€22,888,296
2033	€0	€3,345,649	€2,982,635	€20,678,010	€5,396,505	€23,245,340
2034	€0	€3,414,868	€3,022,568	€21,105,820	€5,552,824	€23,596,098
2035	€0	€3,484,088	€3,061,778	€21,533,638	€5,709,142	€23,940,656
2036	€0	€3,553,307	€3,100,272	€21,961,454	€5,865,460	€24,279,076
2037	€0	€3,622,526	€3,138,059	€22,389,266	€6,021,779	€24,611,426

2038	€0	€3,691,746	€3,175,147	€22,817,082	€6,178,097	€24,937,784
2039	€0	€3,760,965	€3,211,543	€23,244,898	€6,334,416	€25,258,213
2040	€0	€3,830,184	€3,247,257	€23,672,710	€6,490,734	€25,572,780
2041	€0	€3,899,403	€3,282,295	€24,100,526	€6,647,053	€25,881,558
2042	€0	€3,968,623	€3,316,666	€24,528,338	€6,803,371	€26,184,606
2043	€0	€4,037,842	€3,350,378	€24,956,154	€6,959,689	€26,481,999
2044	€0	€4,107,062	€3,383,438	€25,383,972	€7,116,008	€26,773,800
2045	€0	€4,176,281	€3,415,852	€25,811,782	€7,272,326	€27,060,065
2046	€0	€4,245,500	€3,447,631	€26,239,600	€7,428,645	€27,340,872
2047	€0	€4,314,720	€3,478,780	€26,667,416	€7,584,963	€27,616,275
2048	€0	€4,383,938	€3,509,306	€27,095,226	€7,741,282	€27,886,336
2049	€0	€4,453,158	€3,539,219	€27,523,044	€7,897,600	€28,151,126
2050	€0	€4,522,377	€3,568,523	€27,950,854	€8,053,918	€28,410,696
2051	€0	€4,591,597	€3,597,228	€28,378,672	€8,210,237	€28,665,118
2052	€0	€4,660,816	€3,625,340	€28,806,488	€8,366,555	€28,914,446
2053	€0	€4,730,035	€3,652,865	€29,234,300	€8,522,874	€29,158,737
2054	€0	€4,799,255	€3,679,811	€29,662,116	€8,679,192	€29,398,058
2055	€0	€4,868,474	€3,706,185	€30,089,932	€8,835,511	€29,632,463
2056	€0	€4,937,693	€3,731,993	€30,517,744	€8,991,829	€29,862,008
2057	€0	€5,006,913	€3,757,242	€30,945,562	€9,148,147	€30,086,757
2058	€0	€5,076,132	€3,781,939	€31,373,378	€9,304,466	€30,306,763
2059	€0	€5,145,351	€3,806,091	€31,801,188	€9,460,784	€30,522,077
2060	€0	€5,214,571	€3,829,704	€32,229,006	€9,617,103	€30,732,767
2061	€0	€5,283,790	€3,852,784	€32,656,822	€9,773,421	€30,938,880
2062	€0	€5,353,010	€3,875,338	€33,084,634	€9,929,740	€31,140,469
2063	€0	€5,422,229	€3,897,372	€33,512,450	€10,086,058	€31,337,594
2064	€0	€5,491,448	€3,918,893	€33,940,262	€10,242,376	€31,530,303
2065	€0	€5,560,667	€3,939,906	€34,368,078	€10,398,695	€31,718,655
2066	€0	€5,629,887	€3,960,419	€34,795,894	€10,555,013	€31,902,700
2067	€0	€5,699,106	€3,980,436	€35,223,706	€10,711,332	€32,082,486
2068	€0	€5,768,325	€3,999,965	€35,651,522	€10,867,650	€32,258,071
2069	€0	€5,837,545	€4,019,011	€36,079,340	€11,023,969	€32,429,504
2070	€0	€5,906,764	€4,037,578	€36,507,150	€11,180,287	€32,596,829
2071	€0	€5,975,984	€4,055,676	€36,934,968	€11,336,605	€32,760,106
2072	€0	€6,045,203	€4,073,308	€37,362,784	€11,492,924	€32,919,379
2073	€0	€6,114,422	€4,090,480	€37,790,596	€11,649,242	€33,074,695
2074	€0	€6,183,642	€4,107,198	€38,218,412	€11,805,561	€33,226,107
2075	€0	€6,252,861	€4,123,467	€38,646,228	€11,961,879	€33,373,661
2076	€0	€6,322,080	€4,139,294	€39,074,040	€12,118,198	€33,517,402
2077	€0	€6,391,299	€4,154,683	€39,501,856	€12,274,516	€33,657,382

2078	€0	€6,460,519	€4,169,640	€39,929,668	€12,430,834	€33,793,642
2079	€0	€6,529,738	€4,184,171	€40,357,484	€12,587,153	€33,926,234
2080	€0	€6,598,958	€4,198,281	€40,785,302	€12,743,471	€34,055,201
Total	[redacted]	[redacted]	€1,827,427,120	[redacted]		€1,580,363,363
Revenue / Cost	[redacted]	[redacted]	86.48%	[redacted]		[redacted]

Table 45: Cumulative Costs and Revenues for the Airport - Arsenale Route, Excluding Cargo Transportation

Year	Cumulative costs	Cumulative revenue	Overdraft	Interest
2017	€0	€0	€0	€0
2018	€1,645,000,000	€3,051,729	€1,641,948,271	€33,824,134
2019	€1,678,824,134	€6,259,776	€1,672,564,358	€34,454,826
2020	€1,713,278,960	€9,624,142	€1,703,654,819	€35,095,289
2021	€1,748,374,249	€13,144,826	€1,735,229,424	€35,745,726
2022	€1,784,119,976	€16,821,828	€1,767,298,147	€36,406,342
2023	€1,820,526,317	€20,655,149	€1,799,871,168	€37,077,346
2024	€1,857,603,663	€24,644,788	€1,832,958,875	€37,758,953
2025	€1,895,362,616	€28,790,746	€1,866,571,870	€38,451,381
2026	€1,933,813,997	€33,093,022	€1,900,720,975	€39,154,852
2027	€1,975,899,182	€55,662,737	€1,920,236,445	€39,556,871
2028	€2,018,455,605	€78,816,582	€1,939,639,023	€39,956,564
2029	€2,061,480,940	€102,554,561	€1,958,926,379	€40,353,883
2030	€2,104,972,815	€126,876,677	€1,978,096,137	€40,748,780
2031	€2,148,928,805	€151,782,922	€1,997,145,883	€41,141,205
2032	€2,193,346,440	€177,273,300	€2,016,073,139	€41,531,107
2033	€2,238,223,195	€203,347,816	€2,034,875,380	€41,918,433
2034	€2,283,556,496	€230,006,459	€2,053,550,037	€42,303,131
2035	€2,329,343,715	€257,249,239	€2,072,094,475	€42,685,146
2036	€2,375,582,168	€285,076,154	€2,090,506,014	€43,064,424
2037	€2,422,269,118	€313,487,199	€2,108,781,919	€43,440,908
2038	€2,469,401,771	€342,482,378	€2,126,919,393	€43,814,539
2039	€2,516,977,276	€372,061,692	€2,144,915,584	€44,185,261
2040	€2,564,992,721	€402,225,136	€2,162,767,585	€44,553,012
2041	€2,613,445,136	€432,972,715	€2,180,472,422	€44,917,732
2042	€2,662,331,491	€464,304,424	€2,198,027,067	€45,279,358
2043	€2,711,648,691	€496,220,267	€2,215,428,423	€45,637,826
2044	€2,761,393,578	€528,720,247	€2,232,673,331	€45,993,071
2045	€2,811,562,929	€561,804,355	€2,249,758,574	€46,345,027

2046	€2,862,153,456	€595,472,600	€2,266,680,856	€46,693,626
2047	€2,913,161,802	€629,724,979	€2,283,436,822	€47,038,799
2048	€2,964,584,538	€664,561,487	€2,300,023,052	€47,380,475
2049	€3,016,418,172	€699,982,131	€2,316,436,041	€47,718,582
2050	€3,068,659,131	€735,986,903	€2,332,672,228	€48,053,048
2051	€3,121,303,776	€772,575,812	€2,348,727,963	€48,383,796
2052	€3,174,348,388	€809,748,856	€2,364,599,532	€48,710,750
2053	€3,227,789,174	€847,506,029	€2,380,283,144	€49,033,833
2054	€3,281,622,261	€885,847,338	€2,395,774,924	€49,352,963
2055	€3,335,843,699	€924,772,780	€2,411,070,918	€49,668,061
2056	€3,390,449,453	€964,282,353	€2,426,167,099	€49,979,042
2057	€3,445,435,408	€1,004,376,063	€2,441,059,345	€50,285,823
2058	€3,500,797,363	€1,045,053,907	€2,455,743,456	€50,588,315
2059	€3,556,531,029	€1,086,315,879	€2,470,215,150	€50,886,432
2060	€3,612,632,032	€1,128,161,988	€2,484,470,045	€51,180,083
2061	€3,669,095,906	€1,170,592,231	€2,498,503,675	€51,469,176
2062	€3,725,918,091	€1,213,606,605	€2,512,311,486	€51,753,617
2063	€3,783,093,936	€1,257,205,113	€2,525,888,824	€52,033,310
2064	€3,840,618,694	€1,301,387,751	€2,539,230,943	€52,308,157
2065	€3,898,487,519	€1,346,154,524	€2,552,332,995	€52,578,060
2066	€3,956,695,466	€1,391,505,431	€2,565,190,034	€52,842,915
2067	€4,015,237,486	€1,437,440,469	€2,577,797,017	€53,102,619
2068	€4,074,108,430	€1,483,959,641	€2,590,148,789	€53,357,065
2069	€4,133,303,040	€1,531,062,950	€2,602,240,090	€53,606,146
2070	€4,192,815,950	€1,578,750,387	€2,614,065,563	€53,849,751
2071	€4,252,641,684	€1,627,021,960	€2,625,619,724	€54,087,766
2072	€4,312,774,653	€1,675,877,668	€2,636,896,985	€54,320,078
2073	€4,373,209,154	€1,725,317,507	€2,647,891,647	€54,546,568
2074	€4,433,939,363	€1,775,341,479	€2,658,597,884	€54,767,116
2075	€4,494,959,340	€1,825,949,587	€2,669,009,754	€54,981,601
2076	€4,556,263,021	€1,877,141,824	€2,679,121,197	€55,189,897
2077	€4,617,844,217	€1,928,918,196	€2,688,926,021	€55,391,876
2078	€4,679,696,612	€1,981,278,699	€2,698,417,913	€55,587,409
2079	€4,741,813,759	€2,034,223,336	€2,707,590,423	€55,776,363
2080	€4,804,189,080	€2,087,752,109	€2,716,436,971	€55,958,602

Appendix D: Travel Times for Proposed Subway Lines

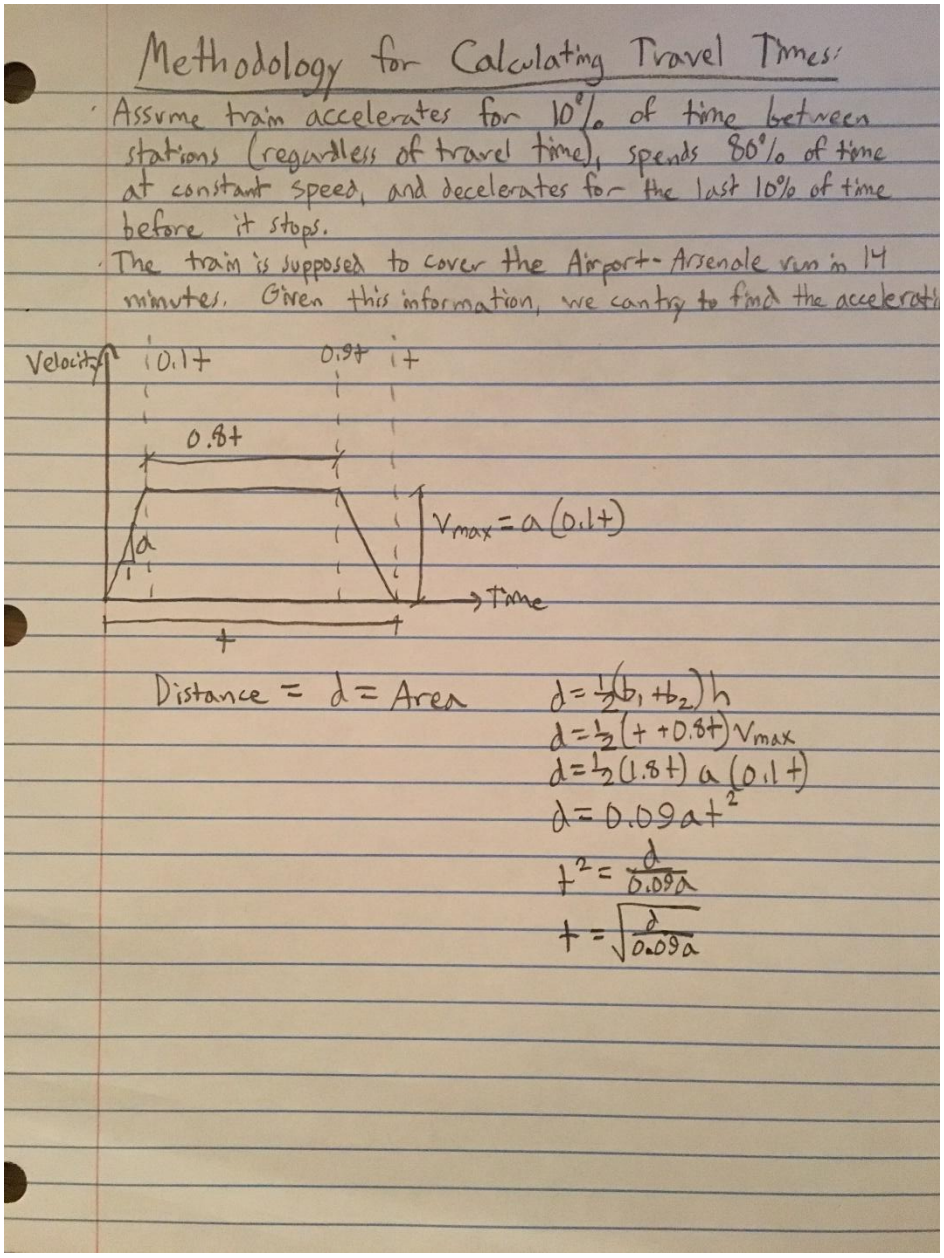

Figure 59. Derivation for Equation 7.

Table 46: Travel Times for Airport-Arsenale Route (Original Proposal)

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Aeropuerto	0	0.0	0.0
Terminal Tessera	615	1.6	1.8
Murano S. Mattia	4901	5.9	6.2
Murano	5896	8.2	8.5
Fondamenta Nuove	7235	10.7	11.0
Ospedale	7696	12.4	12.6
Arsenale	8166	14.0	14.3

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Arsenale	0	0.0	0.0
Ospedale	470	1.4	1.6
Fondamenta Nuove	931	3.0	3.3
Murano	2270	5.5	5.8
Murano S. Mattia	3265	7.8	8.1
Terminal Tessera	7551	12.2	12.5
Aeropuerto	8166	14.0	14.3

Table 47: Train Travel Times for the Route Circumnavigating Venice

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Lido S.M.E.	0	0	0
San Marco Giardinetti	2780	3.3	3.6
Zattere / Giudecca Palanca	3980	5.7	6.0
San Basilio / Sacca Fisola	4763	7.8	8.1
Ferrovia	6483	10.7	10.9
Fondamente Nove	9293	14.2	14.5
Arsenale Nord	10453	16.7	16.9
Lido S.M.E.	14533	20.9	21.2

Table 48: Time Required to Access the Platform for Each Station on the Route Circumnavigating Venice

Station	Access Tunnel Length (m)	Walking speed (m/s)	Time to Access Platform (min.)
Lido S.M.E.	99	1.42	1.2
San Marco Giardinetti	122	1.42	1.4
Zattere	161	1.42	1.9
Giudecca Palanca	163	1.42	1.9
San Basilio	136	1.42	1.6
Sacca Fisola	137	1.42	1.6
Ferrovia	0	1.42	0.0
Fondamente Nove	93	1.42	1.1
Arsenale Nord	100	1.42	1.2

Table 49: Current Travel Times[86] in Minutes Between Stops on the Airport-Arsenale Route (Original Proposal)

To (below) / From (right)	Aeropuerto	Terminal Tessera	Murano S. Mattia	Murano	Fondamenta Nuove	Ospedale	Arsenale
Aeropuerto		18 (18)	76 (64)	76 (47)	65 (51)	50 (48)	76 (61)
Terminal Tessera	18 (18)		65 (65)	88 (88)	73 (71)	69 (67)	75 (74)
Murano S. Mattia	85 (61)	67 (66)		37 (25)	43 (36)	52 (40)	52 (42)
Murano	68 (47)	68 (67)	42 (25)		30 (21)	30 (18)	30 (20)
Fondamenta Nuove	55 (46)	72 (70)	45 (43)	25 (21)		8 (6)	19 (19)
Ospedale	68 (62)	73 (72)	43 (41)	23 (19)	9 (9)		12 (2)
Arsenale	85 (64)	85 (84)	45 (43)	25 (21)	19 (19)	5 (2)	

[86] Google Maps, 2017.

Table 50: Travel Times for Murano - Ferrovia Route

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Murano	0	0.0	0.0
Ferrovia	3600	3.8	3.8
Station	**Distance (m)**	**Arrival Time (minutes)**	**Departure Time (minutes)**
Ferrovia	0	0.0	0.0
Murano	3600	3.8	3.8

Table 51: Current travel times[87] in minutes between stops on the Murano-Piazzale Roma Route

To (below) / From (right)	Murano S. Mattia	Piazzale Roma
Murano S. Mattia		67 (45)
Piazzale Roma	Could not find	

Table 52: Travel Times for Airport - Lido Route (Addendum to original proposal)

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Aeropuerto	0	0.0	0.0
Murano	5896	4.8	5.1
Fondamenta Nuove	7235	7.4	7.7
Lido S.M.E.	11756	11.9	11.9
Station	**Distance (m)**	**Arrival Time (minutes)**	**Departure Time (minutes)**
Lido S.M.E.	0	0.0	0.0
Fondamenta Nuove	4521	4.2	4.5
Murano	5860	6.8	7.1
Aeropuerto	11756	11.9	11.9

[87] Google Maps, 2017.

Table 53: Current Travel Times[88] in Minutes Between Stops on the Airport - Lido Route (Addendum to original proposal)

To (below) / From (right)	Aeropuerto	Murano	Fondamenta Nuove	Lido S.M.E.
Aeropuerto		76 (47)	65 (51)	65 (65)
Murano	68 (47)		30 (21)	48 (38)
Fondamenta Nuove	55 (46)	25 (21)		33 (23)
Lido S.M.E.	84 (76)	64 (49)	34 (27)	

[88] Google Maps, 2017.

Table 54: Travel Times for Airport - F.te Nove - Ferrovia Route

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Aeropuerto	0	0.0	0.0
Terminal Tessera	615	1.6	1.8
Murano S. Mattia	4901	5.9	6.2
Murano	5896	8.2	8.5
Fondamenta Nuove	7235	10.7	11.0
Ferrovia	9875	14.2	14.2
Station	**Distance (m)**	**Arrival Time (minutes)**	**Departure Time (minutes)**
Ferrovia	0	0.0	0.0
Fondamenta Nuove	2640	3.2	3.5
Murano	3979	5.8	6.1
Murano S. Mattia	4974	8.0	8.3
Terminal Tessera	9260	12.4	12.7
Aeropuerto	9875	14.2	14.2

Table 55: Current Travel Times[89] in Minutes Between Stops on the Aeropuerto – F.te Nove – Ferrovia Route

To (below) / From (right)	Aeropuerto	Terminal Tessera	Murano S. Mattia	Murano	Fondamenta Nuove	Ferrovia
Aeropuerto		18 (18)	76 (64)	76 (47)	65 (51)	35 (31)
Terminal Tessera	18 (18)		65 (65)	88 (88)	73 (71)	43 (39)
Murano S. Mattia	85 (61)	67 (66)		37 (25)	43 (36)	67 (45)
Murano	68 (47)	68 (67)	42 (25)		30 (21)	Could Not Find
Fondamenta Nuove	55 (46)	72 (70)	45 (43)	25 (21)		30 (20)
Ferrovia	39 (31)	54 (53)	44 (44)	44 (44)	23 (21)	

[89] Google Maps, 2017.

Appendix E: Cost-Benefit Analysis for the Lido - Mestre - Airport Subway System

Table 56: Station Coordinates and Distances to Platform

Station Entrance	Station Latitude	Station Longitude	Access Tunnel Length (m)	Walking speed (m/s)	Time to Access Platform (min.)
Lido S.M.E.	45.4175	12.36857	99	1.42	1.2
San Marco / San Zaccaria	45.43395	12.34344	149	1.42	1.7
Zattere	45.42943	12.32658	161	1.42	1.9
Giudecca Palanca	45.42668	12.32522	163	1.42	1.9
Piazzale Roma	45.43984	12.31784	0	1.42	0.0
Mestre	45.493	12.24595	0	1.42	0.0
Airport	45.50075	12.33721	0	1.42	0.0

Lido - P.le Roma Line

Table 57: Train Departure and Arrival Times for Each Stop on the Lido - P.le Roma Route (from Lido - P.le Roma)

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Lido S.M.E.	0	0	0
San Marco / San Zaccaria	2510	3.1	3.4
Zattere / Giudecca Palanca	4040	5.9	6.1
Piazzale Roma	6543	9.3	9.6

Table 58: Maintenance Cost per Passenger for the Lido - P.le Roma Line

A	**Maintenance Cost/Car-Mile**	€11.68
B	**Passengers/Car**	100
C = A / B	**Maintenance Cost/Passenger-Mile**	€0.12
D	**Length of Railway (miles)**	4.066
E = C * D	**Maintenance Cost/Passenger-Trip**	€0.47

Table 59: Total Number of Overnight Stays by Tourists from 2004-2015

Year	Arrivals	Overnight Stays	Day Trippers
2004	3018609	6930073	
2005	3237623	7670433	
2006	3496160	8245154	
2007	3626853	8842874	
2008	3433775	8487539	
2009	3405115	8445911	
2010	3708407	8521247	
2011	4167171	9417872	
2012	4106161	9310132	
2013	4251798	9778225	14739991
2014	4280632	9983416	
2015	4495857	10182829	

Table 60: Population of the Historic City, Lido, and Giudecca in 2011 and 2017

Year	Local Population	Rides/year
2011	77465[90]	40281800
2017	70649[91]	36737480

[90] Venice Project Center, n.d.
[91] Commune di Venezia, Portale dei Servizi, 2017.

Table 61: Maintenance Cost and Revenue Generated by Tourists Through 2083 for the Lido - P.le Roma Line

	A	B	C	D = A + B + 0.5 * C	E = 0.47 * D	F = 6 * D
Year	Arrivals	Overnights	Day Trippers	Tourist Trips	Tourist Cost	Tourist Revenue
2018	4833781	10973625	16757590	24186201	€11,485,708	€145,117,206
2019	4959048	11227231	17191862	24782210	€11,768,745	€148,693,260
2020	5084314	11480837	17626130	25378216	€12,051,781	€152,269,296
2021	5209581	11734443	18060401	25974224.5	€12,334,817	€155,845,347
2022	5334848	11988049	18494672	26570233	€12,617,854	€159,421,398
2023	5460115	12241655	18928944	27166242	€12,900,891	€162,997,452
2024	5585382	12495261	19363215	27762250.5	€13,183,927	€166,573,503
2025	5710648	12748867	19797483	28358256.5	€13,466,963	€170,149,539
2026	5835915	13002473	20231755	28954265.5	€13,749,999	€173,725,593
2027	5961182	13256079	20666026	29550274	€14,033,036	€177,301,644
2028	6086449	13509684	21100298	30146282	€14,316,072	€180,877,692
2029	6211715	13763290	21534566	30742288	€14,599,108	€184,453,728
2030	6336982	14016896	21968837	31338296.5	€14,882,144	€188,029,779
2031	6462249	14270502	22403109	31934305.5	€15,165,181	€191,605,833
2032	6587516	14524108	22837380	32530314	€15,448,218	€195,181,884
2033	6712782	14777714	23271648	33126320	€15,731,253	€198,757,920
2034	6838049	15031320	23705919	33722328.5	€16,014,290	€202,333,971
2035	6963316	15284926	24140191	34318337.5	€16,297,327	€205,910,025
2036	7088583	15538532	24574462	34914346	€16,580,363	€209,486,076
2037	7213849	15792137	25008730	35510351	€16,863,398	€213,062,106
2038	7339116	16045743	25443002	36106360	€17,146,435	€216,638,160
2039	7464383	16299349	25877273	36702368.5	€17,429,471	€220,214,211
2040	7589650	16552955	26311545	37298377.5	€17,712,508	€223,790,265
2041	7714917	16806561	26745816	37894386	€17,995,545	€227,366,316
2042	7840183	17060167	27180084	38490392	€18,278,580	€230,942,352
2043	7965450	17313773	27614355	39086400.5	€18,561,617	€234,518,403
2044	8090717	17567379	28048627	39682409.5	€18,844,654	€238,094,457

2045	8215984	17820985	28482898	40278418	€19,127,690	€241,670,508
2046	8341250	18074590	28917166	40874423	€19,410,725	€245,246,538
2047	8466517	18328196	29351438	41470432	€19,693,762	€248,822,592
2048	8591784	18581802	29785709	42066440.5	€19,976,799	€252,398,643
2049	8717051	18835408	30219981	42662449.5	€20,259,835	€255,974,697
2050	8842317	19089014	30654249	43258455.5	€20,542,871	€259,550,733
2051	8967584	19342620	31088520	43854464	€20,825,907	€263,126,784
2052	9092851	19596226	31522792	44450473	€21,108,944	€266,702,838
2053	9218118	19849832	31957063	45046481.5	€21,391,981	€270,278,889
2054	9343384	20103438	32391331	45642487.5	€21,675,016	€273,854,925
2055	9468651	20357043	32825602	46238495	€21,958,052	€277,430,970
2056	9593918	20610649	33259874	46834504	€22,241,089	€281,007,024
2057	9719185	20864255	33694145	47430512.5	€22,524,126	€284,583,075
2058	9844452	21117861	34128417	48026521.5	€22,807,163	€288,159,129
2059	9969718	21371467	34562685	48622527.5	€23,090,198	€291,735,165
2060	10094985	21625073	34996956	49218536	€23,373,235	€295,311,216
2061	10220252	21878679	35431228	49814545	€23,656,271	€298,887,270
2062	10345519	22132285	35865499	50410553.5	€23,939,308	€302,463,321
2063	10470785	22385891	36299767	51006559.5	€24,222,343	€306,039,357
2064	10596052	22639497	36734038	51602568	€24,505,380	€309,615,408
2065	10721319	22893102	37168310	52198576	€24,788,416	€313,191,456
2066	10846586	23146708	37602581	52794584.5	€25,071,453	€316,767,507
2067	10971852	23400314	38036849	53390590.5	€25,354,488	€320,343,543
2068	11097119	23653920	38471121	53986599.5	€25,637,525	€323,919,597
2069	11222386	23907526	38905392	54582608	€25,920,562	€327,495,648
2070	11347653	24161132	39339664	55178617	€26,203,599	€331,071,702
2071	11472920	24414738	39773935	55774625.5	€26,486,635	€334,647,753
2072	11598186	24668344	40208203	56370631.5	€26,769,671	€338,223,789
2073	11723453	24921950	40642474	56966640	€27,052,707	€341,799,840
2074	11848720	25175555	41076746	57562648	€27,335,743	€345,375,888
2075	11973987	25429161	41511017	58158656.5	€27,618,780	€348,951,939
2076	12099253	25682767	41945285	58754662.5	€27,901,815	€352,527,975

2077	12224520	25936373	42379557	59350671.5	€28,184,852	€356,104,029
2078	12349787	26189979	42813828	59946680	€28,467,889	€359,680,080
2079	12475054	26443585	43248100	60542689	€28,750,926	€363,256,134
2080	12600320	26697191	43682368	61138695	€29,033,961	€366,832,170
2081	12725587	26950797	44116639	61734703.5	€29,316,998	€370,408,221
2082	12850854	27204403	44550911	62330712.5	€29,600,035	€373,984,275
2083	12976121	27458008	44985182	62926720	€29,883,071	€377,560,320

Table 62: Maintenance Cost and Revenue Generated by Locals Through 2083 for the Lido - P.le Roma Line

Year	Local Trips	Local Cost	Local Revenue	***Total Cost***	***Total Revenue***
2018	12686122	€6,024,472	€25,372,244	*€17,510,181*	*€170,489,450*
2019	12478802	€5,926,019	€24,957,604	*€17,694,764*	*€173,650,864*
2020	12271482	€5,827,565	€24,542,964	*€17,879,346*	*€176,812,260*
2021	12064162	€5,729,112	€24,128,324	*€18,063,929*	*€179,973,671*
2022	11856842	€5,630,658	€23,713,684	*€18,248,512*	*€183,135,082*
2023	11649522	€5,532,205	€23,299,044	*€18,433,095*	*€186,296,496*
2024	11442202	€5,433,751	€22,884,404	*€18,617,678*	*€189,457,907*
2025	11234882	€5,335,298	€22,469,764	*€18,802,260*	*€192,619,303*
2026	11027562	€5,236,844	€22,055,124	*€18,986,843*	*€195,780,717*
2027	10820242	€5,138,390	€21,640,484	*€19,171,426*	*€198,942,128*
2028	10612922	€5,039,937	€21,225,844	*€19,356,009*	*€202,103,536*
2029	10405602	€4,941,483	€20,811,204	*€19,540,591*	*€205,264,932*
2030	10198282	€4,843,030	€20,396,564	*€19,725,174*	*€208,426,343*
2031	9990962	€4,744,576	€19,981,924	*€19,909,757*	*€211,587,757*
2032	9783642	€4,646,123	€19,567,284	*€20,094,340*	*€214,749,168*
2033	9576322	€4,547,669	€19,152,644	*€20,278,922*	*€217,910,564*
2034	9369002	€4,449,216	€18,738,004	*€20,463,505*	*€221,071,975*
2035	9161682	€4,350,762	€18,323,364	*€20,648,089*	*€224,233,389*
2036	8954362	€4,252,309	€17,908,724	*€20,832,672*	*€227,394,800*
2037	8747042	€4,153,855	€17,494,084	*€21,017,253*	*€230,556,190*
2038	8539722	€4,055,402	€17,079,444	*€21,201,836*	*€233,717,604*

2039	8332402	€3,956,948	€16,664,804	*€21,386,419*	*€236,879,015*
2040	8125082	€3,858,494	€16,250,164	*€21,571,003*	*€240,040,429*
2041	7917762	€3,760,041	€15,835,524	*€21,755,586*	*€243,201,840*
2042	7710442	€3,661,587	€15,420,884	*€21,940,168*	*€246,363,236*
2043	7503122	€3,563,134	€15,006,244	*€22,124,751*	*€249,524,647*
2044	7295802	€3,464,680	€14,591,604	*€22,309,334*	*€252,686,061*
2045	7088482	€3,366,227	€14,176,964	*€22,493,917*	*€255,847,472*
2046	6881162	€3,267,773	€13,762,324	*€22,678,498*	*€259,008,862*
2047	6673842	€3,169,320	€13,347,684	*€22,863,082*	*€262,170,276*
2048	6466522	€3,070,866	€12,933,044	*€23,047,665*	*€265,331,687*
2049	6259202	€2,972,413	€12,518,404	*€23,232,248*	*€268,493,101*
2050	6051882	€2,873,959	€12,103,764	*€23,416,830*	*€271,654,497*
2051	5844562	€2,775,506	€11,689,124	*€23,601,413*	*€274,815,908*
2052	5637242	€2,677,052	€11,274,484	*€23,785,996*	*€277,977,322*
2053	5429922	€2,578,598	€10,859,844	*€23,970,579*	*€281,138,733*
2054	5222602	€2,480,145	€10,445,204	*€24,155,161*	*€284,300,129*
2055	5015282	€2,381,691	€10,030,564	*€24,339,744*	*€287,461,534*
2056	4807962	€2,283,238	€9,615,924	*€24,524,327*	*€290,622,948*
2057	4600642	€2,184,784	€9,201,284	*€24,708,910*	*€293,784,359*
2058	4393322	€2,086,331	€8,786,644	*€24,893,493*	*€296,945,773*
2059	4186002	€1,987,877	€8,372,004	*€25,078,075*	*€300,107,169*
2060	3978682	€1,889,424	€7,957,364	*€25,262,658*	*€303,268,580*
2061	3771362	€1,790,970	€7,542,724	*€25,447,242*	*€306,429,994*
2062	3564042	€1,692,517	€7,128,084	*€25,631,825*	*€309,591,405*
2063	3356722	€1,594,063	€6,713,444	*€25,816,406*	*€312,752,801*
2064	3149402	€1,495,610	€6,298,804	*€26,000,990*	*€315,914,212*
2065	2942082	€1,397,156	€5,884,164	*€26,185,572*	*€319,075,620*
2066	2734763	€1,298,703	€5,469,526	*€26,370,156*	*€322,237,033*
2067	2527443	€1,200,249	€5,054,886	*€26,554,738*	*€325,398,429*
2068	2320123	€1,101,796	€4,640,246	*€26,739,321*	*€328,559,843*
2069	2112803	€1,003,342	€4,225,606	*€26,923,904*	*€331,721,254*
2070	1905483	€904,889	€3,810,966	*€27,108,487*	*€334,882,668*

2071	1698163	€806,435	€3,396,326	*€27,293,070*	*€338,044,079*
2072	1490843	€707,982	€2,981,686	*€27,477,652*	*€341,205,475*
2073	1283523	€609,528	€2,567,046	*€27,662,235*	*€344,366,886*
2074	1076203	€511,075	€2,152,406	*€27,846,818*	*€347,528,294*
2075	868883	€412,621	€1,737,766	*€28,031,401*	*€350,689,705*
2076	661563	€314,168	€1,323,126	*€28,215,983*	*€353,851,101*
2077	454243	€215,714	€908,486	*€28,400,566*	*€357,012,515*
2078	246923	€117,260	€493,846	*€28,585,149*	*€360,173,926*
2079	39603	€18,807	€79,206	*€28,769,733*	*€363,335,340*
2080	0	€0	€0	*€29,033,961*	*€366,832,170*
2081	0	€0	€0	*€29,316,998*	*€370,408,221*
2082	0	€0	€0	*€29,600,035*	*€373,984,275*
2083	0	€0	€0	*€29,883,071*	*€377,560,320*

Table 63: Parameters for the Present Value Analysis for All Branches of the Lido - Mestre - Airport System

Average Interest Rate[92]	2.06%
Inflation Rate[93]	1.33%
Adjusted Interest Rate	0.72%
Resident Ticket Price	€2.00
Tourist Ticket Price	€6.00
Km constructed / year	0.98
Total # of Years to Construct	7

Table 64: Present Value Analysis for the Lido - P.le Roma Line

Year	Construction Cost	Maintenance Cost	Present Value of Costs	Ticket Revenue	Present Value of Revenue
2017	€0.00	€0	€0	€0	€0
2018	€1,373,000,000.00	€0	€1,363,179,404	€0	€0
2019	€0.00	€0	€0	€0	€0

[92] Trading Economics, n.d.
[93] Euro Inflation Calculator, n.d.

2020	€0.00	€0	€0	€0	€0
2021	€0.00	€0	€0	€0	€0
2022	€0.00	€0	€0	€0	€0
2023	€0.00	€0	€0	€0	€0
2024	€0.00	€0	€0	€0	€0
2025	0	€18,802,260	€17,752,924	€192,619,303	€181,869,401
2026	0	€18,986,843	€17,798,978	€195,780,717	€183,532,180
2027	0	€19,171,426	€17,843,466	€198,942,128	€185,161,865
2028	0	€19,356,009	€17,886,406	€202,103,536	€186,758,844
2029	0	€19,540,591	€17,927,818	€205,264,932	€188,323,494
2030	0	€19,725,174	€17,967,724	€208,426,343	€189,856,221
2031	0	€19,909,757	€18,006,142	€211,587,757	€191,357,389
2032	0	€20,094,340	€18,043,091	€214,749,168	€192,827,366
2033	0	€20,278,922	€18,078,589	€217,910,564	€194,266,512
2034	0	€20,463,505	€18,112,657	€221,071,975	€195,675,219
2035	0	€20,648,089	€18,145,313	€224,233,389	€197,053,837
2036	0	€20,832,672	€18,176,575	€227,394,800	€198,402,721
2037	0	€21,017,253	€18,206,461	€230,556,190	€199,722,209
2038	0	€21,201,836	€18,234,990	€233,717,604	€201,012,691
2039	0	€21,386,419	€18,262,180	€236,879,015	€202,274,492
2040	0	€21,571,003	€18,288,048	€240,040,429	€203,507,961
2041	0	€21,755,586	€18,312,611	€243,201,840	€204,713,434
2042	0	€21,940,168	€18,335,886	€246,363,236	€205,891,239
2043	0	€22,124,751	€18,357,893	€249,524,647	€207,041,733
2044	0	€22,309,334	€18,378,647	€252,686,061	€208,165,239
2045	0	€22,493,917	€18,398,164	€255,847,472	€209,262,077
2046	0	€22,678,498	€18,416,461	€259,008,862	€210,332,559
2047	0	€22,863,082	€18,433,556	€262,170,276	€211,377,039
2048	0	€23,047,665	€18,449,465	€265,331,687	€212,395,816
2049	0	€23,232,248	€18,464,202	€268,493,101	€213,389,206
2050	0	€23,416,830	€18,477,784	€271,654,497	€214,357,505
2051	0	€23,601,413	€18,490,228	€274,815,908	€215,301,048

2052	0	€23,785,996	€18,501,549	€277,977,322	€216,220,128
2053	0	€23,970,579	€18,511,762	€281,138,733	€217,115,043
2054	0	€24,155,161	€18,520,881	€284,300,129	€217,986,083
2055	0	€24,339,744	€18,528,924	€287,461,534	€218,833,561
2056	0	€24,524,327	€18,535,904	€290,622,948	€219,657,771
2057	0	€24,708,910	€18,541,836	€293,784,359	€220,458,992
2058	0	€24,893,493	€18,546,735	€296,945,773	€221,237,515
2059	0	€25,078,075	€18,550,615	€300,107,169	€221,993,610
2060	0	€25,262,658	€18,553,491	€303,268,580	€222,727,581
2061	0	€25,447,242	€18,555,377	€306,429,994	€223,439,697
2062	0	€25,631,825	€18,556,286	€309,591,405	€224,130,229
2063	0	€25,816,406	€18,556,233	€312,752,801	€224,799,441
2064	0	€26,000,990	€18,555,231	€315,914,212	€225,447,623
2065	0	€26,185,572	€18,553,295	€319,075,620	€226,075,030
2066	0	€26,370,156	€18,550,437	€322,237,033	€226,681,931
2067	0	€26,554,738	€18,546,670	€325,398,429	€227,268,573
2068	0	€26,739,321	€18,542,009	€328,559,843	€227,835,237
2069	0	€26,923,904	€18,536,465	€331,721,254	€228,382,167
2070	0	€27,108,487	€18,530,053	€334,882,668	€228,909,618
2071	0	€27,293,070	€18,522,783	€338,044,079	€229,417,837
2072	0	€27,477,652	€18,514,669	€341,205,475	€229,907,065
2073	0	€27,662,235	€18,505,724	€344,366,886	€230,377,567
2074	0	€27,846,818	€18,495,959	€347,528,294	€230,829,575
2075	0	€28,031,401	€18,485,388	€350,689,705	€231,263,332
2076	0	€28,215,983	€18,474,021	€353,851,101	€231,679,065
2077	0	€28,400,566	€18,461,871	€357,012,515	€232,077,031
2078	0	€28,585,149	€18,448,950	€360,173,926	€232,457,449
2079	0	€28,769,733	€18,435,270	€363,335,340	€232,820,554
2080	0	€29,033,961	€18,471,512	€366,832,170	€233,379,965
2081	0	€29,316,998	€18,518,173	€370,408,221	€233,969,502
2082	0	€29,600,035	€18,563,221	€373,984,275	€234,538,668
2083	0	€29,883,071	€18,606,677	€377,560,320	€235,087,716

Total	[redacted]	€1,780,543,984	[redacted]	€4,548,385,721

Table 65: Cumulative Cost of the Lido - P.le Roma Line With Interest

Year	Cumulative costs	Cumulative revenue	Overdraft	Interest
2017	€0	€0	€0	€0.00
2018	€1,373,000,000	€0	€1,373,000,000.00	€28,283,800.00
2019	€1,401,283,800	€0	€1,401,283,800.00	€28,866,446.28
2020	€1,430,150,246	€0	€1,430,150,246.28	€29,461,095.07
2021	€1,459,611,341	€0	€1,459,611,341.35	€30,067,993.63
2022	€1,489,679,335	€0	€1,489,679,334.99	€30,687,394.30
2023	€1,520,366,729	€0	€1,520,366,729.29	€31,319,554.62
2024	€1,551,686,284	€0	€1,551,686,283.91	€31,964,737.45
2025	€1,602,453,281	€192,619,303	€1,409,833,978.42	€29,042,579.96
2026	€1,650,482,705	€388,400,020	€1,262,082,684.73	€25,998,903.31
2027	€1,695,653,034	€587,342,148	€1,108,310,886.43	€22,831,204.26
2028	€1,737,840,248	€789,445,684	€948,394,563.91	€19,536,928.02
2029	€1,776,917,767	€994,710,616	€782,207,151.00	€16,113,467.31
2030	€1,812,756,408	€1,203,136,959	€609,619,449.44	€12,558,160.66
2031	€1,845,224,327	€1,414,724,716	€430,499,610.51	€8,868,291.98
2032	€1,874,186,959	€1,629,473,884	€244,713,074.95	€5,041,089.34
2033	€1,899,506,971	€1,847,384,448	€52,122,522.62	€1,073,723.97
2034	€1,921,044,200	€2,068,456,423	-€147,412,223.04	€0.00
2035	€1,941,692,289	€2,292,689,812	-€350,997,523.38	€0.00
2036	€1,962,524,960	€2,520,084,612	-€557,559,651.66	€0.00
2037	€1,983,542,213	€2,750,640,802	-€767,098,588.56	€0.00
2038	€2,004,744,050	€2,984,358,406	-€979,614,356.17	€0.00
2039	€2,026,130,469	€3,221,237,421	-€1,195,106,951.73	€0.00
2040	€2,047,701,472	€3,461,277,850	-€1,413,576,378.01	€0.00
2041	€2,069,457,058	€3,704,479,690	-€1,635,022,632.23	€0.00
2042	€2,091,397,225	€3,950,842,926	-€1,859,445,700.59	€0.00
2043	€2,113,521,976	€4,200,367,573	-€2,086,845,596.91	€0.00
2044	€2,135,831,310	€4,453,053,634	-€2,317,222,323.93	€0.00

2045	€2,158,325,227	€4,708,901,106	-€2,550,575,878.90	€0.00
2046	€2,181,003,726	€4,967,909,968	-€2,786,906,242.49	€0.00
2047	€2,203,866,807	€5,230,080,244	-€3,026,213,436.79	€0.00
2048	€2,226,914,472	€5,495,411,931	-€3,268,497,459.04	€0.00
2049	€2,250,146,720	€5,763,905,032	-€3,513,758,312.00	€0.00
2050	€2,273,563,550	€6,035,559,529	-€3,761,995,979.10	€0.00
2051	€2,297,164,963	€6,310,375,437	-€4,013,210,474.15	€0.00
2052	€2,320,950,959	€6,588,352,759	-€4,267,401,799.91	€0.00
2053	€2,344,921,538	€6,869,491,492	-€4,524,569,953.62	€0.00
2054	€2,369,076,700	€7,153,791,621	-€4,784,714,921.47	€0.00
2055	€2,393,416,443	€7,441,253,155	-€5,047,836,711.74	€0.00
2056	€2,417,940,770	€7,731,876,103	-€5,313,935,332.73	€0.00
2057	€2,442,649,680	€8,025,660,462	-€5,583,010,781.67	€0.00
2058	€2,467,543,174	€8,322,606,235	-€5,855,063,061.32	€0.00
2059	€2,492,621,249	€8,622,713,404	-€6,130,092,155.10	€0.00
2060	€2,517,883,907	€8,925,981,984	-€6,408,098,076.84	€0.00
2061	€2,543,331,149	€9,232,411,978	-€6,689,080,829.29	€0.00
2062	€2,568,962,973	€9,542,003,383	-€6,973,040,409.69	€0.00
2063	€2,594,779,380	€9,854,756,184	-€7,259,976,804.23	€0.00
2064	€2,620,780,369	€10,170,670,396	-€7,549,890,026.71	€0.00
2065	€2,646,965,942	€10,489,746,016	-€7,842,780,074.39	€0.00
2066	€2,673,336,097	€10,811,983,049	-€8,138,646,951.54	€0.00
2067	€2,699,890,835	€11,137,381,478	-€8,437,490,642.82	€0.00
2068	€2,726,630,156	€11,465,941,321	-€8,739,311,164.82	€0.00
2069	€2,753,554,060	€11,797,662,575	-€9,044,108,514.77	€0.00
2070	€2,780,662,548	€12,132,545,243	-€9,351,882,695.43	€0.00
2071	€2,807,955,618	€12,470,589,322	-€9,662,633,704.05	€0.00
2072	€2,835,433,270	€12,811,794,797	-€9,976,361,526.80	€0.00
2073	€2,863,095,506	€13,156,161,683	-€10,293,066,177.50	€0.00
2074	€2,890,942,324	€13,503,689,977	-€10,612,747,653.38	€0.00
2075	€2,918,973,725	€13,854,379,682	-€10,935,405,957.22	€0.00
2076	€2,947,189,708	€14,208,230,783	-€11,261,041,075.19	€0.00
2077	€2,975,590,274	€14,565,243,298	-€11,589,653,023.88	€0.00
2078	€3,004,175,423	€14,925,417,224	-€11,921,241,800.52	€0.00
2079	€3,032,945,156	€15,288,752,564	-€12,255,807,407.87	€0.00

2080	€3,061,979,117	€15,655,584,734	-€12,593,605,616.76	€0.00
2081	€3,091,296,115	€16,025,992,955	-€12,934,696,840.06	€0.00
2082	€3,120,896,149	€16,399,977,230	-€13,279,081,080.54	€0.00
2083	€3,150,779,220	€16,777,537,550	-€13,626,758,329.91	€0.00

Lido - Mestre Line

Table 66: Train Departure and Arrival Times for Each Stop on the Lido - Mestre Route

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Lido S.M.E.	0	0	0
San Marco / San Zaccaria	2510	3.1	3.4
Zattere / Giudecca Palanca	4040	5.9	6.1
Piazzale Roma	6543	9.3	9.6
Central Mestre	14993	15.3	15.3
Station	**Distance (m)**	**Arrival Time (minutes)**	**Departure Time (minutes)**
Central Mestre	0	0	0
Piazzale Roma	8450	5.8	6.0
Zattere / Giudecca Palanca	10953	9.2	9.4
San Marco / San Zaccaria	12483	11.9	12.2
Lido S.M.E.	14993	15.3	15.3

Table 67: Cost Calculations for the Extension to Mestre Using the Comparison Method

	Track and Stations
Avg.	€1,663,265,872.99
Min.	€548,390,768.42
Max.	€3,012,345,389.55
Value to use	*€1,702,000,000.00*

Table 68: Cost Calculations for the Entire Lido - Mestre Line Using the Comparison Method

	Track and Stations	Access Tunnels	*Total*
Avg.	€2,951,165,116.41	€53,637,863.95	*€3,004,802,980.36*
Min.	€973,020,448.63	€17,684,791.05	*€990,705,239.68*
Max.	€5,344,863,245.63	€97,143,682.68	*€5,442,006,928.31*
Value to use	*€3,020,000,000.00*	*€55,000,000.00*	***€3,075,000,000.00***

Table 69: Maintenance Cost per Passenger for the P.le Roma - Mestre Extension

A	**Maintenance Cost/Car-Mile**	€11.68
B	**Passengers/Car**	100
C = A / B	**Maintenance Cost/Passenger-Mile**	€0.12
D	**Length of Railway (miles)**	5.251
E = C * D	**Maintenance Cost/Passenger-Trip**	€0.61

Table 70: Maintenance Cost and Revenue for the P.le Roma - Mestre Extension, Based on 1986 and 1997 Data

	Weekday Ridership[94]	**Yearly Ridership**	**Maintenance Cost**	**Revenue**
1986	*17850*			
1997	*18779.5*			
2018	20554	10688080	€6,554,953.43	€21,376,160.00
2019	20639	10732280	€6,582,061.10	€21,464,560.00
2020	20723	10775960	€6,608,849.86	€21,551,920.00
2021	20808	10820160	€6,635,957.53	€21,640,320.00
2022	20892	10863840	€6,662,746.28	€21,727,680.00
2023	20977	10908040	€6,689,853.95	€21,816,080.00
2024	21061	10951720	€6,716,642.71	€21,903,440.00
2025	21146	10995920	€6,743,750.38	€21,991,840.00
2026	21230	11039600	€6,770,539.13	€22,079,200.00

[94] Pedrocco, 2000.

2027	21315	11083800	€6,797,646.80	€22,167,600.00
2028	21399	11127480	€6,824,435.56	€22,254,960.00
2029	21484	11171680	€6,851,543.23	€22,343,360.00
2030	21568	11215360	€6,878,331.99	€22,430,720.00
2031	21653	11259560	€6,905,439.65	€22,519,120.00
2032	21737	11303240	€6,932,228.41	€22,606,480.00
2033	21822	11347440	€6,959,336.08	€22,694,880.00
2034	21906	11391120	€6,986,124.84	€22,782,240.00
2035	21991	11435320	€7,013,232.51	€22,870,640.00
2036	22075	11479000	€7,040,021.26	€22,958,000.00
2037	22160	11523200	€7,067,128.93	€23,046,400.00
2038	22244	11566880	€7,093,917.69	€23,133,760.00
2039	22329	11611080	€7,121,025.36	€23,222,160.00
2040	22413	11654760	€7,147,814.11	€23,309,520.00
2041	22498	11698960	€7,174,921.78	€23,397,920.00
2042	22582	11742640	€7,201,710.54	€23,485,280.00
2043	22667	11786840	€7,228,818.21	€23,573,680.00
2044	22751	11830520	€7,255,606.96	€23,661,040.00
2045	22836	11874720	€7,282,714.63	€23,749,440.00
2046	22920	11918400	€7,309,503.39	€23,836,800.00
2047	23005	11962600	€7,336,611.06	€23,925,200.00
2048	23089	12006280	€7,363,399.81	€24,012,560.00
2049	23174	12050480	€7,390,507.48	€24,100,960.00
2050	23258	12094160	€7,417,296.24	€24,188,320.00
2051	23343	12138360	€7,444,403.91	€24,276,720.00
2052	23427	12182040	€7,471,192.67	€24,364,080.00
2053	23512	12226240	€7,498,300.34	€24,452,480.00
2054	23596	12269920	€7,525,089.09	€24,539,840.00
2055	23681	12314120	€7,552,196.76	€24,628,240.00
2056	23765	12357800	€7,578,985.52	€24,715,600.00
2057	23849	12401480	€7,605,774.27	€24,802,960.00
2058	23934	12445680	€7,632,881.94	€24,891,360.00

2059	24018	12489360	€7,659,670.70	€24,978,720.00
2060	24103	12533560	€7,686,778.37	€25,067,120.00
2061	24187	12577240	€7,713,567.12	€25,154,480.00
2062	24272	12621440	€7,740,674.79	€25,242,880.00
2063	24356	12665120	€7,767,463.55	€25,330,240.00
2064	24441	12709320	€7,794,571.22	€25,418,640.00
2065	24525	12753000	€7,821,359.97	€25,506,000.00
2066	24610	12797200	€7,848,467.64	€25,594,400.00
2067	24694	12840880	€7,875,256.40	€25,681,760.00
2068	24779	12885080	€7,902,364.07	€25,770,160.00
2069	24863	12928760	€7,929,152.83	€25,857,520.00
2070	24948	12972960	€7,956,260.50	€25,945,920.00
2071	25032	13016640	€7,983,049.25	€26,033,280.00
2072	25117	13060840	€8,010,156.92	€26,121,680.00
2073	25201	13104520	€8,036,945.68	€26,209,040.00
2074	25286	13148720	€8,064,053.35	€26,297,440.00
2075	25370	13192400	€8,090,842.10	€26,384,800.00
2076	25455	13236600	€8,117,949.77	€26,473,200.00
2077	25539	13280280	€8,144,738.53	€26,560,560.00
2078	25624	13324480	€8,171,846.20	€26,648,960.00
2079	25708	13368160	€8,198,634.95	€26,736,320.00
2080	25793	13412360	€8,225,742.62	€26,824,720.00
2081	25877	13456040	€8,252,531.38	€26,912,080.00
2082	25962	13500240	€8,279,639.05	€27,000,480.00

Table 71: Parameters for the Present Value Analysis for the Extension to Mestre

Average Interest Rate	2.06%
Inflation Rate	1.33%
Adjusted Interest Rate	0.72%
Km constructed / year	0.98
Total # of Years to Construct	9

Table 72: Present Value Analysis for the P.le Roma - Mestre Extension Through 2080

Year	Construction Cost	Maintenance Cost	Present Value of Costs	Ticket Revenue	Present Value of Revenue
2017	€0	€0	€0	€0	€0
2018	€1,702,000,000	€0	€1,689,826,181	€0	€0
2019	€0	€0	€0	€0	€0
2020	€0	€0	€0	€0	€0
2021	€0	€0	€0	€0	€0
2022	€0	€0	€0	€0	€0
2023	€0	€0	€0	€0	€0
2024	€0	€0	€0	€0	€0
2025	€0	€0	€0	€0	€0
2026	€0	€0	€0	€0	€0
2027	€0	€6,797,647	€6,326,789	€22,167,600	€20,632,101
2028	€0	€6,824,436	€6,306,291	€22,254,960	€20,565,254
2029	€0	€6,851,543	€6,286,055	€22,343,360	€20,499,262
2030	€0	€6,878,332	€6,265,495	€22,430,720	€20,432,214
2031	€0	€6,905,440	€6,245,195	€22,519,120	€20,366,018
2032	€0	€6,932,228	€6,224,580	€22,606,480	€20,298,789
2033	€0	€6,959,336	€6,204,224	€22,694,880	€20,232,407
2034	€0	€6,986,125	€6,183,559	€22,782,240	€20,165,015
2035	€0	€7,013,233	€6,163,152	€22,870,640	€20,098,467
2036	€0	€7,040,021	€6,142,442	€22,958,000	€20,030,932
2037	€0	€7,067,129	€6,121,990	€23,046,400	€19,964,235
2038	€0	€7,093,918	€6,101,241	€23,133,760	€19,896,573
2039	€0	€7,121,025	€6,080,749	€23,222,160	€19,829,746
2040	€0	€7,147,814	€6,059,967	€23,309,520	€19,761,975
2041	€0	€7,174,922	€6,039,440	€23,397,920	€19,695,034
2042	€0	€7,201,711	€6,018,630	€23,485,280	€19,627,171
2043	€0	€7,228,818	€5,998,073	€23,573,680	€19,560,134
2044	€0	€7,255,607	€5,977,240	€23,661,040	€19,492,195
2045	€0	€7,282,715	€5,956,658	€23,749,440	€19,425,078

2046	€0	€7,309,503	€5,935,807	€23,836,800	€19,357,079
2047	€0	€7,336,611	€5,915,206	€23,925,200	€19,289,898
2048	€0	€7,363,400	€5,894,341	€24,012,560	€19,221,855
2049	€0	€7,390,507	€5,873,725	€24,100,960	€19,154,625
2050	€0	€7,417,296	€5,852,850	€24,188,320	€19,086,553
2051	€0	€7,444,404	€5,832,224	€24,276,720	€19,019,289
2052	€0	€7,471,193	€5,811,345	€24,364,080	€18,951,202
2053	€0	€7,498,300	€5,790,713	€24,452,480	€18,883,920
2054	€0	€7,525,089	€5,769,835	€24,539,840	€18,815,832
2055	€0	€7,552,197	€5,749,201	€24,628,240	€18,748,545
2056	€0	€7,578,986	€5,728,326	€24,715,600	€18,680,471
2057	€0	€7,605,774	€5,707,456	€24,802,960	€18,612,412
2058	€0	€7,632,882	€5,686,829	€24,891,360	€18,545,146
2059	€0	€7,659,671	€5,665,969	€24,978,720	€18,477,120
2060	€0	€7,686,778	€5,645,351	€25,067,120	€18,409,883
2061	€0	€7,713,567	€5,624,505	€25,154,480	€18,341,904
2062	€0	€7,740,675	€5,603,900	€25,242,880	€18,274,708
2063	€0	€7,767,464	€5,583,072	€25,330,240	€18,206,787
2064	€0	€7,794,571	€5,562,483	€25,418,640	€18,139,646
2065	€0	€7,821,360	€5,541,678	€25,506,000	€18,071,797
2066	€0	€7,848,468	€5,521,109	€25,594,400	€18,004,721
2067	€0	€7,875,256	€5,500,329	€25,681,760	€17,936,955
2068	€0	€7,902,364	€5,479,784	€25,770,160	€17,869,958
2069	€0	€7,929,153	€5,459,032	€25,857,520	€17,802,285
2070	€0	€7,956,260	€5,438,515	€25,945,920	€17,735,378
2071	€0	€7,983,049	€5,417,796	€26,033,280	€17,667,811
2072	€0	€8,010,157	€5,397,310	€26,121,680	€17,601,004
2073	€0	€8,036,946	€5,376,626	€26,209,040	€17,533,553
2074	€0	€8,064,053	€5,356,174	€26,297,440	€17,466,857
2075	€0	€8,090,842	€5,335,529	€26,384,800	€17,399,532
2076	€0	€8,117,950	€5,315,114	€26,473,200	€17,332,958
2077	€0	€8,144,739	€5,294,511	€26,560,560	€17,265,770

2078	€0	€8,171,846	€5,274,137	€26,648,960	€17,199,327
2079	€0	€8,198,635	€5,253,579	€26,736,320	€17,132,286
2080	€0	€8,225,743	€5,233,247	€26,824,720	€17,065,985

Table 73: Present Value Analysis for the Entire Lido - Mestre Line Through 2080

Year	Construction Cost	Maintenance Cost	Present Value of Costs	Ticket Revenue	Present Value of Revenue
2017	€0	€0	€0	€0	€0
2018	€3,075,000,000	€0	€3,053,005,585	€0	€0
2019	€0	€0	€0	€0	€0
2020	€0	€0	€0	€0	€0
2021	€0	€0	€0	€0	€0
2022	€0	€0	€0	€0	€0
2023	€0	€0	€0	€0	€0
2024	€0	€0	€0	€0	€0
2025	€0	€18,802,260	€17,752,924	€192,619,303	€181,869,401
2026	€0	€18,986,843	€17,798,978	€195,780,717	€183,532,180
2027	€0	€25,969,073	€24,170,255	€221,109,728	€205,793,966
2028	€0	€26,180,445	€24,192,697	€224,358,496	€207,324,098
2029	€0	€26,392,134	€24,213,873	€227,608,292	€208,822,756
2030	€0	€26,603,506	€24,233,219	€230,857,063	€210,288,435
2031	€0	€26,815,197	€24,251,337	€234,106,877	€211,723,406
2032	€0	€27,026,569	€24,267,671	€237,355,648	€213,126,155
2033	€0	€27,238,258	€24,282,813	€240,605,444	€214,498,919
2034	€0	€27,449,630	€24,296,216	€243,854,215	€215,840,234
2035	€0	€27,661,321	€24,308,465	€247,104,029	€217,152,304
2036	€0	€27,872,693	€24,319,018	€250,352,800	€218,433,652
2037	€0	€28,084,382	€24,328,450	€253,602,590	€219,686,443
2038	€0	€28,295,754	€24,336,231	€256,851,364	€220,909,264
2039	€0	€28,507,445	€24,342,928	€260,101,175	€222,104,238
2040	€0	€28,718,817	€24,348,015	€263,349,949	€223,269,936
2041	€0	€28,930,508	€24,352,051	€266,599,760	€224,408,468

2042	€0	€29,141,878	€24,354,516	€269,848,516	€225,518,410
2043	€0	€29,353,569	€24,355,966	€273,098,327	€226,601,867
2044	€0	€29,564,941	€24,355,886	€276,347,101	€227,657,434
2045	€0	€29,776,632	€24,354,823	€279,596,912	€228,687,156
2046	€0	€29,988,002	€24,352,268	€282,845,662	€229,689,638
2047	€0	€30,199,693	€24,348,762	€286,095,476	€230,666,938
2048	€0	€30,411,065	€24,343,805	€289,344,247	€231,617,671
2049	€0	€30,622,756	€24,337,927	€292,594,061	€232,543,831
2050	€0	€30,834,126	€24,330,635	€295,842,817	€233,444,058
2051	€0	€31,045,817	€24,322,453	€299,092,628	€234,320,337
2052	€0	€31,257,189	€24,312,895	€302,341,402	€235,171,330
2053	€0	€31,468,880	€24,302,475	€305,591,213	€235,998,963
2054	€0	€31,680,250	€24,290,716	€308,839,969	€236,801,915
2055	€0	€31,891,940	€24,278,124	€312,089,774	€237,582,106
2056	€0	€32,103,313	€24,264,230	€315,338,548	€238,338,242
2057	€0	€32,314,684	€24,249,292	€318,587,319	€239,071,404
2058	€0	€32,526,375	€24,233,564	€321,837,133	€239,782,661
2059	€0	€32,737,746	€24,216,584	€325,085,889	€240,470,730
2060	€0	€32,949,437	€24,198,842	€328,335,700	€241,137,464
2061	€0	€33,160,809	€24,179,882	€331,584,474	€241,781,600
2062	€0	€33,372,499	€24,160,186	€334,834,285	€242,404,937
2063	€0	€33,583,870	€24,139,305	€338,083,041	€243,006,228
2064	€0	€33,795,561	€24,117,715	€341,332,852	€243,587,269
2065	€0	€34,006,932	€24,094,972	€344,581,620	€244,146,827
2066	€0	€34,218,623	€24,071,546	€347,831,433	€244,686,653
2067	€0	€34,429,994	€24,046,999	€351,080,189	€245,205,528
2068	€0	€34,641,685	€24,021,793	€354,330,003	€245,705,195
2069	€0	€34,853,057	€23,995,498	€357,578,774	€246,184,452
2070	€0	€35,064,748	€23,968,568	€360,828,588	€246,644,995
2071	€0	€35,276,120	€23,940,579	€364,077,359	€247,085,648
2072	€0	€35,487,809	€23,911,979	€367,327,155	€247,508,069
2073	€0	€35,699,181	€23,882,350	€370,575,926	€247,911,120

2074	€0	€35,910,871	€23,852,133	€373,825,734	€248,296,432
2075	€0	€36,122,243	€23,820,917	€377,074,505	€248,662,864
2076	€0	€36,333,933	€23,789,135	€380,324,301	€249,012,023
2077	€0	€36,545,305	€23,756,382	€383,573,075	€249,342,801
2078	€0	€36,756,996	€23,723,087	€386,822,886	€249,656,777
2079	€0	€36,968,368	€23,688,849	€390,071,660	€249,952,840
2080	€0	€37,259,704	€23,704,759	€393,656,890	€250,445,950
Total			€3,598,922,946		€4,967,605,299

Table 74: Cumulative Cost of the P.le Roma - Mestre Extension With Interest

Year	Cumulative costs	Cumulative revenue	Overdraft	Interest
2017	€0	€0	€0	€0.00
2018	€1,702,000,000	€0	€1,702,000,000	€35,061,200
2019	€1,737,061,200	€0	€1,737,061,200	€35,783,461
2020	€1,772,844,661	€0	€1,772,844,661	€36,520,600
2021	€1,809,365,261	€0	€1,809,365,261	€37,272,924
2022	€1,846,638,185	€0	€1,846,638,185	€38,040,747
2023	€1,884,678,932	€0	€1,884,678,932	€38,824,386
2024	€1,923,503,318	€0	€1,923,503,318	€39,624,168
2025	€1,963,127,486	€0	€1,963,127,486	€40,440,426
2026	€2,003,567,912	€0	€2,003,567,912	€41,273,499
2027	€2,051,639,058	€22,167,600	€2,029,471,458	€41,807,112
2028	€2,100,270,606	€44,422,560	€2,055,848,046	€42,350,470
2029	€2,149,472,619	€66,765,920	€2,082,706,699	€42,903,758
2030	€2,199,254,709	€89,196,640	€2,110,058,069	€43,467,196
2031	€2,249,627,344	€111,715,760	€2,137,911,584	€44,040,979
2032	€2,300,600,552	€134,322,240	€2,166,278,312	€44,625,333
2033	€2,352,185,221	€157,017,120	€2,195,168,101	€45,220,463
2034	€2,404,391,809	€179,799,360	€2,224,592,449	€45,826,604
2035	€2,457,231,645	€202,670,000	€2,254,561,645	€46,443,970
2036	€2,510,715,637	€225,628,000	€2,285,087,637	€47,072,805

2037	€2,564,855,571	€248,674,400	€2,316,181,171	€47,713,332
2038	€2,619,662,821	€271,808,160	€2,347,854,661	€48,365,806
2039	€2,675,149,652	€295,030,320	€2,380,119,332	€49,030,458
2040	€2,731,327,924	€318,339,840	€2,412,988,084	€49,707,555
2041	€2,788,210,401	€341,737,760	€2,446,472,641	€50,397,336
2042	€2,845,809,448	€365,223,040	€2,480,586,408	€51,100,080
2043	€2,904,138,346	€388,796,720	€2,515,341,626	€51,816,037
2044	€2,963,209,990	€412,457,760	€2,550,752,230	€52,545,496
2045	€3,023,038,201	€436,207,200	€2,586,831,001	€53,288,719
2046	€3,083,636,423	€460,044,000	€2,623,592,423	€54,046,004
2047	€3,145,019,038	€483,969,200	€2,661,049,838	€54,817,627
2048	€3,207,200,064	€507,981,760	€2,699,218,304	€55,603,897
2049	€3,270,194,469	€532,082,720	€2,738,111,749	€56,405,102
2050	€3,334,016,867	€556,271,040	€2,777,745,827	€57,221,564
2051	€3,398,682,835	€580,547,760	€2,818,135,075	€58,053,583
2052	€3,464,207,610	€604,911,840	€2,859,295,770	€58,901,493
2053	€3,530,607,404	€629,364,320	€2,901,243,084	€59,765,608
2054	€3,597,898,100	€653,904,160	€2,943,993,940	€60,646,275
2055	€3,666,096,572	€678,532,400	€2,987,564,172	€61,543,822
2056	€3,735,219,380	€703,248,000	€3,031,971,380	€62,458,610
2057	€3,805,283,764	€728,050,960	€3,077,232,804	€63,390,996
2058	€3,876,307,642	€752,942,320	€3,123,365,322	€64,341,326
2059	€3,948,308,638	€777,921,040	€3,170,387,598	€65,309,985
2060	€4,021,305,401	€802,988,160	€3,218,317,241	€66,297,335
2061	€4,095,316,303	€828,142,640	€3,267,173,663	€67,303,777
2062	€4,170,360,756	€853,385,520	€3,316,975,236	€68,329,690
2063	€4,246,457,909	€878,715,760	€3,367,742,149	€69,375,488
2064	€4,323,627,969	€904,134,400	€3,419,493,569	€70,441,568
2065	€4,401,890,896	€929,640,400	€3,472,250,496	€71,528,360
2066	€4,481,267,724	€955,234,800	€3,526,032,924	€72,636,278
2067	€4,561,779,259	€980,916,560	€3,580,862,699	€73,765,772
2068	€4,643,447,394	€1,006,686,720	€3,636,760,674	€74,917,270

2069	€4,726,293,817	€1,032,544,240	€3,693,749,577	€76,091,241
2070	€4,810,341,319	€1,058,490,160	€3,751,851,159	€77,288,134
2071	€4,895,612,502	€1,084,523,440	€3,811,089,062	€78,508,435
2072	€4,982,131,093	€1,110,645,120	€3,871,485,973	€79,752,611
2073	€5,069,920,650	€1,136,854,160	€3,933,066,490	€81,021,170
2074	€5,159,005,873	€1,163,151,600	€3,995,854,273	€82,314,598
2075	€5,249,411,313	€1,189,536,400	€4,059,874,913	€83,633,423
2076	€5,341,162,686	€1,216,009,600	€4,125,153,086	€84,978,154
2077	€5,434,285,578	€1,242,570,160	€4,191,715,418	€86,349,338
2078	€5,528,806,762	€1,269,219,120	€4,259,587,642	€87,747,505
2079	€5,624,752,903	€1,295,955,440	€4,328,797,463	€89,173,228
2080	€5,722,151,873	€1,322,780,160	€4,399,371,713	€90,627,057

Table 75: Cumulative Cost of the Lido - Mestre Line With Interest

Year	Cumulative costs	Cumulative revenue	Overdraft	Interest
2017	€0	€0	€0	€0
2018	€3,075,000,000	€0	€3,075,000,000	€63,345,000
2019	€3,138,345,000	€0	€3,138,345,000	€64,649,907
2020	€3,202,994,907	€0	€3,202,994,907	€65,981,695
2021	€3,268,976,602	€0	€3,268,976,602	€67,340,918
2022	€3,336,317,520	€0	€3,336,317,520	€68,728,141
2023	€3,405,045,661	€0	€3,405,045,661	€70,143,941
2024	€3,475,189,602	€0	€3,475,189,602	€71,588,906
2025	€3,565,580,767	€192,619,303	€3,372,961,464	€69,483,006
2026	€3,654,050,617	€388,400,020	€3,265,650,597	€67,272,402
2027	€3,747,292,092	€609,509,748	€3,137,782,344	€64,638,316
2028	€3,838,110,854	€833,868,244	€3,004,242,610	€61,887,398
2029	€3,926,390,386	€1,061,476,536	€2,864,913,850	€59,017,225
2030	€4,012,011,117	€1,292,333,599	€2,719,677,518	€56,025,357
2031	€4,094,851,671	€1,526,440,476	€2,568,411,195	€52,909,271
2032	€4,174,787,510	€1,763,796,124	€2,410,991,386	€49,666,423

2033	€4,251,692,191	€2,004,401,568	€2,247,290,623	€46,294,187
2034	€4,325,436,008	€2,248,255,783	€2,077,180,225	€42,789,913
2035	€4,395,887,242	€2,495,359,812	€1,900,527,430	€39,150,865
2036	€4,462,910,800	€2,745,712,612	€1,717,198,188	€35,374,283
2037	€4,526,369,465	€2,999,315,202	€1,527,054,263	€31,457,318
2038	€4,586,122,537	€3,256,166,566	€1,329,955,971	€27,397,093
2039	€4,642,027,075	€3,516,267,741	€1,125,759,334	€23,190,642
2040	€4,693,936,534	€3,779,617,690	€914,318,844	€18,834,968
2041	€4,741,702,010	€4,046,217,450	€695,484,560	€14,326,982
2042	€4,785,170,870	€4,316,065,966	€469,104,904	€9,663,561
2043	€4,824,188,000	€4,589,164,293	€235,023,707	€4,841,488
2044	€4,858,594,429	€4,865,511,394	-€6,916,965	€0
2045	€4,888,371,061	€5,145,108,306	-€256,737,245	€0
2046	€4,918,359,062	€5,427,953,968	-€509,594,906	€0
2047	€4,948,558,755	€5,714,049,444	-€765,490,689	€0
2048	€4,978,969,820	€6,003,393,691	-€1,024,423,871	€0
2049	€5,009,592,575	€6,295,987,752	-€1,286,395,177	€0
2050	€5,040,426,701	€6,591,830,569	-€1,551,403,868	€0
2051	€5,071,472,518	€6,890,923,197	-€1,819,450,679	€0
2052	€5,102,729,707	€7,193,264,599	-€2,090,534,892	€0
2053	€5,134,198,587	€7,498,855,812	-€2,364,657,225	€0
2054	€5,165,878,837	€7,807,695,781	-€2,641,816,944	€0
2055	€5,197,770,777	€8,119,785,555	-€2,922,014,778	€0
2056	€5,229,874,090	€8,435,124,103	-€3,205,250,013	€0
2057	€5,262,188,774	€8,753,711,422	-€3,491,522,648	€0
2058	€5,294,715,150	€9,075,548,555	-€3,780,833,405	€0
2059	€5,327,452,896	€9,400,634,444	-€4,073,181,548	€0
2060	€5,360,402,332	€9,728,970,144	-€4,368,567,812	€0
2061	€5,393,563,141	€10,060,554,618	-€4,666,991,477	€0
2062	€5,426,935,640	€10,395,388,903	-€4,968,453,263	€0
2063	€5,460,519,510	€10,733,471,944	-€5,272,952,434	€0
2064	€5,494,315,071	€11,074,804,796	-€5,580,489,725	€0

2065	€5,528,322,003	€11,419,386,416	-€5,891,064,413	€0
2066	€5,562,540,627	€11,767,217,849	-€6,204,677,222	€0
2067	€5,596,970,621	€12,118,298,038	-€6,521,327,417	€0
2068	€5,631,612,306	€12,472,628,041	-€6,841,015,735	€0
2069	€5,666,465,363	€12,830,206,815	-€7,163,741,452	€0
2070	€5,701,530,111	€13,191,035,403	-€7,489,505,292	€0
2071	€5,736,806,230	€13,555,112,762	-€7,818,306,532	€0
2072	€5,772,294,040	€13,922,439,917	-€8,150,145,877	€0
2073	€5,807,993,220	€14,293,015,843	-€8,485,022,623	€0
2074	€5,843,904,092	€14,666,841,577	-€8,822,937,485	€0
2075	€5,880,026,335	€15,043,916,082	-€9,163,889,747	€0
2076	€5,916,360,268	€15,424,240,383	-€9,507,880,115	€0
2077	€5,952,905,573	€15,807,813,458	-€9,854,907,885	€0
2078	€5,989,662,568	€16,194,636,344	-€10,204,973,776	€0
2079	€6,026,630,936	€16,584,708,004	-€10,558,077,068	€0
2080	€6,063,890,640	€16,978,364,894	-€10,914,474,254	€0

Lido - Airport Line

Table 76: Train Departure and Arrival Times for Each Stop on the Lido - Airport Route

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Lido S.M.E.	0	0	0
San Marco / San Zaccaria	2510	3.1	3.4
Zattere / Giudecca Palanca	4040	5.9	6.1
Piazzale Roma	6543	9.3	9.6
Marco Polo Airport	13763	14.9	14.9

Station	Distance (m)	Arrival Time (minutes)	Departure Time (minutes)
Marco Polo Airport	0	0	0
Piazzale Roma	7220	5.3	5.6
Zattere / Giudecca Palanca	9723	8.7	9.0
San Marco / San Zaccaria	11253	11.5	11.7
Lido S.M.E.	13763	14.9	14.9

Table 77: Cost Calculations for the Extension to Airport Using the Comparison Method

	Track and Stations
Avg.	€1,421,157,349.46
Min.	€468,565,840.00
Max.	€2,573,861,977.82
Value to use	*€1,455,000,000.00*

Table 78: Cost Calculations for the Entire Lido - Airport Line Using the Comparison Method

	Track and Stations	Access Tunnels	*Total*
Avg.	€2,709,056,592.89	€53,637,863.95	*€2,762,694,456.84*
Min.	€893,195,520.21	€17,684,791.05	*€910,880,311.26*
Max.	€4,906,379,833.90	€97,143,682.68	*€5,003,523,516.58*
Value to use	*€2,773,000,000.00*	*€55,000,000.00*	***€2,828,000,000.00***

Table 79: Maintenance Cost per Passenger for the P.le Roma - Airport Extension

A	**Maintenance Cost/Car-Mile**	€11.68
B	**Passengers/Car**	100
C = A / B	**Maintenance Cost/Passenger-Mile**	€0.12
D	**Length of Railway (miles)**	4.486
E = C * D	**Maintenance Cost/Passenger-Trip**	€0.52

Table 80: Total Arrivals and Tourist Arrivals in Marco Polo Airport, 2007 - 2016

Year	Total Arrivals	Tourist Arrivals (estimated except for 2007)	% Tourist
2007	*7076114*	*2,484,000*	*35.10%*
2008	*6893644*		
2009	*6717600*		
2010	*6868968*		
2011	*8584651*		
2012	*8188455*		
2013	*8403790*		
2014	*8475188*		
2015	*8751028*		
2016	*9624748*		

Table 81: Projected Ridership of P.le Roma - Airport Extension, Based on Table 79

Resident Fare	€2.00							
Tourist Fare	€6.00							
% of Tourists Using System	50%							
Locals Using System	15%							
	A	**B**	**C = A * B**	**D = C * 50%**	**E = A - C**	**F = E * 30%**	**G = 0.52 * (E + F)**	**H = 6*D + 2*F**
Year	# of People Using Airport	% Tourists	# of Tourist Arrivals	**# of Tourists Using System**	**# of Local Arrivals**	**# of Locals Using System**	**Operating Cost**	**Total Revenue**
2018	9886185	35.10%	3470448	1735224	6415737	962361	€1,413,597	€12,336,066
2019	10182764	35.10%	3574559	1787280	6608205	991231	€1,456,004	€12,706,142
2020	10479344	35.10%	3678670	1839335	6800674	1020101	€1,498,410	€13,076,212
2021	10775923	35.10%	3782781	1891391	6993142	1048971	€1,540,818	€13,446,288
2022	11072502	35.10%	3886893	1943447	7185609	1077841	€1,583,225	€13,816,364
2023	11369082	35.10%	3991004	1995502	7378078	1106712	€1,625,632	€14,186,436
2024	11665661	35.10%	4095115	2047558	7570546	1135582	€1,668,039	€14,556,512

2025	11962241	35.10%	4199227	2099614	7763014	1164452	€1,710,446	€14,926,588
2026	12258820	35.10%	4303338	2151669	7955482	1193322	€1,752,852	€15,296,658
2027	12555400	35.10%	4407449	2203725	8147951	1222193	€1,795,260	€15,666,736
2028	12851979	35.10%	4511560	2255780	8340419	1251063	€1,837,667	€16,036,806
2029	13148558	35.10%	4615672	2307836	8532886	1279933	€1,880,074	€16,406,882
2030	13445138	35.10%	4719783	2359892	8725355	1308803	€1,922,481	€16,776,958
2031	13741717	35.10%	4823894	2411947	8917823	1337673	€1,964,887	€17,147,028
2032	14038297	35.10%	4928006	2464003	9110291	1366544	€2,007,295	€17,517,106
2033	14334876	35.10%	5032117	2516059	9302759	1395414	€2,049,702	€17,887,182
2034	14631456	35.10%	5136228	2568114	9495228	1424284	€2,092,109	€18,257,252
2035	14928035	35.10%	5240339	2620170	9687696	1453154	€2,134,516	€18,627,328
2036	15224614	35.10%	5344451	2672226	9880163	1482024	€2,176,923	€18,997,404
2037	15521194	35.10%	5448562	2724281	10072632	1510895	€2,219,330	€19,367,476
2038	15817773	35.10%	5552673	2776337	10265100	1539765	€2,261,737	€19,737,552
2039	16114353	35.10%	5656785	2828393	10457568	1568635	€2,304,144	€20,107,628
2040	16410932	35.10%	5760896	2880448	10650036	1597505	€2,346,551	€20,477,698
2041	16707511	35.10%	5865007	2932504	10842504	1626376	€2,388,958	€20,847,776
2042	17004091	35.10%	5969118	2984559	11034973	1655246	€2,431,365	€21,217,846
2043	17300670	35.10%	6073229	3036615	11227441	1684116	€2,473,772	€21,587,922
2044	17597250	35.10%	6177341	3088671	11419909	1712986	€2,516,179	€21,957,998
2045	17893829	35.10%	6281452	3140726	11612377	1741857	€2,558,586	€22,328,070
2046	18190409	35.10%	6385564	3192782	11804845	1770727	€2,600,993	€22,698,146
2047	18486988	35.10%	6489675	3244838	11997313	1799597	€2,643,400	€23,068,222
2048	18783567	35.10%	6593786	3296893	12189781	1828467	€2,685,807	€23,438,292
2049	19080147	35.10%	6697897	3348949	12382250	1857338	€2,728,214	€23,808,370
2050	19376726	35.10%	6802008	3401004	12574718	1886208	€2,770,621	€24,178,440
2051	19673306	35.10%	6906120	3453060	12767186	1915078	€2,813,028	€24,548,516
2052	19969885	35.10%	7010231	3505116	12959654	1943948	€2,855,435	€24,918,592
2053	20266464	35.10%	7114342	3557171	13152122	1972818	€2,897,842	€25,288,662
2054	20563044	35.10%	7218454	3609227	13344590	2001689	€2,940,249	€25,658,740
2055	20859623	35.10%	7322565	3661283	13537058	2030559	€2,982,656	€26,028,816
2056	21156203	35.10%	7426676	3713338	13729527	2059429	€3,025,063	€26,398,886

2057	21452782	35.10%	7530787	3765394	13921995	2088299	€3,067,470	€26,768,962
2058	21749362	35.10%	7634899	3817450	14114463	2117169	€3,109,877	€27,139,038
2059	22045941	35.10%	7739010	3869505	14306931	2146040	€3,152,284	€27,509,110
2060	22342520	35.10%	7843121	3921561	14499399	2174910	€3,194,691	€27,879,186
2061	22639100	35.10%	7947233	3973617	14691867	2203780	€3,237,099	€28,249,262
2062	22935679	35.10%	8051344	4025672	14884335	2232650	€3,279,505	€28,619,332
2063	23232259	35.10%	8155455	4077728	15076804	2261521	€3,321,913	€28,989,410
2064	23528838	35.10%	8259566	4129783	15269272	2290391	€3,364,319	€29,359,480
2065	23825417	35.10%	8363678	4181839	15461739	2319261	€3,406,726	€29,729,556
2066	24121997	35.10%	8467789	4233895	15654208	2348131	€3,449,133	€30,099,632
2067	24418576	35.10%	8571900	4285950	15846676	2377001	€3,491,540	€30,469,702
2068	24715156	35.10%	8676012	4338006	16039144	2405872	€3,533,948	€30,839,780
2069	25011735	35.10%	8780123	4390062	16231612	2434742	€3,576,355	€31,209,856
2070	25308315	35.10%	8884234	4442117	16424081	2463612	€3,618,761	€31,579,926
2071	25604894	35.10%	8988345	4494173	16616549	2492482	€3,661,168	€31,950,002
2072	25901473	35.10%	9092457	4546229	16809016	2521352	€3,703,575	€32,320,078
2073	26198053	35.10%	9196568	4598284	17001485	2550223	€3,745,983	€32,690,150
2074	26494632	35.10%	9300679	4650340	17193953	2579093	€3,788,390	€33,060,226
2075	26791212	35.10%	9404791	4702396	17386421	2607963	€3,830,797	€33,430,302
2076	27087791	35.10%	9508902	4754451	17578889	2636833	€3,873,203	€33,800,372
2077	27384370	35.10%	9613013	4806507	17771357	2665704	€3,915,611	€34,170,450
2078	27680950	35.10%	9717124	4858562	17963826	2694574	€3,958,017	€34,540,520
2079	27977529	35.10%	9821236	4910618	18156293	2723444	€4,000,425	€34,910,596
2080	28274109	35.10%	9925347	4962674	18348762	2752314	€4,042,832	€35,280,672

Table 82: Present Value Analysis for the P.le Roma -Airport Extension Through 2080

Average Interest Rate	2.06%
Inflation Rate	1.33%
Adjusted Interest Rate	0.72%
Km constructed / year	0.98
Total # of Years to Construct	8

Table 83: Present Value Analysis for the P.le Roma -Airport Extension Through 2080

Year	Construction Cost	Maintenance Cost	Present Value of Costs	Ticket Revenue	Present Value of Revenue
2017	€0	€0	€0	€0	€0
2018	€1,455,000,000	€0	€1,444,592,887	€0	€0
2019	€0	€0	€0	€0	€0
2020	€0	€0	€0	€0	€0
2021	€0	€0	€0	€0	€0
2022	€0	€0	€0	€0	€0
2023	€0	€0	€0	€0	€0
2024	€0	€0	€0	€0	€0
2025	€0	€0	€0	€0	€0
2026	€0	€1,752,852	€1,643,190	€15,296,658	€14,339,660
2027	€0	€1,795,260	€1,670,907	€15,666,736	€14,581,537
2028	€0	€1,837,667	€1,698,142	€16,036,806	€14,819,213
2029	€0	€1,880,074	€1,724,903	€16,406,882	€15,052,748
2030	€0	€1,922,481	€1,751,194	€16,776,958	€15,282,185
2031	€0	€1,964,887	€1,777,020	€17,147,028	€15,507,563
2032	€0	€2,007,295	€1,802,388	€17,517,106	€15,728,943
2033	€0	€2,049,702	€1,827,302	€17,887,182	€15,946,361
2034	€0	€2,092,109	€1,851,767	€18,257,252	€16,159,858
2035	€0	€2,134,516	€1,875,789	€18,627,328	€16,369,491
2036	€0	€2,176,923	€1,899,372	€18,997,404	€16,575,298
2037	€0	€2,219,330	€1,922,523	€19,367,476	€16,777,320

2038	€0	€2,261,737	€1,945,244	€19,737,552	€16,975,608
2039	€0	€2,304,144	€1,967,543	€20,107,628	€17,170,201
2040	€0	€2,346,551	€1,989,422	€20,477,698	€17,361,136
2041	€0	€2,388,958	€2,010,889	€20,847,776	€17,548,468
2042	€0	€2,431,365	€2,031,946	€21,217,846	€17,732,226
2043	€0	€2,473,772	€2,052,599	€21,587,922	€17,912,462
2044	€0	€2,516,179	€2,072,853	€21,957,998	€18,089,213
2045	€0	€2,558,586	€2,092,712	€22,328,070	€18,262,515
2046	€0	€2,600,993	€2,112,181	€22,698,146	€18,432,416
2047	€0	€2,643,400	€2,131,264	€23,068,222	€18,598,952
2048	€0	€2,685,807	€2,149,966	€23,438,292	€18,762,158
2049	€0	€2,728,214	€2,168,292	€23,808,370	€18,922,085
2050	€0	€2,770,621	€2,186,245	€24,178,440	€19,078,757
2051	€0	€2,813,028	€2,203,831	€24,548,516	€19,232,224
2052	€0	€2,855,435	€2,221,054	€24,918,592	€19,382,521
2053	€0	€2,897,842	€2,237,917	€25,288,662	€19,529,678
2054	€0	€2,940,249	€2,254,425	€25,658,740	€19,673,745
2055	€0	€2,982,656	€2,270,583	€26,028,816	€19,814,750
2056	€0	€3,025,063	€2,286,394	€26,398,886	€19,952,727
2057	€0	€3,067,470	€2,301,863	€26,768,962	€20,087,721
2058	€0	€3,109,877	€2,316,994	€27,139,038	€20,219,764
2059	€0	€3,152,284	€2,331,790	€27,509,110	€20,348,886
2060	€0	€3,194,691	€2,346,257	€27,879,186	€20,475,130
2061	€0	€3,237,099	€2,360,397	€28,249,262	€20,598,527
2062	€0	€3,279,505	€2,374,214	€28,619,332	€20,719,107
2063	€0	€3,321,913	€2,387,714	€28,989,410	€20,836,914
2064	€0	€3,364,319	€2,400,898	€29,359,480	€20,951,970
2065	€0	€3,406,726	€2,413,772	€29,729,556	€21,064,318
2066	€0	€3,449,133	€2,426,339	€30,099,632	€21,173,987
2067	€0	€3,491,540	€2,438,602	€30,469,702	€21,281,005
2068	€0	€3,533,948	€2,450,567	€30,839,780	€21,385,415
2069	€0	€3,576,355	€2,462,235	€31,209,856	€21,487,241

2070	€0	€3,618,761	€2,473,610	€31,579,926	€21,586,512
2071	€0	€3,661,168	€2,484,698	€31,950,002	€21,683,268
2072	€0	€3,703,575	€2,495,500	€32,320,078	€21,777,535
2073	€0	€3,745,983	€2,506,020	€32,690,150	€21,869,342
2074	€0	€3,788,390	€2,516,262	€33,060,226	€21,958,724
2075	€0	€3,830,797	€2,526,230	€33,430,302	€22,045,709
2076	€0	€3,873,203	€2,535,926	€33,800,372	€22,130,321
2077	€0	€3,915,611	€2,545,354	€34,170,450	€22,212,601
2078	€0	€3,958,017	€2,554,518	€34,540,520	€22,292,566
2079	€0	€4,000,425	€2,563,420	€34,910,596	€22,370,255
2080	€0	€4,042,832	€2,572,064	€35,280,672	€22,445,692
Total			€1,565,207,986		€1,052,574,533

Table 84: Present Value Analysis for the Entire Lido - Airport Line Through 2080

Year	Construction Cost	Maintenance Cost	Present Value of Costs	Ticket Revenue	Present Value of Revenue
2017	€0	€0	€0	€0	€0
2018	€2,828,000,000	€0	€2,807,772,291	€0	€0
2019	€0	€0	€0	€0	€0
2020	€0	€0	€0	€0	€0
2021	€0	€0	€0	€0	€0
2022	€0	€0	€0	€0	€0
2023	€0	€0	€0	€0	€0
2024	€0	€0	€0	€0	€0
2025	€0	€13,655,241	€12,893,155	€108,504,922	€102,449,364
2026	€0	€16,013,594	€15,011,743	€127,119,142	€119,166,247
2027	€0	€16,051,301	€14,939,464	€128,477,874	€119,578,507
2028	€0	€16,089,008	€14,867,452	€129,836,596	€119,978,765
2029	€0	€16,126,715	€14,795,705	€131,195,328	€120,367,188
2030	€0	€16,164,423	€14,724,224	€132,554,062	€120,743,918
2031	€0	€16,202,130	€14,653,009	€133,912,788	€121,109,093
2032	€0	€16,239,837	€14,582,059	€135,271,520	€121,462,873

2033	€0	€16,277,544	€14,511,374	€136,630,254	€121,805,398
2034	€0	€16,315,251	€14,440,955	€137,988,980	€122,136,801
2035	€0	€16,352,959	€14,370,801	€139,347,714	€122,457,239
2036	€0	€16,390,666	€14,300,911	€140,706,446	€122,766,843
2037	€0	€16,428,373	€14,231,285	€142,065,168	€123,065,744
2038	€0	€16,466,080	€14,161,925	€143,423,900	€123,354,097
2039	€0	€16,503,787	€14,092,828	€144,782,632	€123,632,029
2040	€0	€16,541,495	€14,023,995	€146,141,360	€123,899,671
2041	€0	€16,579,202	€13,955,426	€147,500,092	€124,157,163
2042	€0	€16,616,909	€13,887,121	€148,858,820	€124,404,628
2043	€0	€16,654,616	€13,819,078	€150,217,552	€124,642,206
2044	€0	€16,692,324	€13,751,299	€151,576,286	€124,870,021
2045	€0	€16,730,031	€13,683,782	€152,935,012	€125,088,194
2046	€0	€16,767,738	€13,616,527	€154,293,740	€125,296,860
2047	€0	€16,805,445	€13,549,535	€155,652,472	€125,496,144
2048	€0	€16,843,152	€13,482,803	€157,011,198	€125,686,162
2049	€0	€16,880,859	€13,416,334	€158,369,932	€125,867,048
2050	€0	€16,918,566	€13,350,126	€159,728,658	€126,038,910
2051	€0	€16,956,274	€13,284,178	€161,087,392	€126,201,880
2052	€0	€16,993,981	€13,218,491	€162,446,124	€126,356,069
2053	€0	€17,031,688	€13,153,064	€163,804,852	€126,501,593
2054	€0	€17,069,396	€13,087,896	€165,163,584	€126,638,573
2055	€0	€17,107,102	€13,022,988	€166,522,310	€126,767,118
2056	€0	€17,144,809	€12,958,339	€167,881,038	€126,887,346
2057	€0	€17,182,517	€12,893,949	€169,239,772	€126,999,373
2058	€0	€17,220,224	€12,829,816	€170,598,504	€127,103,305
2059	€0	€17,257,931	€12,765,941	€171,957,230	€127,199,248
2060	€0	€17,295,639	€12,702,324	€173,315,964	€127,287,322
2061	€0	€17,333,346	€12,638,964	€174,674,696	€127,367,627
2062	€0	€17,371,053	€12,575,860	€176,033,424	€127,440,268
2063	€0	€17,408,760	€12,513,012	€177,392,156	€127,505,357
2064	€0	€17,446,468	€12,450,420	€178,750,884	€127,562,991

2065	€0	€17,484,174	€12,388,083	€180,109,610	€127,613,277
2066	€0	€17,521,882	€12,326,001	€181,468,342	€127,656,321
2067	€0	€17,559,589	€12,264,173	€182,827,070	€127,692,218
2068	€0	€17,597,296	€12,202,599	€184,185,802	€127,721,074
2069	€0	€17,635,004	€12,141,279	€185,544,536	€127,742,985
2070	€0	€17,672,710	€12,080,211	€186,903,262	€127,758,043
2071	€0	€17,710,418	€12,019,397	€188,261,996	€127,766,355
2072	€0	€17,748,125	€11,958,833	€189,620,728	€127,768,011
2073	€0	€17,785,833	€11,898,522	€190,979,456	€127,763,105
2074	€0	€17,823,539	€11,838,461	€192,338,182	€127,751,730
2075	€0	€17,861,247	€11,778,650	€193,696,914	€127,733,986
2076	€0	€17,898,954	€11,719,090	€195,055,642	€127,709,957
2077	€0	€17,936,661	€11,659,779	€196,414,374	€127,679,739
2078	€0	€17,974,368	€11,600,717	€197,773,102	€127,643,417
2079	€0	€18,012,075	€11,541,903	€199,131,834	€127,601,086
2080	€0	€18,163,253	€11,555,528	€200,968,448	€127,856,860
Total			€3,134,635,942		€2,801,928,994

Table 85: Cumulative Cost of the P.le Roma -Airport Extension With Interest

Year	Cumulative costs	Cumulative revenue	Overdraft	Interest
2017	€0	€0	€0	€0
2018	€1,455,000,000	€0	€1,455,000,000	€29,973,000
2019	€1,484,973,000	€0	€1,484,973,000	€30,590,444
2020	€1,515,563,444	€0	€1,515,563,444	€31,220,607
2021	€1,546,784,051	€0	€1,546,784,051	€31,863,751
2022	€1,578,647,802	€0	€1,578,647,802	€32,520,145
2023	€1,611,167,947	€0	€1,611,167,947	€33,190,060
2024	€1,644,358,007	€0	€1,644,358,007	€33,873,775
2025	€1,678,231,782	€0	€1,678,231,782	€34,571,575
2026	€1,715,181,537	€17,683,304	€1,697,498,233	€34,968,464
2027	€1,752,585,718	€35,794,424	€1,716,791,294	€35,365,901

2028	€1,790,444,871	€54,333,356	€1,736,111,515	€35,763,897
2029	€1,828,759,556	€73,300,104	€1,755,459,452	€36,162,465
2030	€1,867,530,345	€92,694,670	€1,774,835,675	€36,561,615
2031	€1,906,757,820	€112,517,046	€1,794,240,774	€36,961,360
2032	€1,946,442,575	€132,767,238	€1,813,675,337	€37,361,712
2033	€1,986,585,218	€153,445,248	€1,833,139,970	€37,762,683
2034	€2,027,186,368	€174,551,068	€1,852,635,300	€38,164,287
2035	€2,068,246,657	€196,084,706	€1,872,161,951	€38,566,536
2036	€2,109,766,731	€218,046,160	€1,891,720,571	€38,969,444
2037	€2,151,747,249	€240,435,426	€1,911,311,823	€39,373,024
2038	€2,194,188,882	€263,252,508	€1,930,936,374	€39,777,289
2039	€2,237,092,316	€286,497,406	€1,950,594,910	€40,182,255
2040	€2,280,458,252	€310,170,116	€1,970,288,136	€40,587,936
2041	€2,324,287,404	€334,270,642	€1,990,016,762	€40,994,345
2042	€2,368,580,501	€358,798,980	€2,009,781,521	€41,401,499
2043	€2,413,338,288	€383,755,134	€2,029,583,154	€41,809,413
2044	€2,458,561,525	€409,139,106	€2,049,422,419	€42,218,102
2045	€2,504,250,985	€434,950,888	€2,069,300,097	€42,627,582
2046	€2,550,407,462	€461,190,488	€2,089,216,974	€43,037,870
2047	€2,597,031,763	€487,857,904	€2,109,173,859	€43,448,981
2048	€2,644,124,710	€514,953,130	€2,129,171,580	€43,860,935
2049	€2,691,687,146	€542,476,174	€2,149,210,972	€44,273,746
2050	€2,739,719,929	€570,427,028	€2,169,292,901	€44,687,434
2051	€2,788,223,936	€598,805,700	€2,189,418,236	€45,102,016
2052	€2,837,200,061	€627,612,188	€2,209,587,873	€45,517,510
2053	€2,886,649,215	€656,846,488	€2,229,802,727	€45,933,936
2054	€2,936,572,332	€686,508,604	€2,250,063,728	€46,351,313
2055	€2,986,970,360	€716,598,536	€2,270,371,824	€46,769,660
2056	€3,037,844,271	€747,116,280	€2,290,727,991	€47,188,997
2057	€3,089,195,055	€778,061,842	€2,311,133,213	€47,609,344
2058	€3,141,023,723	€809,435,220	€2,331,588,503	€48,030,723
2059	€3,193,331,304	€841,236,408	€2,352,094,896	€48,453,155

2060	€3,246,118,853	€873,465,414	€2,372,653,439	€48,876,661
2061	€3,299,387,444	€906,122,236	€2,393,265,208	€49,301,263
2062	€3,353,138,173	€939,206,870	€2,413,931,303	€49,726,985
2063	€3,407,372,159	€972,719,320	€2,434,652,839	€50,153,848
2064	€3,462,090,545	€1,006,659,582	€2,455,430,963	€50,581,878
2065	€3,517,294,495	€1,041,027,660	€2,476,266,835	€51,011,097
2066	€3,572,985,200	€1,075,823,554	€2,497,161,646	€51,441,530
2067	€3,629,163,874	€1,111,047,260	€2,518,116,614	€51,873,202
2068	€3,685,831,756	€1,146,698,782	€2,539,132,974	€52,306,139
2069	€3,742,990,111	€1,182,778,122	€2,560,211,989	€52,740,367
2070	€3,800,640,229	€1,219,285,272	€2,581,354,957	€53,175,912
2071	€3,858,783,428	€1,256,220,240	€2,602,563,188	€53,612,802
2072	€3,917,421,052	€1,293,583,024	€2,623,838,028	€54,051,063
2073	€3,976,554,474	€1,331,373,620	€2,645,180,854	€54,490,726
2074	€4,036,185,093	€1,369,592,032	€2,666,593,061	€54,931,817
2075	€4,096,314,340	€1,408,238,260	€2,688,076,080	€55,374,367
2076	€4,156,943,672	€1,447,312,300	€2,709,631,372	€55,818,406
2077	€4,218,074,579	€1,486,814,156	€2,731,260,423	€56,263,965
2078	€4,279,708,580	€1,526,743,824	€2,752,964,756	€56,711,074
2079	€4,341,847,226	€1,567,101,308	€2,774,745,918	€57,159,766
2080	€4,404,492,100	€1,607,886,610	€2,796,605,490	€57,610,073

Table 86: Cumulative Cost of the Lido - Airport Line With Interest

Year	Cumulative costs	Cumulative revenue	Overdraft	Interest
2017	€0	€0	€0	€0
2018	€2,828,000,000	€0	€2,828,000,000	€58,256,800
2019	€2,886,256,800	€0	€2,886,256,800	€59,456,890
2020	€2,945,713,690	€0	€2,945,713,690	€60,681,702
2021	€3,006,395,392	€0	€3,006,395,392	€61,931,745
2022	€3,068,327,137	€0	€3,068,327,137	€63,207,539
2023	€3,131,534,676	€0	€3,131,534,676	€64,509,614

2024	€3,196,044,291	€0	€3,196,044,291	€65,838,512
2025	€3,275,538,044	€108,504,922	€3,167,033,122	€65,240,882
2026	€3,356,792,520	€235,624,064	€3,121,168,456	€64,296,070
2027	€3,437,139,892	€364,101,938	€3,073,037,954	€63,304,582
2028	€3,516,533,482	€493,938,534	€3,022,594,948	€62,265,456
2029	€3,594,925,653	€625,133,862	€2,969,791,791	€61,177,711
2030	€3,672,267,786	€757,687,924	€2,914,579,862	€60,040,345
2031	€3,748,510,261	€891,600,712	€2,856,909,549	€58,852,337
2032	€3,823,602,434	€1,026,872,232	€2,796,730,202	€57,612,642
2033	€3,897,492,621	€1,163,502,486	€2,733,990,135	€56,320,197
2034	€3,970,128,069	€1,301,491,466	€2,668,636,603	€54,973,914
2035	€4,041,454,942	€1,440,839,180	€2,600,615,762	€53,572,685
2036	€4,111,418,293	€1,581,545,626	€2,529,872,667	€52,115,377
2037	€4,179,962,043	€1,723,610,794	€2,456,351,249	€50,600,836
2038	€4,247,028,959	€1,867,034,694	€2,379,994,265	€49,027,882
2039	€4,312,560,628	€2,011,817,326	€2,300,743,302	€47,395,312
2040	€4,376,497,434	€2,157,958,686	€2,218,538,748	€45,701,898
2041	€4,438,778,534	€2,305,458,778	€2,133,319,756	€43,946,387
2042	€4,499,341,830	€2,454,317,598	€2,045,024,232	€42,127,499
2043	€4,558,123,945	€2,604,535,150	€1,953,588,795	€40,243,929
2044	€4,615,060,198	€2,756,111,436	€1,858,948,762	€38,294,345
2045	€4,670,084,573	€2,909,046,448	€1,761,038,125	€36,277,385
2046	€4,723,129,697	€3,063,340,188	€1,659,789,509	€34,191,664
2047	€4,774,126,806	€3,218,992,660	€1,555,134,146	€32,035,763
2048	€4,823,005,721	€3,376,003,858	€1,447,001,863	€29,808,238
2049	€4,869,694,819	€3,534,373,790	€1,335,321,029	€27,507,613
2050	€4,914,120,998	€3,694,102,448	€1,220,018,550	€25,132,382
2051	€4,956,209,654	€3,855,189,840	€1,101,019,814	€22,681,008
2052	€4,995,884,643	€4,017,635,964	€978,248,679	€20,151,923
2053	€5,033,068,254	€4,181,440,816	€851,627,438	€17,543,525
2054	€5,067,681,175	€4,346,604,400	€721,076,775	€14,854,182
2055	€5,099,642,459	€4,513,126,710	€586,515,749	€12,082,224
2056	€5,128,869,493	€4,681,007,748	€447,861,745	€9,225,952

2057	€5,155,277,962	€4,850,247,520	€305,030,442	€6,283,627
2058	€5,178,781,813	€5,020,846,024	€157,935,789	€3,253,477
2059	€5,199,293,222	€5,192,803,254	€6,489,968	€133,693
2060	€5,216,722,554	€5,366,119,218	-€149,396,664	€0
2061	€5,234,055,900	€5,540,793,914	-€306,738,014	€0
2062	€5,251,426,953	€5,716,827,338	-€465,400,385	€0
2063	€5,268,835,714	€5,894,219,494	-€625,383,780	€0
2064	€5,286,282,181	€6,072,970,378	-€786,688,197	€0
2065	€5,303,766,356	€6,253,079,988	-€949,313,632	€0
2066	€5,321,288,237	€6,434,548,330	-€1,113,260,093	€0
2067	€5,338,847,826	€6,617,375,400	-€1,278,527,574	€0
2068	€5,356,445,122	€6,801,561,202	-€1,445,116,080	€0
2069	€5,374,080,126	€6,987,105,738	-€1,613,025,612	€0
2070	€5,391,752,837	€7,174,009,000	-€1,782,256,163	€0
2071	€5,409,463,255	€7,362,270,996	-€1,952,807,741	€0
2072	€5,427,211,380	€7,551,891,724	-€2,124,680,344	€0
2073	€5,444,997,213	€7,742,871,180	-€2,297,873,967	€0
2074	€5,462,820,752	€7,935,209,362	-€2,472,388,610	€0
2075	€5,480,681,999	€8,128,906,276	-€2,648,224,277	€0
2076	€5,498,580,953	€8,323,961,918	-€2,825,380,965	€0
2077	€5,516,517,614	€8,520,376,292	-€3,003,858,678	€0
2078	€5,534,491,982	€8,718,149,394	-€3,183,657,412	€0
2079	€5,552,504,057	€8,917,281,228	-€3,364,777,171	€0
2080	€5,570,667,310	€9,118,249,676	-€3,547,582,366	€0