Universitat de Girona

FINAL DEGREE PROJECT

PLAN OF IMPLEMENTATION OF A TRAM SYSTEM IN THE URBAN AREA OF GIRONA

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Degree: ACCOUNTING AND FINANCE, ACCOUNTING AND AUDITING SPECIALISATION

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CALL: ABRIL 2022

SUMMARY

PLAN OF IMPLEMENTATION OF A TRAM SYSTEM IN THE URBAN AREA OF GIRONA

This Final Degree Project presents a preliminary study on the implementation of a tram system in the urban area of Girona. Specifically, it is proposed to improve the quality the current public transport as well as to decongest the traffic of urban centres and connect the municipalities of Salt and Vilablareix with the urban nucleus of the city of Girona in an efficient way.

This work analyses the historical evolution of the tram and the current tram networks in Spain, Catalonia and Europe in order to collect data and develop a competitive solution for a tram system in the urban area of Girona.

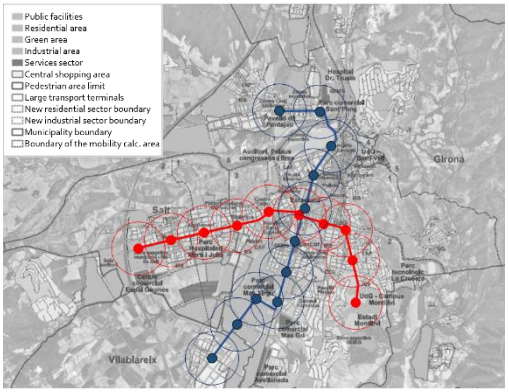
Consequently, a preliminary study of the tram is carried out and relevant comparisons are carried out with other transport systems. As a result, it is concluded that the tram allows to reduce CO2 emissions from 183 g/vkm (traveller per kilometre) to 26.4 g/vkm.

A mobility study is then presented. Firstly, the current transport system is described, including: private transport, which represents 30% of the total; the public transport, which represents 5% and non-motorised tranaport, which assumes the most demand among the population - at 65%. Secondly, a population distribution is calculated, population growth is adjusted and a demand model is drawn up. The latter depends heavily on the socioeconomic conditions and the location of municipal facilities, commercial areas and the areas of heritage interest because they are determinants of the direction of travel for personal or work reasons.

This feasibility study proposes the construction of two tram lines:

L1: Espai Gironès - Salt – Girona -UdG Montilivi

L2: Vilablareix - Eixample - Correus - Fontajau



It is estimated in the first year of operation that total demand for the most likely (optimistic) scenario will be about 8.5M users and that it would end up consolidating about 12-15M passengers per year.

The implementation proposal is accompanied by a comparative table, which includes the width of the tracks between stop points and the parameters of the stopping points (the platforms, the length of the curb, the possibility of installing a bike lane) as well as the number of lanes available to road traffic with the width corresponding to each lane.

Finally, an economic-financial analysis is carried out, which determines the feasibility of the project, (NPV = € 15,522,740.59 and IRR = 5.45%) and provides, as a synthesis, a management plan and the delivery of the system.

Keywords: Girona, tram, public transport, congestion, economic and financial analysis, sustainability, route parameters.

RESUM

PLA D'IMPLEMENTACIÓ D'UN SISTEMA TRAMVIARI A L'ÀREA URBANA DE GIRONA

En aquest Treball Final de Grau s'aborda un estudi preliminar sobre la implantació d'un sistema tramviari a l'àrea urbana de Girona. Concretament, es proposa corregir el dèficit de qualitat del transport públic actual a més de descongestionar el trànsit dels nuclis urbans i connectar els municipis de Salt i Vilablareix amb el nucli urbà de la ciutat de Girona, d'un mode eficient.

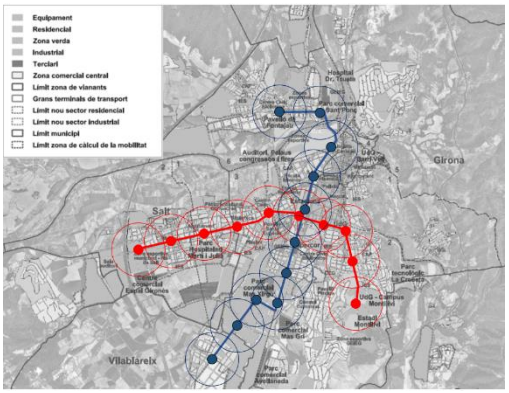
S'analitza sumàriament l'evolució històrica del tramvia i la xarxa actual de tramvies a Espanya, Catalunya i Europa amb la finalitat de recopilar dades i desenvolupar una solució capdavantera per al tramvia de l'àrea urbana de Girona.

Consegüentment, es realitza un estudi preliminar del tramvia i es duen a terme les comparacions pertinents amb els altres sistemes de transport, resultant d'aquest, s'obté que el tramvia permet reduir les emissions de CO^2 de 183 g/vkm (viatger per quilòmetre) a 26,4 g/vkm.

A continuació es procedeix a generar l'estudi de mobilitat, en primer lloc, es descriu el sistema de transport actual, entre els quals s'inclou el transport privat, que representa el 30% del total, el transport públic, que representa el 5% i el no motoritzat, que assumeix la demanda més entre la població, un 65%. En segon lloc, s'elabora una distribució de població, s'ajusta un creixement poblacional i s'elabora un model de demanda. Aquest últim, en funció de l'anàlisi socioeconòmica i la ubicació dels equipaments municipals, zones comercials i zones d'interès patrimonial, ja que són determinants de la direcció dels desplaçaments per motius personals o laborals.

Aquest estudi de viabilitat proposa la construcció de dues línies de tramvia:

- L1: Espai Gironès - Salt – Girona -UdG Montilivi
- L2: Vilablareix - Eixample - Correus - Fontajau.



S'estima que la demanda total per a l'escenari més probable (optimista) sigui el primer any d'explotació d'uns 8'5M d'usuaris i que s'acabaria consolidant amb uns 12-15M de passatgers anuals.

La proposta d'implementació ve acompanyada d'un d'una taula de comptabilitat, que inclou l'amplada de les plataformes entre punts de parades i en punt de parada, de l'andana, la longitud de la voravia, la possibilitat d'instal·lació de carril bici i el nombre de carrils disponibles per al tràfic rodat amb l'amplada corresponent a cada carril.

Per últim es dur a terme l'anàlisi economicofinancera, que determinarà la viabilitat del projecte, (VAN = 15.522.740,59 € i TIR = 5,45%) i s'aborda, a tall de síntesi, el pla de gestió i el fiançament del sistema.

Paraules Clau: Girona, tramvia, transport públic, congestió, anàlisi economicofinancer, sostenibilitat, paràmetres de traçat.

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BLOCK I: GENERALITIES

1. INTRODUCTION AND OBJECTIVES

1.1. INTRODUCTION

Catalonia and especially the province of Girona has experienced remarkable growth in the recent years, a development that has not been accompanied by a good regional transportation network, limiting the country's growth capacity and creating territorial imbalances.

The Urban Area of Girona, a population entity that comprises the municipalities adjacent to the city of Girona, located in the northeast of Catalonia, is becoming a powerful regional economy formed by the large urban center of Girona and an industrial-residential environment of considerable magnitude, creating a balanced economic ecosystem.

The area is equipped with good communication infrastructures: airport, high-speed line, regional train services, motorways and highways. Despite the strong investment in the public facilities, Girona's mobility is characterised by the excessive use of private vehicles. One of the main reasons is the poor interconnection between the means of transport themselves and also with the different destinations of potential users.

Within the urban area, the inefficiency of public transport increases considerably as a result of inconsistent routes and constant delays on virtually all lines, encouraging the use of private vehicles that ends up producing strong congestion along the main arteries of the city at peak times and on rainy days, for example.

Cities are currently polluting sources and should be subject to innovation and investment as much as possible to create what is known as "sustainable cities", the cities of the future. The excessively high use of private vehicles also causes a problem with the supply of parking.

Girona City Council and ATM Àrea de Girona (Girona's Municipal Transportation Authority) have taken different measures to alleviate the situation:

- Extension of the network of bike lanes, together with the opening of the new Girocleta (Girona's public bike rental scheme) stations.
- Reorganisation and expansion of the bus network (e.g. line L12).

Despite the application of these measures, the real effect has been minimal and the situation has improved much. Consequently, from my point of view, a new comprehensive concept of mobility is needed.

As a result of this situation, an initiative arises to implement a tram system, since the technological advancement in this field of transport allow for an optimal solution to current problems.

Currently, a public transport system that includes a tram system is in place in many cities in the European Union, United Kingdom and the United States with excellent results.

At first one might think that with a population census of 100,000 inhabitants, a tram is unnecessary/inefficient; however, the strong population growth expected for the coming years, and the urban layout of the municipalities adjacent to Girona suggests that the implementation of a tram system is an alternative to bus lines (or at least a few of these) and a new concept of mobility based on speed, comfort and accessibility should be put in place.

1.2 OBJECTIVES

The objective of this project is to analyse route alternatives and deliver a feasibility study for the implementation of a tram system in the urban area of Girona, with the purpose of decongesting the traffic of the urban centres and connecting the municipalities of Salt and Vilablareix with the urban nucleus of the city of Girona.

The plan aims to be an opportunity for the modernisation of the streets around the tram system, reversing the negative trends of the falling levels of comfort and decreasing quality of life, which are currently affected by the presence of vehicles and pollution. Recent studies show that trams are associated with an increase in retail sales, development, growth of environmental values and increased tourism, benefiting owners, businesses and public institutions.

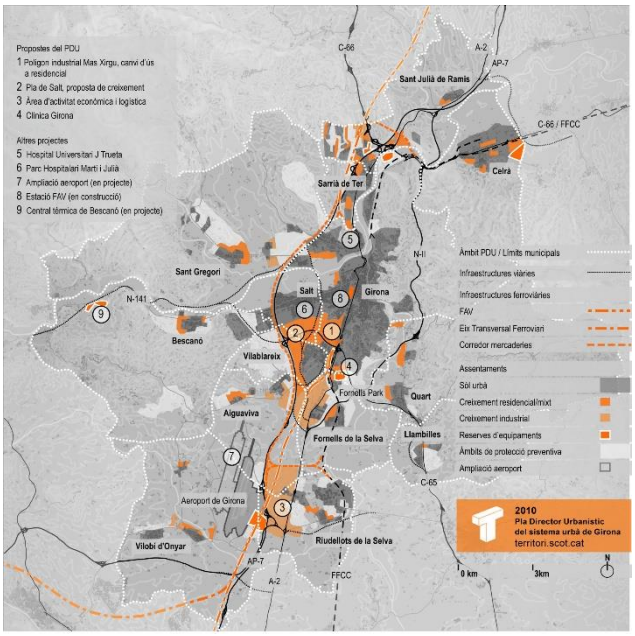
The implementation of a tram system involves the development of a fast and effective mode of collective transport, whose main advantage is a link between the Espai Gironès/Zona Esportiva de Salt and the University of Girona (Montilivi campus)/Montilivi Stadium and Vilablareix – Fontajau, currently served by inefficient solutions, with the consequent energy savings and improvement of the environment.

At the same time, the implementation of a tram route would be an opportunity to introduce new patterns of public architecture aimed at a modernised and intelligent aesthetic 'smart city' that is cited in most of the plans and plans of action promoted by the Girona City Council, anyway.

1.3. SCOPE OF THE STUDY

The project targets the Urban Area of Girona, a population entity that includes the city of Girona and the municipalities adjacent to the city of Girona. Specifically, these are the municipalities of Salt, Sarrià de Ter, Quart, Fornells de la Selva, Vilablareix, Aiguaviva and Sant Gregori.

The municipalities affected by the project are (by territorial and urban continuity): Girona, Salt and Vilablareix.



Picture 1: Urban Master Plan of the Urban System of Girona.
Source: http://territori.scot.cat/

2. CONCEPTUAL HYPOTHESES

For the drafting of this study, the following principles apply to the establishment of a public transport system based on the tram:

I. A tram is a public passenger transport railway using electric propulsion that runs on rails mostly through urban and surface areas. It can either move without separation from the rest of the vehicles or segregated from the rest of the road traffic.

II. The tram is a heavy public transport system and it is used when there is a strong demand for transport.

III. A tram route must be visible and pass through the main arteries of the urban network. It is a structural tool in the field of urban development that should not be concealed under any circumstances.

IV. For a good operation, the tram must be presented as an integral system of urban mobility - safe, fast, comfortable and accessible. For this reason, the integration of the tram should be considered as an extension of the pedestrian area.

V. The tram must solve the main mobility problem which is the use of private vehicles in the area. The recovery of the space for people is one of the main objectives in redistributing traffic and car parks to the main arteries, fulfilling at all times the necessary mobility for the operation of the city.

VI. The creation of a new comprehensive transport system entails strong restrictions on private vehicles, consequently a comprehensive fare system must be made available to citizens that guarantee a quality standard.

VII. In order to guarantee safety, feasibility of exploitation and a long-term guarantee, as far as possible, the two tracks corresponding to both directions of tram traffic must be located on the same road.

3. PREVIOUS TECHNICAL STUDIES

The lack of connectivity between Salt and Girona has led to the idea of building a tram between the two cities, first developed by a civil association. The construction of this new means of transport was first intended to definitively solve the problem of inadequate transportation connections, as well as to favour the architectural development of the two municipalities.

The cancellation of the Olot train was the origin of the poor connectivity between Girona and Salt. The service, suppressed in 1969, connected Girona with Olot, passing through Salt (current Passeig dels Països Catalans), which allowed for good mobility between these two municipalities.

Consequently, different studies and projects have been carried out on the implementation of a tram in Girona, *its commarca (Girona's greater municipal area)* and even at the provincial level. For the realisation of this work, the data provided by mainly these two documents has been of great help:

- *ESTUDI DE VIABILITAT D'UN TRAMVIA INTERCOMARCAL A LES COMARQUES GIRONINES*. *(authorship: Diputació de Girona, 2008).*
  Excerpt: "TramGavarres is a tram-line project that would surround les Gavarres. In 2006 at the request of the Association for the Promotion of Public Transport (PTP), la Diputació de Girona (Girona's greater area authority) began studying it in 2008. Fundamentally, it would have been a railway ring between Girona and the Costa Brava around the Gavarres massif, which would have taken advantage of the existing network between Flaçà and Riudellots."
- *ESTUDI DE LA IMPLEMENTACIÓ D'UN TRAMVIA A LA CIUTAT DE GIRONA. (author: Oriol Roura Vidal - Final degree project, 2017)*
  Excerpt: The project aims to "provide a solid and complete basis for the implementation of a tram in the city of Girona".

BLOCK II: THEORETICAL FRAMEWORK

2. HISTORICAL EVOLUTION OF THE TRAM

Over the previous two centuries, the tram was the most popular and economical means of urban transport, being present in most large cities. Despite its main advantages, the tram has always led to controversies and it was disputed between its supporters and opponents.

At some point in time, however, some so-called "experts" argued that the tram was outdated and un-eco-friendly and, consequently, many cities decided to remove the rails and the accompanying infrastructure (e.g. wires/cabling/tracks).

Later, however, most of the urban areas that had decided to remove the tram infrastructure re-introduced it, pointing out that tram is a modern and ecological means of transport.

2.1 BEGINNINGS AND EVOLUTION

The tram is a means of passenger transport that was invented by the Englishman John Outram in 1775 in Wales, United Kingdom.

In its origins, the structure of a tram was travelling on iron rails and was driven by horses. At that point in time, unlike today, it was used for interurban and peripheral transport.

The first urban tram was built in New York in 1832, half a century after its invention. The route of this line connected the neighbourhoods of Harlem and Manhattan. The capacity was forty-six people, double the pioneering means of transport of the time, the omnibus.

The main drawback of this construction, and which consequently made it remarkably unpopular, was that the rails protruded significantly, causing pedestrian to fall and leading to traffic accidents. In 1852, Émile Louba, a French mechanic, corrected the error by fixing the rails to the ground.

The faeces produced by horses were quickly a public hygiene problem. In addition to this, the tram's major disadvantages were the maintenance of the horses, the limitation of speed and the power needed to move a wagon.

The need to address the latter weak points of the tram accelerated its development: the introduction of traction from a steam engine or by means of a continuously moving cable.

Picture 2: Contrast between the electric traction tram and the animal traction tram in New York.
Source: edisontechcenter.org

The first steam tram system was built in London in 1973 and it presented improvements: traction of more than one coach and more power than horses.

The emission of polluting fumes and a high level of noise pollution produced by these trams ended with the appearance of the electric motor.

The electric tram was invented in 1881 by Werner von Siemens in Germany. At first, it was the rails (tracks) that provided the electrical energy needed but it was quickly replaced by aerial wiring avoiding electrical discharges to pedestrians. The world's first electric tram line was launched in 1880 in Sestroretsk, Russia, invented by Fyodor Pirotsky. However, the first major electrical rail system was built in Richmond, Virginia, USA eight years later, designed by Frank J. Sprague.

From that moment on, the tram became rapidly popular throughout the major cities of the world, being synonymous with public urban transport, replacing animal traction and steam-operated vehicles.

Picture 3: World's first electric tram line in Sestroretsk, Russia (1880).
Source: theculturetrip.com

The golden stage of the tram ended in the 1920s. The decline of this transport medium had three main reasons: the sense of infrastructure insecurity, the exponential growth of the automotive sector and the Great Depression that began in 1929 in the United States.

These factors promoted bus and train as the main methods of public transport. In Europe, countries such as Italy, Spain, France and Britain suspended investments aimed at trams, while the northern European countries (Germany or Switzerland, for example) continued to believe in trams, although implementing some improvements (placing lines underground, etc.)

The growing number of private vehicles in circulation in urban areas, the increase in carbon dioxide emissions and the worrying congestion of the main arteries once again drew the attention of urban dwellers to the tram. Many cities have implemented the new technological advances of this field in its urban areas to date.

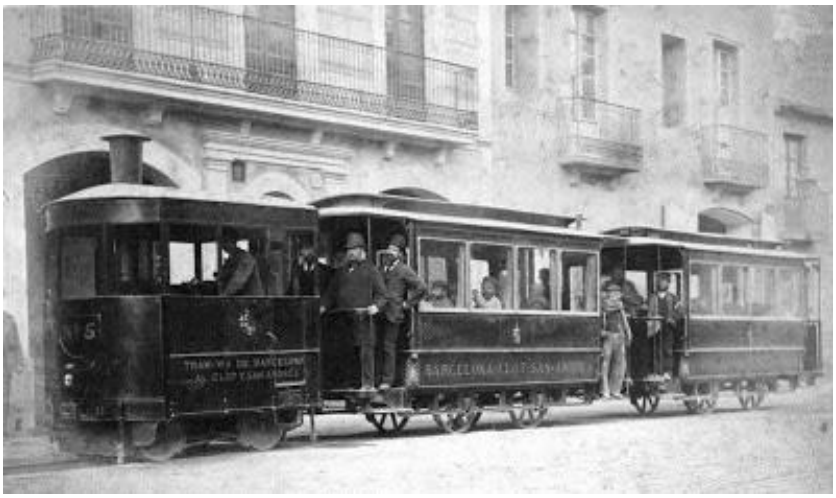
Today, there are a total of 390 cities with a tram service (tram, light rail and train-tram), with a total of 20,000 km of lines and more than 40,000 stops. The most significant networks in the world are: Melbourne with a 256 km of tracks and St. Petersburg with 205 km.

2.2 TRAM IN SPAIN AND CATALONIA

Since the 19th century Spain has had different animal traction tram networks: Madrid (1871), Barcelona (1872), Bilbao (1872), Valencia (1876), Cádiz (1880), Malaga (1884), Zaragoza (1885), Seville (1887) and Palma de Mallorca (1891).

The implementation of tram in Madrid (1871) was the response of the high cost of the omnibus. The success of connecting the main axes led to the introduction of this public transport to other Spanish cities.

In 1877, a steam traction tram was implemented in the city of Barcelona, specifically in the Sant Andreu neighbourhood. A few years later Madrid and Valencia began to replace animal traction with steam traction.



Picture 4: Steam tram from Barcelona to Sant Andreu (1880). Source: enarchenhologos.blogspot.com

The first Spanish city to establish an electric tram was the city of Bilbao in 1896.

The decline of the tram in the United States led to a similar phenomenon in Spain: in the late 1960s and early 1970s in Spain, Spanish tram systems were dismantled - in Madrid, Barcelona, Valencia, Seville, Granada or Zaragoza (the last line in operation in Spain) - and they which were replaced by bus lines. The public opinion believed that the trams were outdated, uncomfortable and highly noisy.

Years later, in 1994, Valencia reopened its the tram network and its was a success.

Barcelona implemented its new tram system in 2002, which under the commercial name of "TRAM" serves the Metropolitan Area of Barcelona with a total of six lines in two currently non-connected networks: Trambaix (T1, T2 and T3) and Trambesòs (T4, T5 and T6). [1]

The tram network runs through 9 municipalities, totalling 29.2 kilometres of rail, 56 stops, 11 interchanges and 41 trams.

[1] "Barcelona unleashes the tram connection on the Diagonal. The works will begin in autumn 2021 between Girona and Castillejos" Diari ARA, 2021 streets: https://www.ara.cat/societat/pacte-ajuntament-barcelona-comuns-erc-enllac-tramvies-obres-comencaran-tardor-mobilitat-ada-colau_1_1005737.html

2.3 THE TRAM NETWORK OF SPAIN TODAY

Currently the tram network of Spain consists of 11 systems in the following cities and urban areas:

NETWORK	CITY	LENGTH	LINES	INAUGURATION
METRO DE GRANADA	Grenade	15.9 km	1	2017
METRO LIGERO DE MADRID	Madrid	36.0 km	1 2 3 4	2007
METROCENTRO	Seville	2.0 km	L1	2007
METROVALÈNCIA	Valency	28.3 km	4 6 8	1994
TRAM METROPOLITÀ D'ALACANT	Alicante	110.7 km	L1 L2 L3 L4 L5 L9	1999
TRAM DE BARCELONA	Barcelona	46.2 km	T1 T2 T3 T4 T5 T6	2002
TRAMVIA DE BILBAO	Bilbao	5.6 km	TR	2002
TRAMVIA DE MÚRCIA	Murcia	18.0 km	L1	2011
TRAMVIA DE TENERIFE	Santa Cruz de Tenerife	15.1 km	L1 L2	2007
TRAMVIA DE VITÒRIA	Vitoria	9.63 km		2008
TRAMVIA DE SARAGOSSA	Zaragoza	12.8 km	L1	2011

Table 1: Trams in service in Spain (2021). Source: Wikimedia Foundation, Inc.

3. PRELIMINARY STUDY OF THE TRAM

Public transport is a means of transport system capable of providing a solution to travel needs of the general public, which can be used by anyone.

Users of public transport, unlike private transport, must adapt to the frequencies and lines provided by the operator, which depend to a greater or lesser extent on public policies. The service can be free or paid and may be offered by both public or private companies.

The following section contains a comparative study between tram and bus, which are the only public transport systems that could be compatible with the requirements of Girona. However, it is worth noting that trolleybus and metro have been considered, too.

3.1 COMPARATIVE STUDY WITH OTHER TRANSPORT SYSTEMS

Bus and minibus are a means of public transport that circulates on the surface, by road and by manual driving. Generally, they use fossil fuel combustion engines, although they are gradually being replaced by electric buses, electric hybrids or natural gas.

An exclusive support infrastructure is not necessary, so you can share the road with other transport systems.

Tram, on the other, is a fully electric transport system, with no batteries, which does not generate gases in situ or noise pollution.

As a collective transport system, it allows to reduce CO2 emissions from 183 g/vkm (traveller for kilometre) to 26.4 g/vkm in the case of tram, as it can be seen in the following figure.

Along the same lines, the implementation of a new mode of "green" transport (electric bus, tram or metro), would reduce NOx and PM emissions, which are closely linked to urban pollution and phenomena such as acid rain.

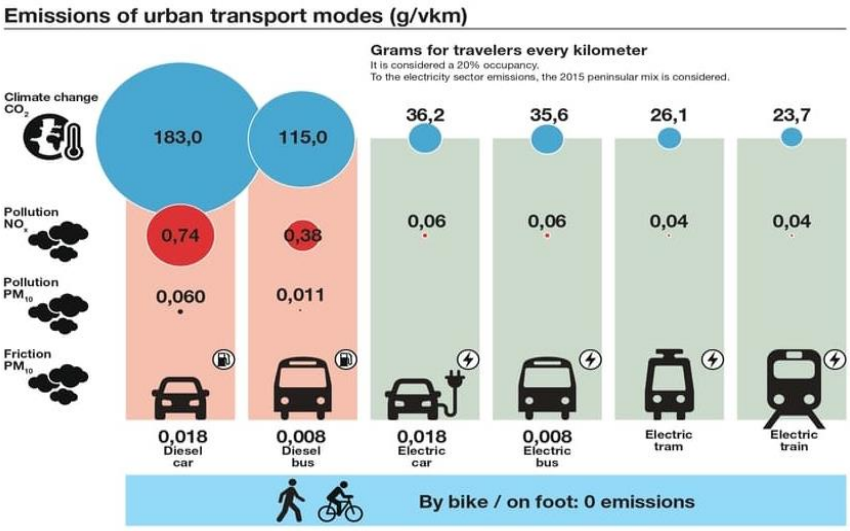


Table 2: NOx, PM and CO2 emissions from urban modes of transport.
Source: transportpublic.org

The transport capacity of tram, understood in number of seats, versus bus and minibus is higher and the adaptability of the system is also greater, being able to incorporate an additional convoy at peak times or suppressing its capacity accordingly.

The transport capacity of a standard bus is 60p (1,200 p h) while a standard tram's is 200p (4,000p/h), making it a very attractive alternative.

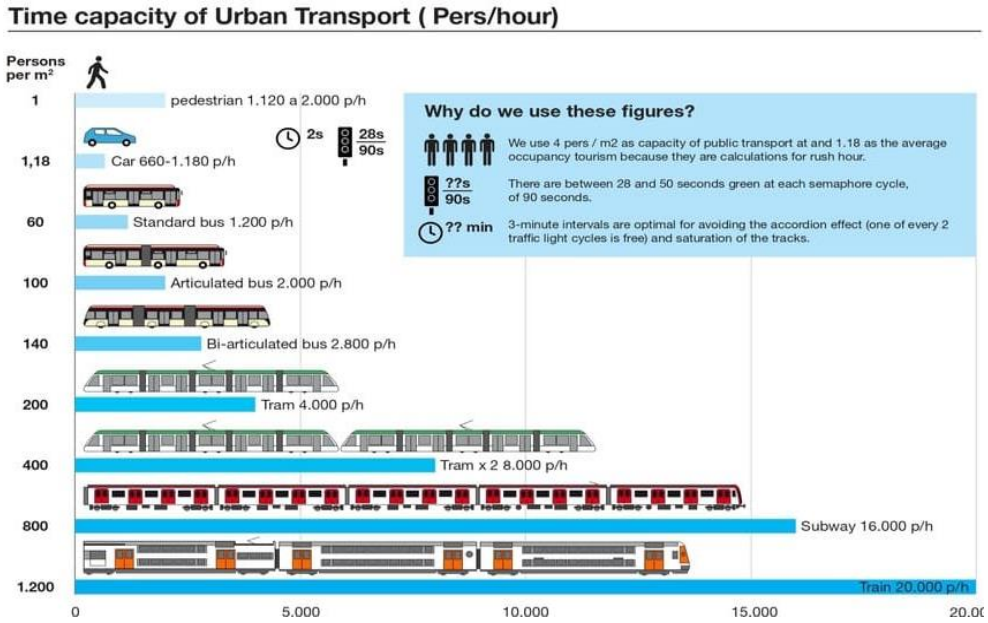


Table 3: Capacity per hour depending on mode of transport with exclusive lane.
Source: transportpublic.org

An exclusive lane for a tram allows speed, comfort and accessibility of the system. Segregation avoids congestion in private vehicles, but it should be borne in mind that this same segregation leads to traffic congestion when occupying space on public roads, which could be intended for additional roads for cars. A shared road is not a good solution as it does not prevent traffic jams and can alter the speed of movement.

The execution of the service is significantly faster compared to other means of transport, because the acceleration and brake cycle is shorter and the access and exit more agile as there are several doors.

At the same time, it should be borne in mind that the investment needed for the implementation of the tram system is much higher than that of buses.

Other modes of public transport that have been considered for the urban area of Girona (trolleybus and metro) but have been quickly discarded for the following reasons:

I. Trolleybus service, an electric traction bus that feeds on a double air cable from which it takes the current, has numerous drawbacks and has become obsolete.

II. Metro service, which requires a large investment and very high maintenance costs, considering the urban area of Girona and its potential demand, would be a totally deficient implementation.

Therefore, taking into account the previous analysis, it is assumed that the best transport system in the urban area of Girona could be a tram system complemented with bus lines.

3.2 TRAM INFRASTRUCTURES

The architecture of a tram system is conditioned by the compatibility with the streets, the influx of pedestrians and cars in the area as well as the economy of the area.

3.2.1 Positioning of tram lines

There are three main alternatives regarding the location of the tram line.

- Own lane (separated): the line runs completely separate from the road (bridge, tunnel, park or field)
- Separate lane: the line circulates on the road, but somehow segregated from the rest of the road infrastructure.
- Joint lane: The tram line runs in a lane that is shared with other vehicles.

Tram lines located on the surface of an urban area are surrounded by asphalt or grass, allowing circulation for people or vehicles. In an intercity area, the tracks are usually segregated and sometimes use the same lane as railways.

3.2.2 Power supply system

A tram's power supply is direct and it uses a pantograph. The catenary is usually located between 7 and 10 meters from the ground and requires support points.

The nominal voltage usually ranges from 500 to 750 volts, depending on the city. A tram system requires transformers that allow to convert the values of voltage and intensity.

3.2.3 Stations

Tram stations are where tram convoys stop and admit passenger boarding and disembarking. Their design is usually conditioned by the road or the segregation of the tram services from other traffic.

- Station located on the street (bus type): where users wait for the tram on the sidewalk and cross the street once their convoy arrives.
- Platform station: this model has gained strength in recent years and is compatible with segregated lanes. They usually have a raised platform (train station type) that favours accessibility to transport.

3.2.4 Signage

Most tram systems have specific signage to improve the safety of all users of public roads.

3.2.5 Maintenance workshop and depot

The workshops and depots are tram system installations that contain repair and maintenance workshops and storage units. These structures are usually located at the end of the line.

BLOCK III: PRACTICAL FRAMEWORK

4. ANALYSIS OF THE NETWORK AND INFRASTRUCTURES OF PUBLIC TRANSPORT IN GIRONA

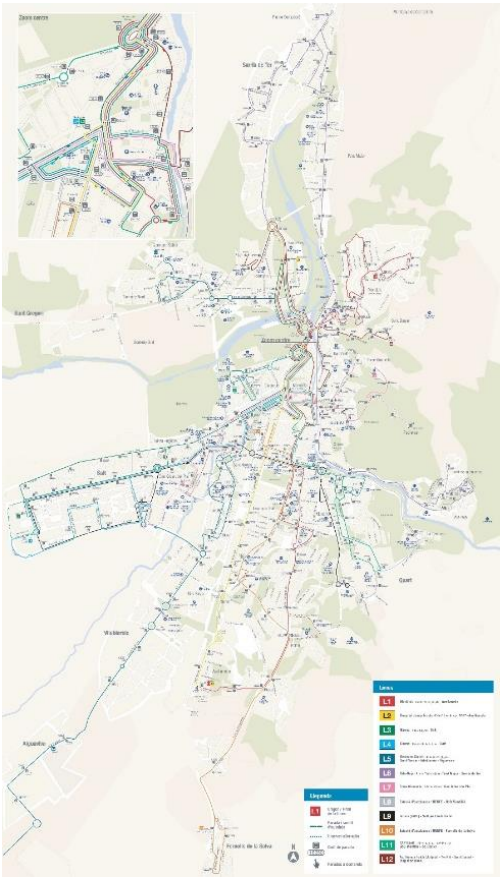
The public transport services offered in the study area is as follows: urban and intercity bus lines, taxi service and public bicycle service.

4.1 URBAN AND INTERCITY BUS SERVICE

The study area has 12 bus lines. The service is offered by TMG (Transports Municipals del Gironès, S.A. – which is owned in 100% by the Girona City Council) and TEISA (Interurban Electric Transports S.A.).

There are a total of 12 day lines that have the following route:

L1	Montjuïc - Ramon Folch (Jutjats) - Avellaneda
L2	Hospital Josep Trueta - Estació d'autobusos / RENFE - Avellaneda
L3	GIRONA (sq. Marquès de Camps) - SALT (by carrer Major)
L4	GIRONA (sq. Marquès de Camps) - SALT (by Espai Gironès)
L5	Germans Sàbat - Ramon Folch (Jutjats) - Sant Narcís - Vilablareix - Aiguaviva
L6	SARRIÀ DE TER - GIRONA - Vila-roja
L7	Torre Gironella - Can Gibert del Pla - Hospital de Salt
L8	Estació d'autobusos / RENFE - UdG Montilivi
L9	Girona (UdG Montilivi) - Salt per Emili Grahit
L10	Estació d'autobusos / RENFE - Fornells de la Selva
L11	CAP Güell - CAP Santa Clara - CAP Montilivi - UdG-Montilivi - St. Daniel
L12	Av. Ramon Folch - Barri Vell - Sant Daniel - Puig d'en Roca



Picture 5: Girona traffic network map.
Source: www.girona.cat

The frequency of service is, together with the journey time, one of the main factors when it comes to attracting users. The average frequency of service is between 15 and 30 minutes in winter, while in August the time decreases considerably.

The following table contains the transit frequencies, the distance in km, the number of buses destined, the route time and the commercial speed of each line:

	Frequency winter / August (min)	Distance (km) Two senses	Number buses	Travel time (hours)	Speed commercial
L1	15 / 30	19,1	5	1	19,1
L2	15 / 30	16	4	0,83	19,1
L3	10 / 10	9	5	0,83	10.84
L4	15 / 15	9,5	4	1	9.5
L5 (urban)	15 / 30	14	4	1	14
L5 Hospital	30	2,3	0,5	0,15	n / d
L5 Vilablareix	30	4,4	0,5	0,17	n / d
L5 Aiguaviva	60	8,7	1	0,43	n / d
L6	15 / 15	18,2	5	1	18.2
L7	15 / 30	12,9	3	0,83	15,5
L8	30	8,2	1	0,5	16,5
L9	60/-	12,2	1	1	12.2
L10 (urban)	60	8,9	0,5	0,5	17,7
L10 Fornells	60	4,3	0,5	0,37	n / d
L11	15 / 30	11,3	4	0,75	15,1
L12	60	10	1	0,75	13,3

Table 4: Characteristics of the Girona Traffic Network. Source: prepared by the Author

4.1.1 Tickets and TMG fares

The following section contains information on the bus fares of the public transport run by TMG and TEISA. Please keep in mind that the price of a ticket or a rechargeable card determines the economic accessibility of the population to the system.

	Price	**Characteristics**
Single ticket	1 trip -> 1,40€	A single ticket that allows a trip on the TMG or TEISA lines without the possibility of transfer.
BUS card 12 / T12	Free	Allows children from 4 to 12 years old to make an unlimited number of trips to the fare zone in which they reside, with all forms of transport integrated.
BUS Card 18	30 trips -> 6,50 € 120 trips -> 21,50 €	Allows all teenagers registered (residing) in Girona, between 13 and 18 years old, to make trips at a reduced rate on all Girona urban transport lines.
BUS Card 25	30 trips -> 12,50 € 120 trips -> 45,50 €	Allows all persons registered (residing) in Girona, between 19 and 25 years old, to make trips at a reduced rate on all the lines of urban transport in Girona and will allow the transfer.
TMG 50-30 Multiperson Card	The purchase price of the card is € 2.5 The price of the recharging is € 33.80	A multi-person card that allows to make 50 trips on TMG buses for 30 consecutive days from the time of recharging.
UdG Card	380 trips -> 115,00 €	Allows UdG students to make 380 trips on the TMG lines for 115 euros.
BUS Card 65	40 free monthly trips	Valid for all urban lines of Girona, this card is for citizens between 65 and 69 years old, who are registered in Girona and who meet the required economic conditions.
BUS card 70	40 free monthly trips	Valid for all urban lines in Girona, this card is for citizens who are 70 years old or older and who are registered in Girona.
SOCIAL BUS Card	40 free monthly trips	Valid for all urban lines in Girona, this card is for citizens between 18 and 69 years of age who are registered in Girona, who receive a pension because of their incapacity to work (retirement, absolute permanent disability, disability with severe disability, disability of 65% or higher, and widowhood between 60 and 64 years old) and who meet the required economic conditions.
Children under 4 years old travel free of charge.		

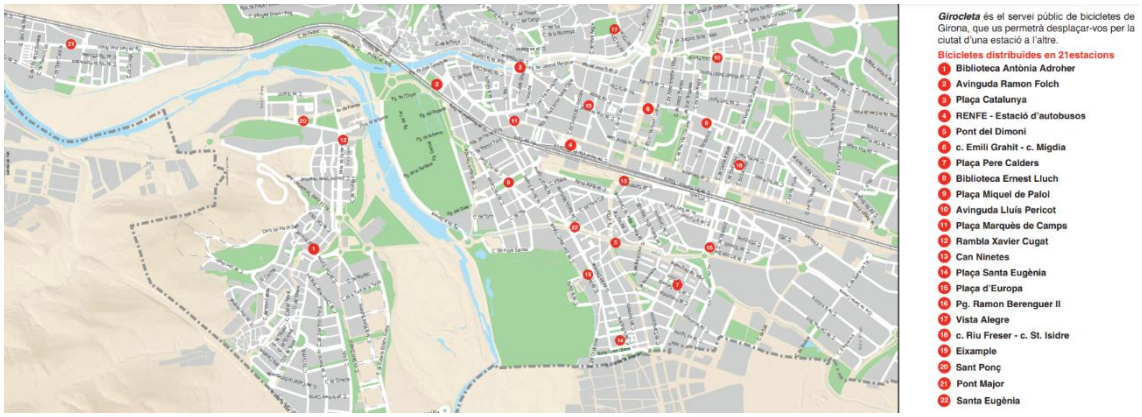
Table 5: TMG Fares (2021). Source: Prepared by the Author from TMG data (girona.cat)

4.2 PUBLIC BICYCLE SERVICE: GIROCLETA

In 2009, the public bicycle service of the city of Girona was launched with the aim of promoting urban cycling. The initial network had 8 stations and 160 bicycles. Year after year, the network has been expanded with now 22 stations and 220 bicycles available.

The number of active users of Girocleta in 2020 was 3,035, a 15.5% drop compared to 2019, which was 3,592. The following picture shows the locations of the Girocleta stations.

In accordance with the website below, the service hours are: working days, Saturdays and holidays - 24h.



Picture 6: Map of Girocleta stations (2021). Source: girocleta.cat

4.2.1 Girocleta subscriptions

The service has two types of subscriptions:

	Price
One-day passes	Ticket: 2€ (includes the first 60 minutes) In case of excess time, 0.50€ will be charged for every half hour or fraction.
Annual subscription	Annual membership fee - 30 € Includes the first 30 minutes for every trip. Additional fee from the first 30 minutes - € 0.50 (applies to every fraction of 30 minutes)

Table 6: Girocleta subscriptions (2021). Source: Own analysis based on girocleta.cat data

5. PUBLIC TRANSPORT USE IN THE URBAN SYSTEM OF GIRONA

According to the data published on the transparency portal TMG and data requested from TEISA, a total of 3,256,202 bus trips have been made in 2020. It should be borne in mind that the values of 2020 are not typical or representative and that for the sake of this analysis 2019 is used as a reference.

In 2019, a total of 6,202,202 trips were recorded, an increase of 0.12 points compared to 2018. The number of free trips represents 23.27% of the total, following the trend of previous years.

The following table contains information on the number of trips made per line per year, as well as the % of free trips.

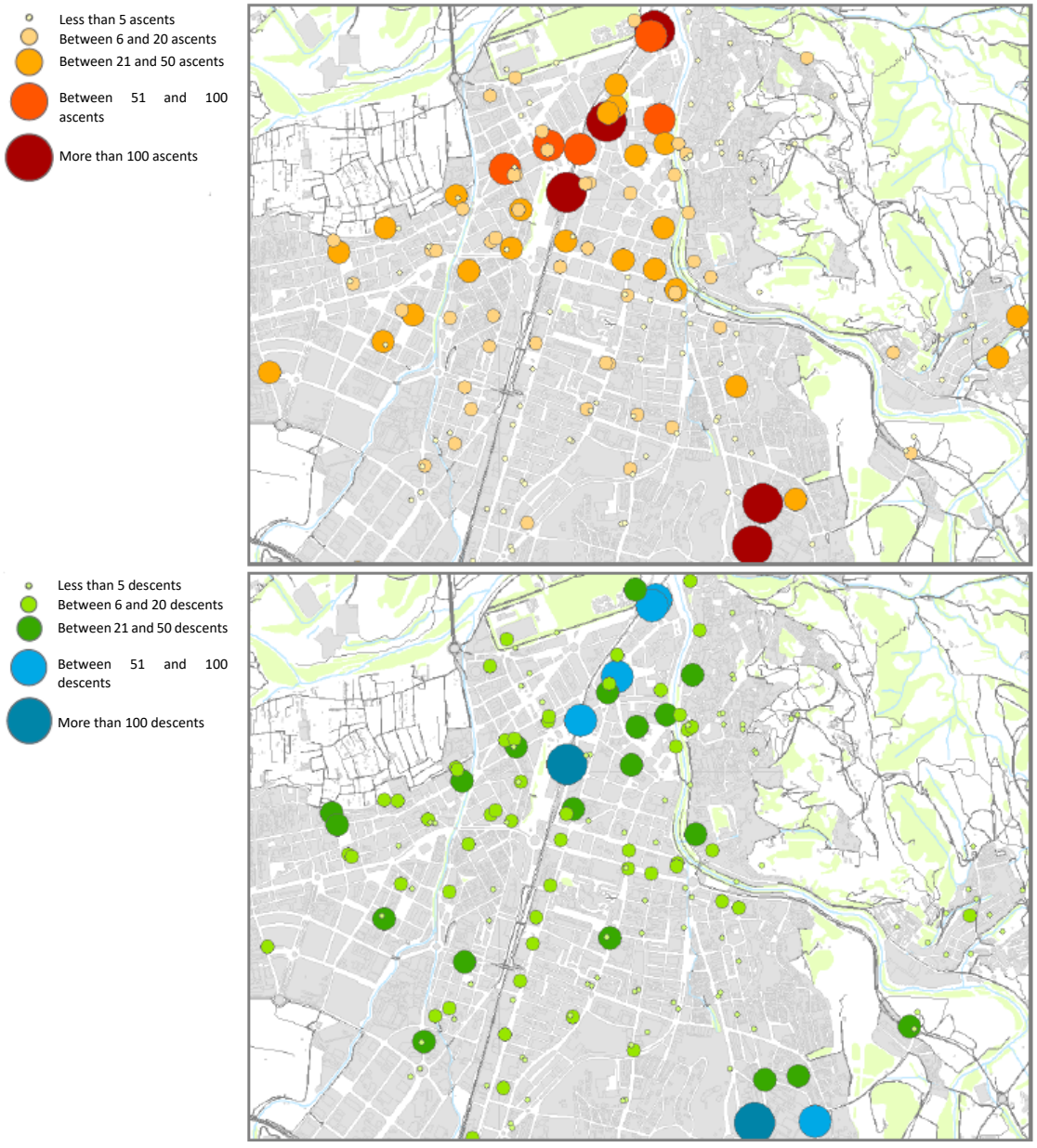
	Trips							% increase	%
	2006	**2008**	**2010**	**2015**	**2018**	**2019**	**2020**	**2020/2019**	**Free**
L1	308.029	520.471	703.953	768.456	806.457	804.267	414.555	-48,5%	24,80%
L2	248.632	404.418	512.318	574.986	667.041	699.360	344.722	-50,7%	20,60%
L3	968.868	1.092.125	1.126.426	1.064.173	1.230.223	1.299.297	751.848	-42,1%	n/d
L4	227.405	542.658	617.099	588.267	685.284	693.836	336.890	-51,4%	n/d
L5	607.839	708.133	841.648	830.791	949.647	950.736	491.276	-48,3%	25,70%
L6	395.725	597.875	659.157	705.187	794.586	781.906	455.509	-41,7%	n/d
L7	47.743	93.298	196.232	223.608	242.445	241.938	119.103	-50,8%	35,30%
L8	166.488	126.446	139.790	210.674	229.159	217.269	80.387	-63,0%	3,40%
L9					20.294	82.058	54.070	-34,1%	n/d
L10	21.053	68.613	81.678	88.192	97.221	102.490	64.527	-37,0%	12,20%
L11	70.949	244.675	353.028	360.750	349.100	329.045	139.778	-57,5%	29,30%
L12							3.802	100,0%	36,60%
TOTAL	3.062.731	4.398.712	5.231.329	5.415.084	6.071.457	6.202.202	3.256.467		

Table 7: Number of trips made by TMG-TEISA bus per year. Source: Prepared by the Author

The following diagrams show consolidated data on boardings and disembarking instances at the TMG-TEISA stops in the city of Girona for 2014.

This analysis shows that the stops with the highest demand (+100 ascents/descents) are: Estació, Plaça Marquès de Camps, Correus and Universitat de Girona (campus Montilivi). Next, the stops with 51 – 100 ascents/descents are: Santa Eugènia, Centre, Emili Grahit, Montjuïc and Carrer Migdia.

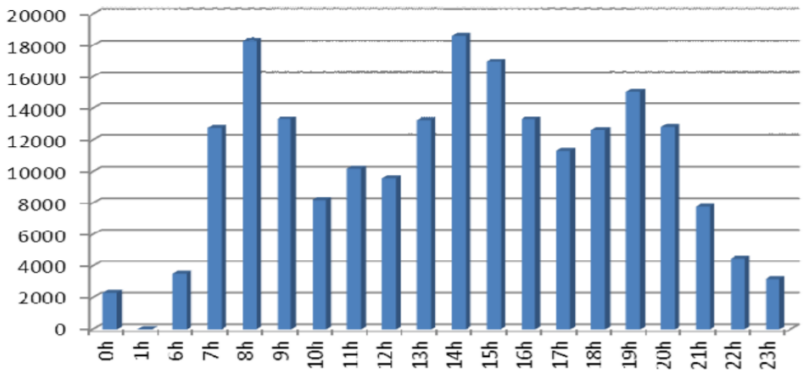
It is assumed for the sake of the feasibility study that the trend is the same as the one shown in this analysis as the location of the key facilities and the leisure and commercial surfaces have not changed.



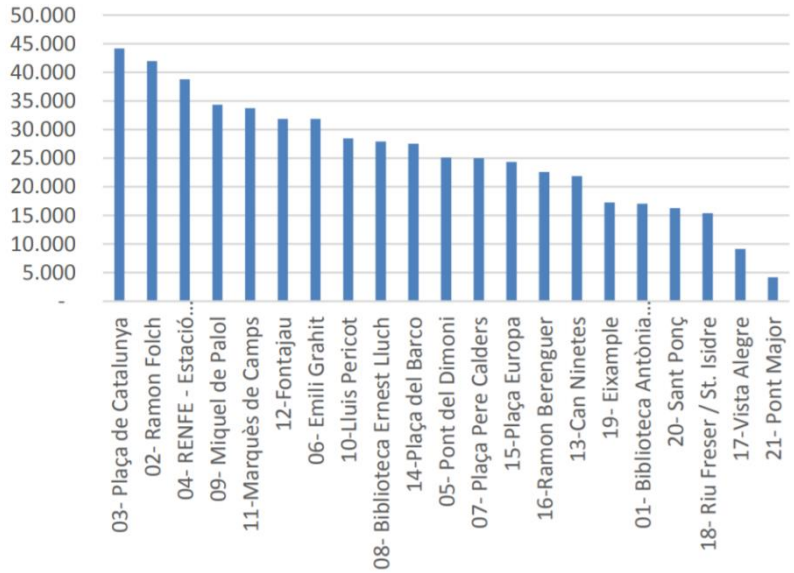
Picture 7: Girona Urban Mobility Plan (2014). Source: web.girona.cat/mobilitat

Regarding Girocleta, in 2019 the number of trips made was 538,817, an increase of 10.3 points compared to the previous year. On average, every day there were 1,496 journeys, equivalent to 11 uses per bicycle per day.

The following charts show the distribution of trips by station and hour. It is confirmed that there are a considerably higher number of trips to the city centre than to the "outskirts". At the same time, you can define the rush hour in the city of Girona: 8h, 14-15h and 19h.



Picture 9: Distribution of trips by hour Girocleta (2019). Source: girona.cat/bus/cat/transparencia



Picture 8: Distribution of trips by Girocleta station (2019). Source: girona.cat/bus/cat/transparencia

The data above show that the use of public transport (bus lines and Girocleta) increases year after year. The bus service has gone from 3,062,731 trips in 2006 to 6,202,202 trips in 2019 representing a 103% rise.

The average commute time is 25 minutes and the average service access time is 9 minutes.

6. MOBILITY STUDY

6.1 POPULATION DISTRIBUTION AND EVOLUTION

The study area registered a total of 138,570 people residing in the area in 2020. 74.60% of the residents were registered in the city of Girona, followed by Salt with 32,138 inhabitants (23.19%) and Vilablareix, with 3,063 inhabitants (2.21%).

In the last ten years, the population of the study area has increased by almost 10,000 people (by almost 7%). The most significant increase, in absolute terms, has been in the city of Girona (6,647 people), while in relative terms the largest increase has occurred in Vilablareix (2.21%).

The system's annual growth rate has been 0.75% (see the following table for more detail).

Municipality	Population 2011	Population 2020	% population compared to total 2020	Absolute increase 2011 - 2020	Relative increase 2011 - 2020	Annual growth rate
Girona	96.722	103.369	74,60%	6.647	6,87%	0,74%
Salt	30.389	32.138	23,19%	1.749	5,76%	0,62%
Vilablareix	2.401	3.063	2,21%	662	27,57%	2,74%
TOTAL	**129.512**	**138.570**	**100,00%**	**9.058**	**6,99%**	**0,75%**

Table 8: Population of the area of study and study data (2011-2020). Source: idescat.cat

6.2 POPULATION AFTE SEASONAL POPULATION AFTE AND TOURISM

The population load that each municipality supports is essential for tram planning.

Firstly, seasonal population estimates have been considered, measuring the number of people in each locality on average annually.

For the sake of this measurement, individuals with a direct link to the municipality have been taken into account and the following data has been looked at: residence, work, study or holidays for 2019 (considering 2020 not a representative year). The unit of measurement is the equivalent full-time annually.

At the same time, it has been considered that the tourist population attracted by key events or holiday periods can multiply the population of Girona by up to 35%.

The following table contains information on the the annual full-time equivalent population or (AFTE - annual full-time equivalents equivalent) of the population for 2019.

	Seasonal population AFTE					
Municipality, 2019	**Non-resident present**	**Absent resident**	**Total**	**Resident population**	**POPULATION AFTE**	**POPULATION AFTE (%)**
Girona	20168	-10361	9807	101852	111659	109,63%
Salt	2.507	-3.254	-747	31.362	30.615	97,62%
Vilablareix	100	50	150	2897	3047	105,18%

Table 9: Population AFTE of the area of study and study data (2019). Source: idescat.cat

6.3 POPULATION GROWTH

The implementation of a tram system is a long-term investment, consequently a long-term population approach is needed.

The study carried out is an approximate projection of the resident population and a total AFTE for each municipality until 2050 in two scenarios: most likely and pessimistic.

For the drafting of this appearance, the information provided in the Urban Master Plan of the Urban System of Girona and the Repository of the urban projects of 2017 have been taken into account.

The hypotheses for designing the growth strategies that have been considered for each municipality have been the following:

> For both the most likely and pessimistic scenario, it is established that 85% of new households will be permanently inhabited.
>
> It is assumed that the high-speed line and the incorporation of new operators will increase the number of visitors to Girona by 25%.
>
> The Girona-Costa Brava Airport is considered to assume part of the air traffic of the Josep Tarradellas Barcelona-El Prat Airport and will increase tourism in the city of Girona by 20%.

Girona:

I. It is established that the annual growth rate will be 0.85%, in the most likely scenario and 0.55% in the pessimistic scenario, assuming the continuity of recent years.
II. The % on Resident Population AFTE is established that it is 9.27% of the resident population in both scenarios, assuming the continuity of recent years.
III. The total AFTE (people equivalent to full time annually) is the result of the application of the following formula: *No resident present + Resident absent*
IV. Population AFTE is the sum of the resident population + Total AFTE and results in: the number of people who have a direct link with the municipality, residence, work, study or vacation.

Salt:

I. It is established that the annual growth rate will be 0.80%, in the most likely scenario and 0.52% in the pessimistic scenario, assuming the continuity of recent years.
II. The % on resident population AFTE is established that it is 2.43% of the resident population in both scenarios, assuming the continuity of recent years.
III. The total AFTE (people equivalent to full time annually) is the result of the application of the following formula: No resident present + Resident absent
IV. Population AFTE is the sum of the resident population + Total AFTE and results in: the number of people who have a direct link with the municipality, residence, work, study or vacation.

Vilablareix:

I. It is established that the annual growth rate will be 0.90%, in the most likely scenario and 0.59% in the pessimistic scenario, assuming the continuity of recent years.
II. The % on Resident Population AFTE is established that it is 4.90% of the resident population in both scenarios, assuming the continuity of recent years.
III. The total AFTE (people equivalent to full time annually) is the result of the application of the following formula: No resident present + Resident absent
IV. Population AFTE is the sum of the resident population + Total AFTE and results in: the number of people who have a direct link with the municipality, residence, work, study or vacation.

The following table, prepared by the Author, based on data from the Institute of Statistics of Catalonia, summarises all the previous hypotheses and establishes the population approach to the horizon of the year 2050 in the most probable and pessimistic scenario:

	2020		Most Likely Estimate, 2050				Minimum estimate, 2050			
	Resident population	**AFTE population (estimate)**	**Annual growth rate (forecast)**	**Resident population**	**POPULATION AFTE**	**% POPULATION AFTE with respect to total**	**Annual growth rate (forecast)**	**Resident population**	**POPULATION AFTE**	**% POPULATION AFTE with respect to total**
Girona	103.369	112.951	0,85%	133.235	145.585	76,91%	0,55%	121.934	133.237	76,84%
Salt	30.389	29.650	0,80%	38.579	39.516	20,88%	0,52%	35.489	36.351	20,96%
Vilablareix	3.063	3.213	0,90%	3.990	4.185	2,21%	0,59%	3.632	3.809	2,20%
TOTAL	**136.821**	**145.814**		**175.804**	**189.286**	**100,00%**		**161.055**	**173.397**	**100,00%**

Table 10: Most likely and minimum estimate of AFTE population in the area of study by 2050. Source: own analysis based on data and studies of idescat.cat

6.4 INTRA-MUNICPAL AND INTER-MUNICIPAL MOBILITY GIRONA-SALT-VILABLAREIX

The number of intra-municipal trips (whose origin and destination is Girona) totals 232,818 trips on weekdays and 167,500 on holidays and weekends with a population of 97,227 inhabitants, according to the Urban Mobility Plan of Girona in November 2014, with data from 2006. The figures include single and return tips in aggregate.

The document concludes that approximately 65% of Girona's internal journeys are made without using motorised vehicles, 31% by private vehicle and 4% by public transport.

Regarding the bicycle, the City Council calculated that, on a working day, 5,342 trips were made, which is 2.3% of the total urban trips. In accordance with the one studied in the previous section; this data is excluded from the study by differing significantly from reality.

Mode of transport	Modal distribution 2006	INTERNAL journeys by mode of transport 2006
By foot	62,8%	146.184
Bicycle	2,3%	5.342
Public transport	3,5%	8.165
Private transport	31,4%	73.127
TOTAL	**100%**	**232.818**

Table 11: Internal displacements and modal distribution on working days. Source: web.girona.cat/mobilitat/plans/mobilitat

In the absence of a correlation between the data of the Urban Mobility Plan of Girona in November 2014 (data 2006) and the Annual Reports of TMG and TEISA, a new table of total travel and modal distribution (on foot, bicycle, public transport and private transport) is drawn up for 2020.

The following table shows the trend of annual and daily users of TMG and TEISA from 2006 to 2020.

An increase of 2.15 percentage points has been applied to the number of annual trips in 2019 to obtain a corrected figure for 2020. Therefore , the estimate shows the number of trips without the decrease motivated by mobility restrictions.

The notable increase in the use of public transport is mainly motivated by the Salt-Girona connection.

	2006	2008	2010	2015	2018	2019	2020	correction 2020
nº of annual trips	3.062.731	4.398.712	5.231.329	5.415.084	6.071.457	6.202.202	3.256.467	**6.339.565**
nº of daily trips	8.508	12.219	14.531	15.042	16.865	17.228	9.046	**17.610**
% increase		44%	19%	4%	12%	2%	-47%	**0%**

Table 12: Nº of annual, daily trips and % increase in the TMG bus service 2006 - 2020 and 2020 with correction. Source: own analysis based on the girona.cat database

Then, the data of total displacements and modal distribution have been updated with a population of 103,098 inhabitants and the new socioeconomic context of Girona, which has produced a change in the behaviour of agents, considerably increasing the number of trips.

A displacement correction of +25% is applied for Foot mode, a correction of +55% for Bicycle mode, +187.45% for Public Transport mode and +20% for Private Vehicle mode.

The following table shows the approximate total displacements and the distribution by mode of transport of the working days (from Monday to Friday) and of Saturdays and holidays in the city of Girona for the year 2020, based on 2006.

	2006	2020
Population	89.890	103.369

Daily urban commutes WORKING DAY

Mode of transport	2006	2020	% correction	2020 with correction	% compared to total 2020 with correction
Non-motorised	151.508	174.226	*126,05%*	219.619	*64,95%*
By foot	*146184*	*168.104*	*25,00%*	*210.130*	*62,14%*
Bicycle	*5324*	*6.122*	*55,00%*	*9.489*	*2,81%*
Public transport	8.165	9.389	*187,56%*	17.610	*5,21%*
Private vehicle	73.127	84.092	*20,00%*	100.910	*29,84%*
Total	**232.800**	**267.707**		**338.139**	**100%**

Daily urban commutes SATURDAYS AND HOLIDAYS

Mode of transport	2006	2020	% correction	2020 with correction	% compared to total 2020 with correction
Non-motorised	109.043	125.393	*126,06%*	158.069	*65,29%*
By foot	*105190*	*120.963*	*25,00%*	*151.203*	*62,45%*
Bicycle	*3852,5*	*4.430*	*55,00%*	*6.866*	*2,84%*
Public transport	5.863	6.741	*70,00%*	11.459	*4,73%*
Private vehicle	52.595	60.481	*20,00%*	72.577	*29,98%*
Total	**167.500**	**192.615**		**242.105**	**100%**

Table 13: Total approximate displacements and distribution by mode of transport of working days and Saturdays and holidays in Girona (year 2020, based on 2006). Source: prepared by the Author based on data from the Urban Mobility Plan of Girona girona.cat

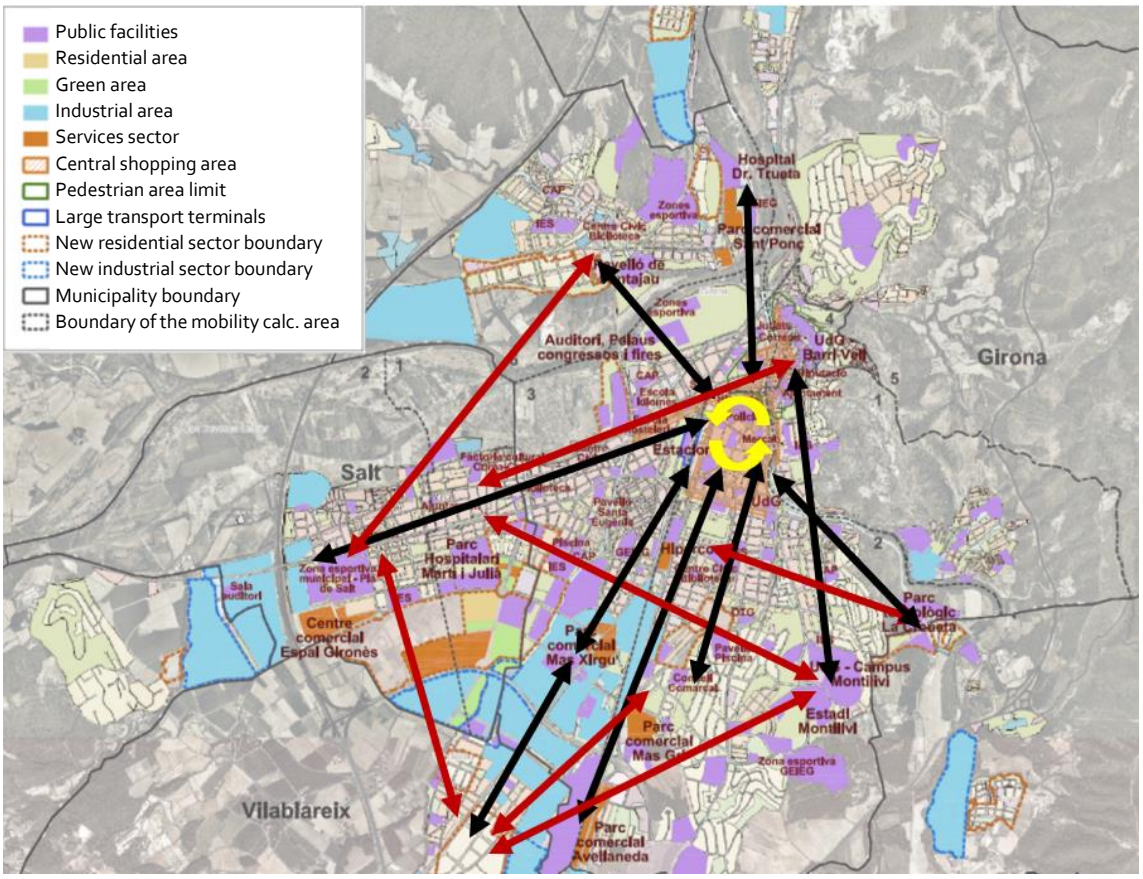
7. LAYOUT OF THE PROPOSAL

7.1 PREVIOUS ASPECTS

The location of certain municipal facilities, commercial areas, areas of heritage interest or even hospitals determine the direction of travel for personal or work reasons. In this sense, the location of a tram line must respond to this demand in order to attract customers.

The location of the stops should also consider the density of the population that they have within their catchment radius.

The following picture contains the delimitation by areas of the urban system of Girona, the location of the facilities, the main uses of the area and the principals flows of displacements.



Picture 10: Main flows of displacements in the urban area of Girona on a map of location of main areas, facilities and uses (2007). Source: Prepared by the Author. Map: Most Engineers most.cat/

7.2 TRAM ROUTE

The implementation of a tram system requires streets wide enough to allow the simultaneous circulation of the tram with the other agents of the traffic (motorised vehicles, pedestrians and bicycles).

This feasibility study proposes the construction of two tram lines:

L1: Espai Gironès-Salt-Girona-UdG Montilivi

L2: Vilablareix-Eixample-Correus-Fontajau

At this point, and taking into account to the previous studies, two similar proposals are proposed.

Proposal I would use the space occupied by the current viaduct to locate the layout of line 2 while Proposal II would use Carrer Barcelona. The distance between the viaduct and Carrer Barcelona is 100 metres practically along the entire route affected by the tram, so that the study of demand and locations of the stops is identical for both proposals.

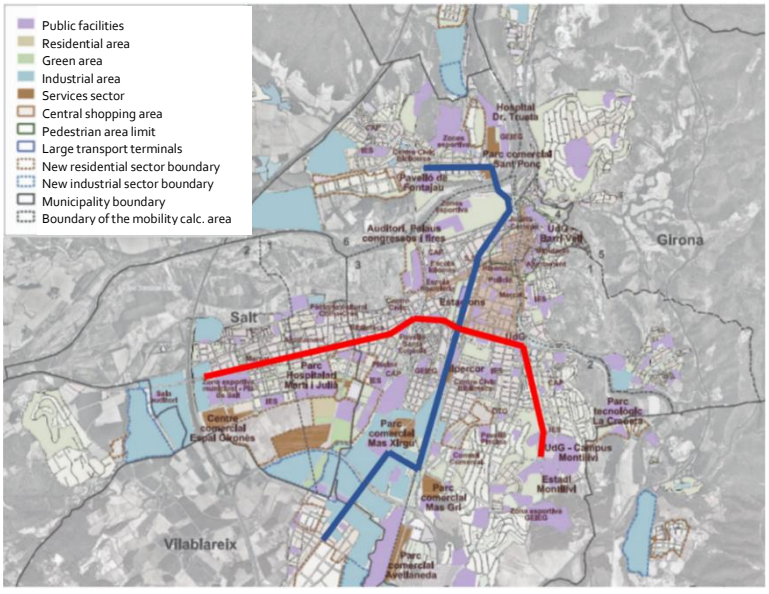
7.2.1 Proposal I

Proposition I involves the need to free up the space occupied by the current viaduct built for the regional train services through Girona.

The demolition of the infrastructure built in the 1970s would allow the implementation of a virtually rectilinear line parallel to one of the main arteries of the city, Barcelona street.

Taking into account the specificities of the roads in the study area, the circulating demand and the visibility of the lines, it is concluded that the ideal route for line 1 is to use three of the main arteries of the city: Passeig d'Olot (in Salt, Passeig dels Països Catalans), Carrer Emili Grahit and Avinguda Montilivi.

The freed space of the viaduct would incorporate the route of line 2 and bike lane, turning this currently run-down area into a green corridor that would cross the city from north to south. An upgrade and refurbishment of the area would allow for a potentially attractive and dynamic commercial axis around an area of high population density.



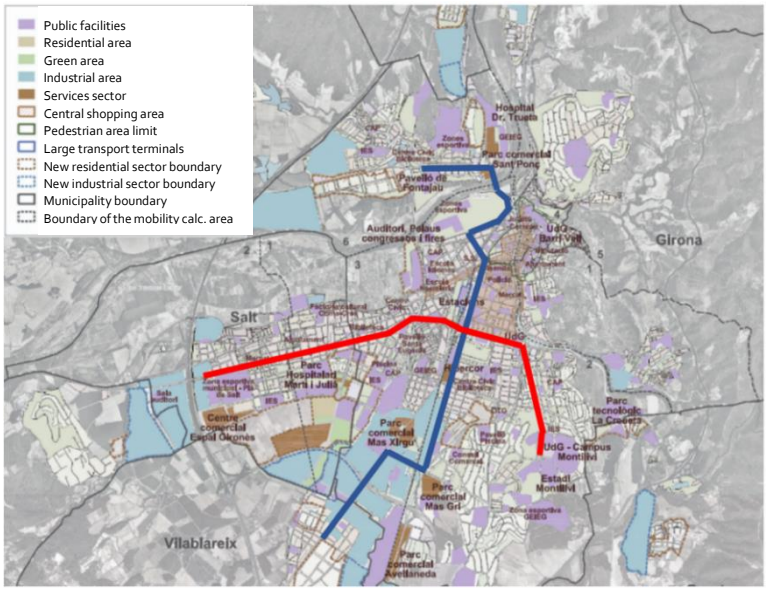
Picture 11: First proposal of the tram line. Source: Prepared by the Author. Map: Most Engineers (most.cat)

7.2.2 Proposal II

Proposition II assumes the unfeasibility of eliminating and placing the regional train service lines underground. Consequently, in this proposal, the viaduct is kept.

The impossibility of releasing this space leads to relocating the route of line 2 (Vilablareix-Eixample-Correus-Fontajau) 100 m from proposal I.

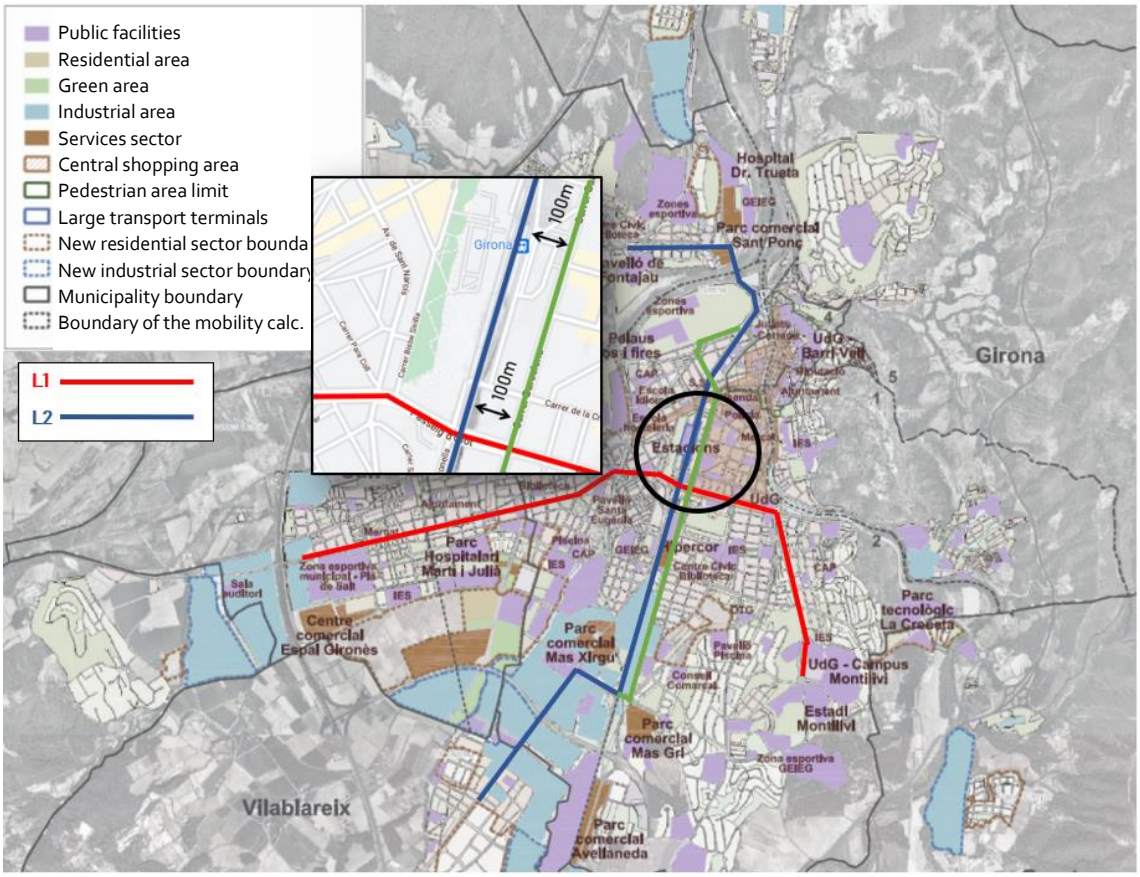
The ideal route of Proposal II, taking into account the specificities of the study area, the working demand and the visibility of the lines is to use the four mains arteries the city: Carrer Barcelona, Passeig d'Olot (in Salt Passeig dels Països Catalans), Carrer Emili Grahit and Avinguda Montilivi.



Picture 12: Second proposal of the tram line. Source: Prepared by the Author. Map: Most Engineers (most.cat)

7.2.3 Differences between Proposal I and Proposal II

The following map contains the two proposals combined. The layout of Line 1 is the same for both Proposal I and Proposal II. With regard to Proposal II, the route difference is 100 meters practically the entire route, so that the study of demand and locations of the stops is identical for both proposals.



Picture 13: First and second proposal of the tram line. Source: Prepared by the Author.

The streets spaces proposed by the layout of the lines are suitable in terms of width, immediate population density and areas of interest (see point 8.2)

Special remarks:

- It is recommended that there should be a stop at the end of line 1 (UdG Montilivi – Montilivi Stadium) for public use facilities even if there is low population density.
- One needs to consider the low population density and the "factual" abandonment of the area the south of Barcelona street; however, there may be a need for a stop due to the location of companies and public facilities (e.g. Institut Ermessenda and Clínica Girona).

7.2.4 General characteristics of Line 1:

Line 1 begins its route in the Espai Gironès – Salt Sports Area and ends at the University of Girona (Montilivi campus) – Montilivi Stadium.

It is recommended for this line to pass through Passeig dels Països Catalans in Salt due to its rectilinearity and the characteristic central axis. The avenue is located between the new and the old part of the town and it is connected to Passeig d'Olot.

The link between Passeig dels Països Catalans and Passeig d'Olot would take place at the Rotonda del Tren d'Olot, running through Santa Eugènia and Can Gibert del Pla.

The route continues along Carrer Emili Grahit (the main axis of the city) to Plaça dels Països Catalans and it would then climb towards Avinguda Montilivi, passing through Avinguda de Lluís Pericot to the University of Girona (Montilivi campus) – Montilivi Stadium.

7.2.5 General characteristics of Line 2:

Line 2 begins the route in Vilablareix and ends Fontajau, passing through the freed-up space of the viaduct/Carrer Barcelona (main axis of the city), Rotonda del Rellotge, Passeig de la Devesa, Avinguda de França and Rambla Xavier Cugat.

It has been proposed for this line to have its start in Vilablareix to connect the town and the commercial and industrial park Mas Xirgu with the city of Girona.

Its extension to the Josep Trueta Hospital is ruled out due to its possible relocation to the municipality of Salt (in front of Santa Caterina)[2].

Picture 14: Computer recreation of line L1 at the height of Passeig dels Països Catalans. Source: pinterest.es

[2] https://www.diaridegirona.cat/comarques/2021/10/24/nou-trueta-s-acabara-d-58742986.html

7.3 LOCATION OF THE PARADA POINTS

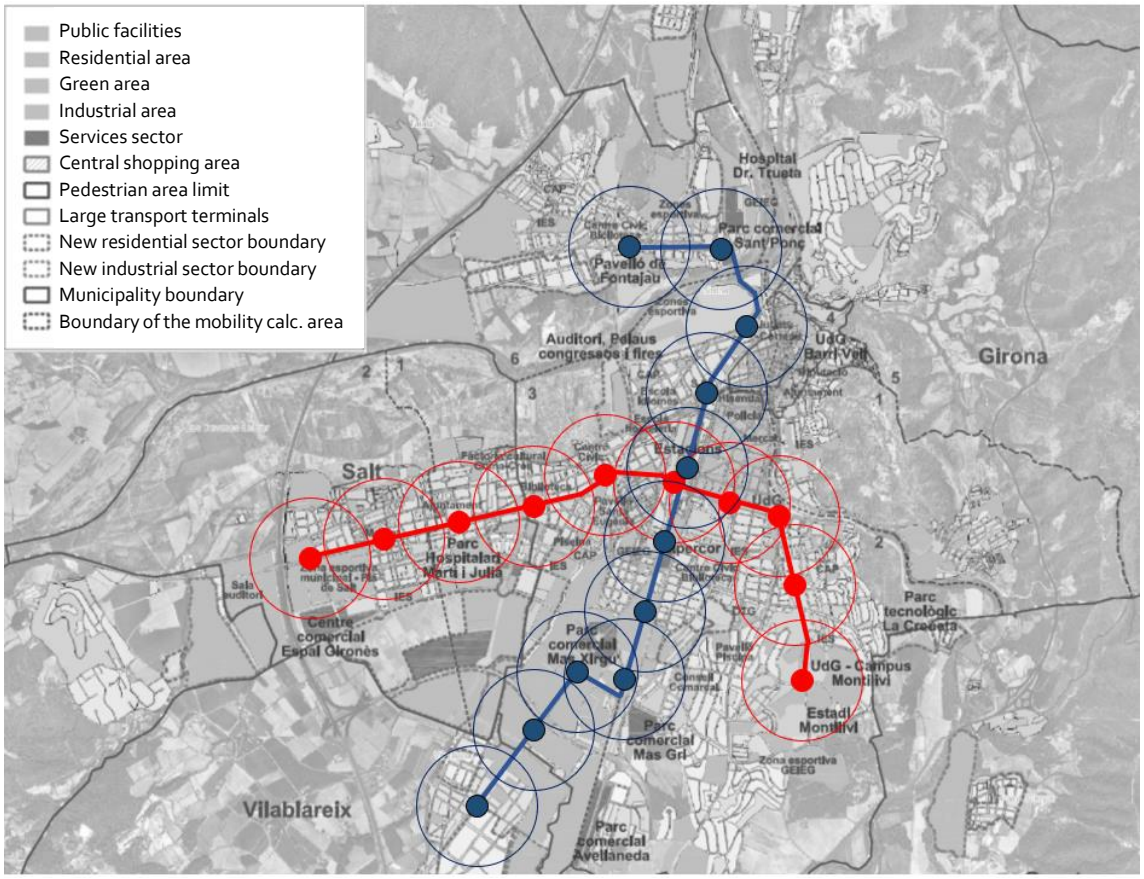
The location of the stops has been calculated according to the following factors: resident population, work centres, areas of interest, commercial areas and public facilities.

For location proposal, an isochronous system has been mainly used, a map that defines the accessible area from a point within a certain time frame.

> The objective to comply with the rule that from any point in the accessible area it should not take more than 5 minutes to reach the stop. An average walking speed of 5 km/h is assumed in this calculation.

At the same time, the CROW manual "Recommendations for traffic provisions in built-up areas" has been taken into account, specifying that "For medium and low capacity systems it is recommended that stops be found with an intermediate distance ranging from 300 m to 450 m."[3]

The following Picture contains the route of each line, the location of the stops and the accessible area of each of them. The analysis of the different factors has served to determine this proposal.



Picture 15: Location of the stopping points. Source: Prepared by the Author. Map: Most Engineers (most.cat)

[3] https://go.itdp.org/download/attachments/93094025/MDC-30AgostoWeb.pdf?api=v2

Location of stops Line 1

LOCATION	LOCATION – NAME	JUSTIFICATION
Passeig dels Països Catalans (Salt)	Espai Gironès – Zona esportiva de Salt	Access to the commercial area of Espai Gironès (250m from the stop) and the Salt sports area (20m from the stop)
	Mercat de Salt	Area of high density of population. Access to the Salt Market (120m) and numerous commercial surfaces.
	Hospital de Santa Caterina	Area of high density of population. Access to Hospital de Santa Caterina (300m) and EUSES (400m)
Rotonda del Tren d'Olot	Rotonda del Tren d'Olot	Limit between Salt and Girona. Medium-high population area.
Passeig d'Olot	Pavelló municipal d'esports Santa Eugènia	Area of high density of population. Boundary between the estates of Santa Eugènia and Can Gibert del Pla Access to the municipal sports pavilion of Santa Eugènia and the Municipal Swimming Pool of Can Gibert del Pla
	Plaça Europa – Parc Central - Estació	Transfer stop between L1 and L2. Area of high density of population. Access to the High Speed Station, Regional Services and Buses. Educational Facilities in the vicinity.
Carrer Emili Grahit	Biblioteca Pública Carles Rahola	Area of very high density of population. Access to the Carles Rahola Public Library and the commercial area of Girona.
	Facultat de Medicina - UdG	Area of high density of population. Access to the Faculty of Medicine - UdG
Avinguda de Montilivi	Avinguda de Montilivi / Carrer Francesc Romaguera	Link stop between the town Avinguda Lluís Pericot and Montilivi Area of medium population density.
	Universitat de Girona (campus Montilivi) – Estadi Montilivi	Access to the University of Girona (Montilivi campus), Montilivi Stadium and Montilivi Institute Low population density area.

Table 14: Location, name and justification of the stopping points. Line 1. Source: Prepared by the Author.

Location of Line 2 stops

LOCATION	LOCATION – NAME	JUSTIFICATION
GI-533 Ctra. De Santa Coloma	Vilablareix	Access to the municipality of Vilablareix with a population of 3,000 habitants. Facilitates travel between Vilablareix and Girona. Proximity to the sports area.
	Parc comercial - Polígon Industrial Mas Xirgu	Access to industrial and commercial surfaces.
Carrer Barcelona	Clínica Girona	Access to the commercial surfaces of the Mas Gri shopping park and the future Girona Clinic
	c. Barcelona. 142 (Institut Ermessenda)	Area of medium density of population but in development. Access to the future Ermessenda Institute and the Masjid Al Nasr Mosque.
	El Corte Inglés - Plaça Salvador Dalí	Area of high density of population. Limit between the estates of Sant Pau and Sant Narcís. Access to the commercial area El Corte Inglés, the Cassià Costal school, the Parc Migdia, the GEiEG and Wellness/sport area.
Crta. Barcelona / Pg. d'Olot	Plaça Europa – Parc Central - Estació	Transfer stop between L1 and L2 tram. Area of high density of population. Access to the High Speed Station, Regional Services and Buses. Educational Facilities in the vicinity.
	Plaça Marquès de Camps	Area of high density of population. Access to commercial area and connection point between the estates of Sant Narcís, Eixample and Barri Vell
Rotonda del Rellotge	Correus	Strategic meeting point for the local population. Access to the Neighbourhoods Barri Vell and Devesa-Güell. Key location for city events (Fairs of St. Narcissus, ...) Area of medium population density.
Rambla de Xavier Cugat 2	OCINE	Facilitates travel between the estates of Fontajau and Girona Centre. Proximity to the sports area of GEiEG Sant Ponç, municipal sports facilities and leisure surfaces. Area of medium population density.
	Pavelló Girona-Fontajau	Area of medium population density. Access to the Girona-Fontajau Municipal Pavilion, a location where mass events take place.

Table 15: Location, name and justification of the stopping points. Line 2. Source: Prepared by the Author.

8. TECHNICAL CHARACTERISTICS

In accordance with the above, this section will detail the technical designs of the different alternatives presented and also the technical characteristics of the mobile material necessary for the implementation of the tram in the city of Girona.

8.1 LAYOUT ARCHITECTURE

The following publications have been taken into account for the configuration of the route:

- Manual of Design of the Urban Roads for the Sustainable Mobility drafted by the AMB Mobility. [4]
- Urban Mobility Plan of Girona approved on 15 December 2014 by the Plenary Session of the Girona City Council, which specifies the width of the traffic lanes according to the hierarchy of the road.

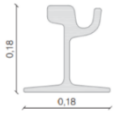
CRITERI	PRIMÀRIA	SECUNDÀRIA	VEÏNAL	CIRCULACIÓ RESTRINGIDA
Vehicle privat				
Velocitat de circulació	50	40	30	20 o 30
Prioritat de vianants en calçada	No	No	Possible (zona 30)	Si
Bicicleta				
Carrils bici	Segregat (en vorera o calçada)	Compartit amb marques viaries "sharrows"o segregat. Doble línia de parada	Compartit amb marques viaries "sharrows". Doble línia de parada	Compartir
Transport públic				
Parades	En carril de circulació	En carril de circulació	En carril de circulació	En carril de circulació
Freqüència de pas	Alta	Mitja	Excepcional	Excepcional
Prioritització	Semafòrica	Semafòrica	Senyalització viària	Senyalització viària
Seguretat				
Amplada de carrils de circulació	3,50	3,25 i si passa transport públic 3,50	3,00 i si passa transport públic 3,50	3 o plataforma única
Tractament pas de vianants	Senyalització viària. Semaforització en funció de intensitat de vianants i IMD, número de carrils de circulació sense refugi, sentits de circulació i entorn	Senyalització viària. Semaforització en funció de intensitat de vianants i IMD, número de carrils de circulació sense refugi, sentits de circulació i entorn	Si zona 30 no cal senyalitzar pas de vianants. Si limitació velocitat a 30, senyalització viària.	No cal senyalitzar
Sistemes de pacificació	Sistemes de detecció de velocitat instantanis i de trams	Canvis en l'alineació horitzontal de les vies	Canvis en l'alineació horitzontal de les vies i passos de vianants elevats. Plataforma única	Canvis d'alineació vertical i horitzontal. Plataforma única.
Gestió de l'estacionament	En línia. Preferiblement de serveis (Càrrega i descàrrega, contenidors). Aparcaments dissuasoris	En línia. En passos de vianants no semaforitzats sense orella: P de motos	Si	Només càrregues i descàrregues i veïns
Càrregues i descarregues	De 8.00 a 19.00 hores. Ocasional nocturnes fins a les 23.00	De 8.00 a 19.00 hores. Molt excepcional nocturnes fins a les 23.00	De 8.00 a 19.00 hores.	Accés de 7.00 a 11.00, prolongació operacions fins a les 12.00. En bicicleta fins a les 20.00
Restricció d'accés	No	No	Ocasional	Si

Picture 16: Network management criteria. Source: Girona City Council. In accordance with current regulations, the value marked in yellow should be 40 km/h due to recent changes web.girona.cat/documents

[4] http://www3.amb.cat/repositori/MOBILITAT/Manual_2014_10.pdf

8.1.1 Basic vehicle dimensions

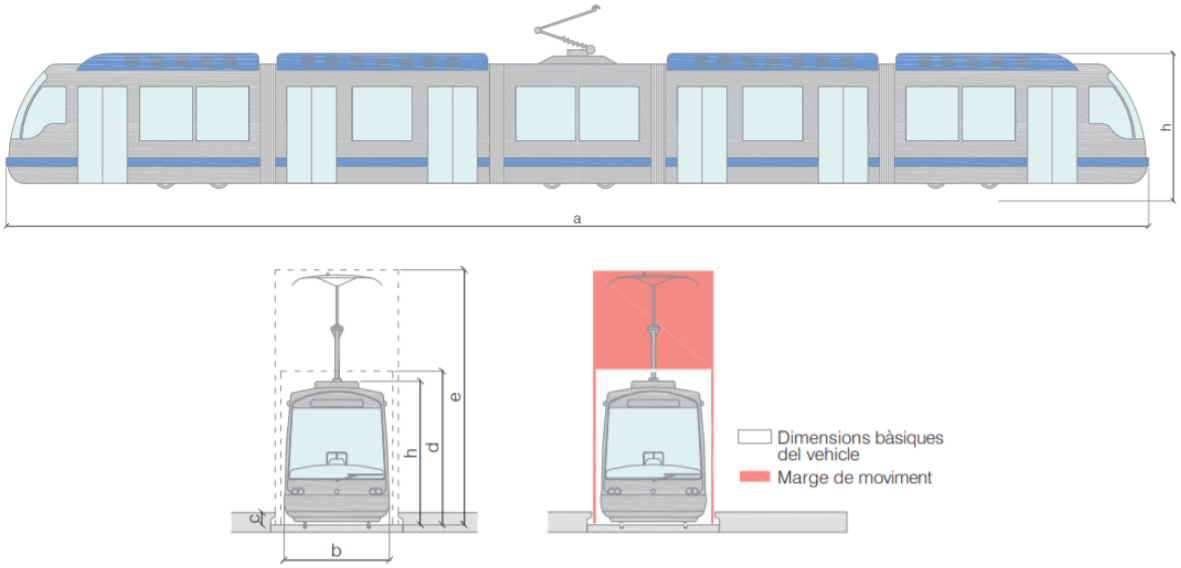
The following route characteristics are proposed considering the specificities of the streets and the compatibility with the tram system:

Track width:	1,435 mm (UIC width)
Minimum curved radius:	18 m
Recommended curved radius to avoid speed reduction and deterioration of mobile material:	Greater than 35 m
Maximum gradient:	70‰ (in urban area)
Lane typology	Model Ri-60N 
Distances between wheelbase	3.10 m without infrastructure of the catenary at the rail gauge 3.50 m with catenary infrastructure at the rail gauge

The transition between a straight and curved area would be made through an Euler spiral railway transition zone.

In accordance with the above, the following guidelines for a tram system are advised:

Vehicle length (a)	25 – 30 m
Vehicle width (b)	2.40 m
Floor height (c)	0,35 – 0,50 m
Vehicle height (h)	3.50 m
Height capture (e)	Minimum 3.80 m (d) Maximum 6.50 m



Picture 17: Parameters of the route and type of convoy. Source: AMB Mobilitat

8.1.2 Types of vertical lay-outs

The implementation of reserved platforms (segregation of other vehicles) is chosen in order to guarantee safety and punctuality, in such a way that the horizontal circulation of any other vehicle above the road is prohibited, except in the duly determined areas that can be for example roundabouts and interactions.

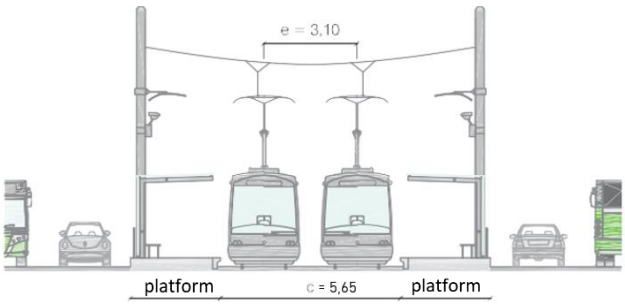
The level of segregation can be reached by installing the following elements:

- Physical elements of separation: curbs or green stripes with vegetation, ...
- Reserved platforms

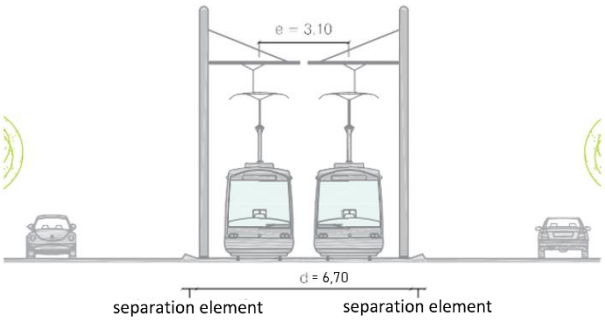
The following section parameters are proposed:

		without infrastructure of the catenary at the rail gauge	with catenary infrastructure at the rail gauge
One way	At a stopping point	2,80	
	Between stopping points	3,35	
Two way	At a stopping point	5.65 (a)	6,00 (c)
	Between stopping points	6.70 (b)	7.10 (d)

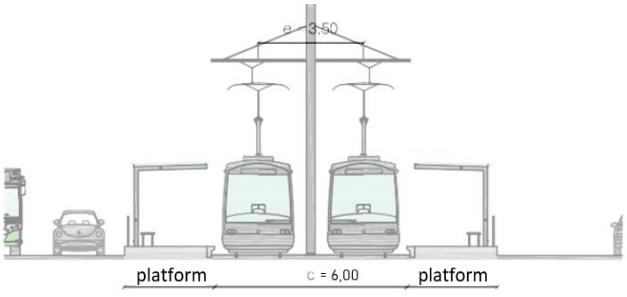
a. Example of a bidirectional platform with platforms and side posts.



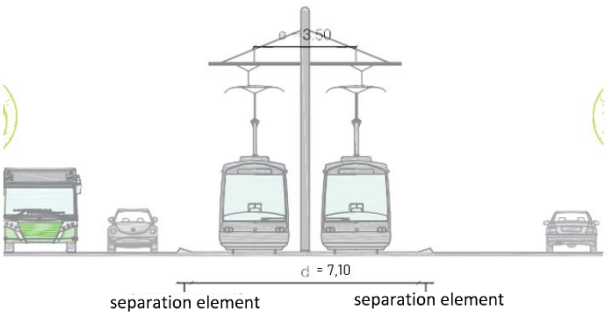
b. Example of a bidirectional platform with dividers and side posts.



c. Example of a bidirectional platform with platforms and central



d. Example of a bidirectional platform with dividers and central post.



Section 1: Vertical lay-out parameters. Source: www.amb.cat

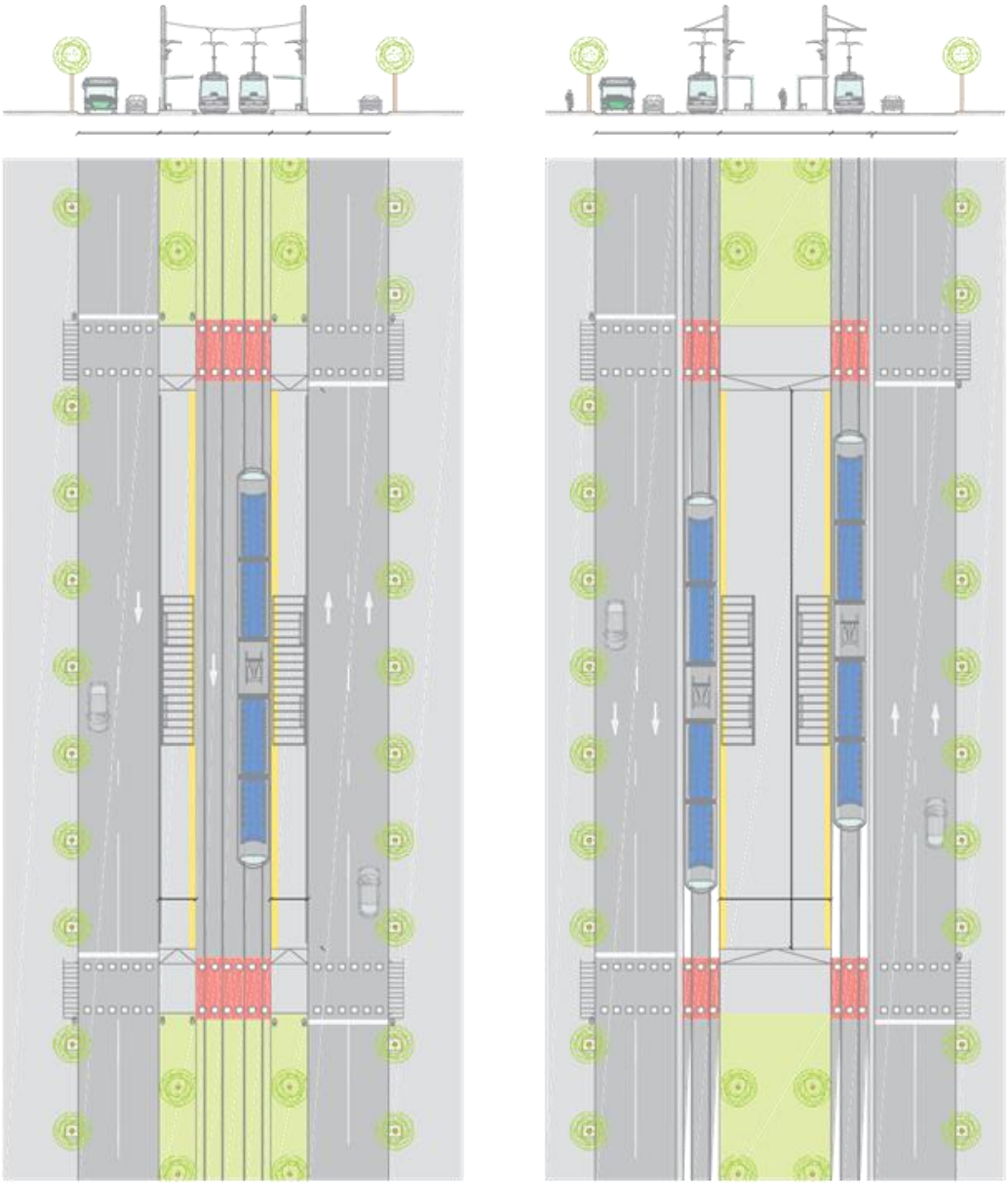
8.1.3 Stops

The following characteristics are proposed for the stops:

Platform width	Minimum 3 m Recommended 5 m
Platform length	35 – 40 m
Platform height	0.35 m

Stop point without infrastructure of the catenary at the rail gauge

Stop with catenary infrastructure at the rail gauge



Section 2: Stopping points. Source: amb.cat

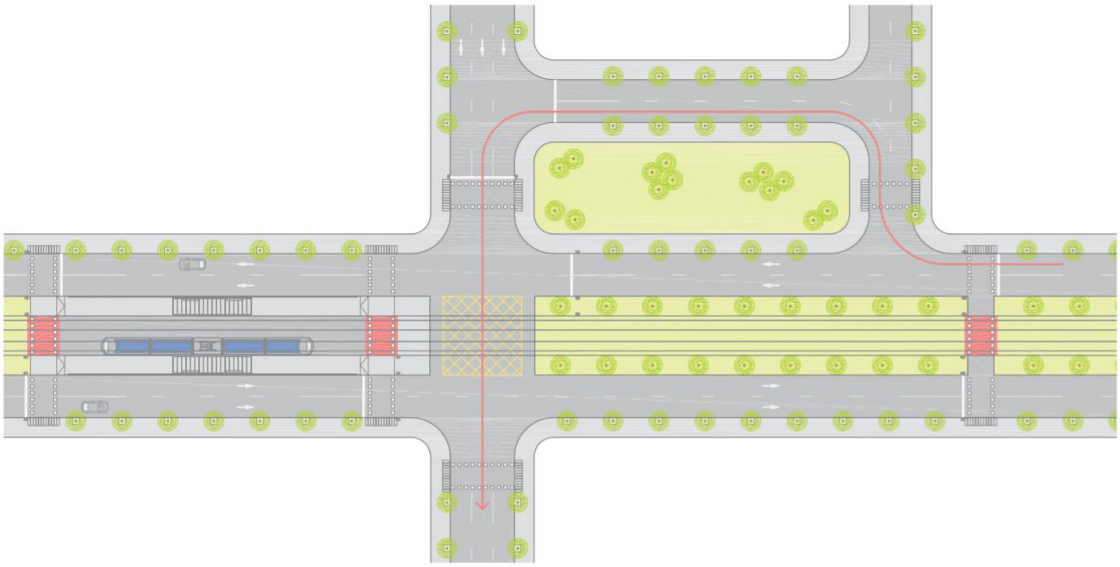
8.1.4 Intersections

Interactions shared between the different agents of the road network are points of special attention, since the design must be safe and fluid.

Specific signage for trams is recommended and horizontally and vertically signal the interactions between vehicles and trams.

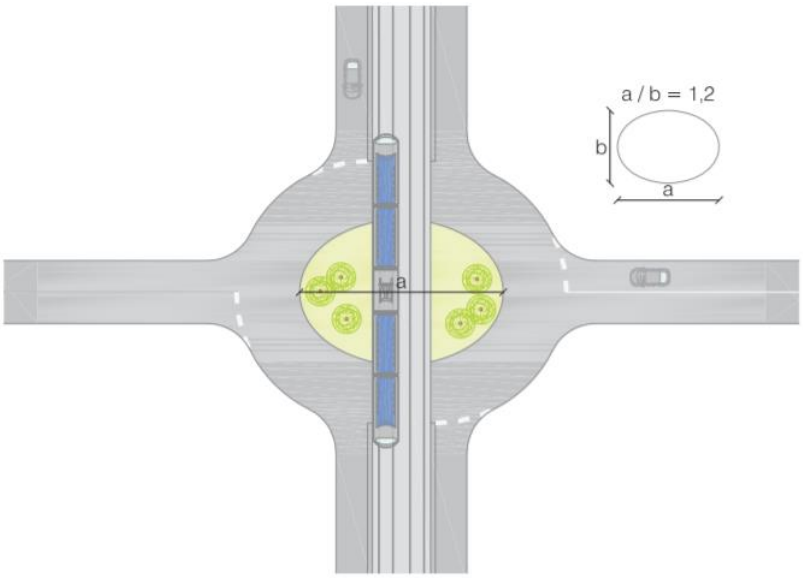
It is proposed the use of a yellow grid and a vertical signal P-6.

Intersections of increased risk:



Section 3: Crossroads of special attention Source: amb.cat

Intersection of increased risk between tram and roundabout:



Section 4: Intersection of special attention between tram and roundabout. Source: amb.cat

8.1. 5 Maintenance workshop, depot and CTC

The workshops and depots would be located on a plot at the end of line 1, near the AP-7 Mediterranean Motorway.

According to the characteristics of the service, it requires a plot large enough to accommodate an installation of about 7,200 m².

Installation parts:

- Workshop: area for the repair and maintenance of the units. Composed of: a paint and wheel track, two maintenance tracks and a washing train.
- Depots: accommodating the units, made up of eight tracks.

The building also includes: office and administration area, changing rooms, and the CTC.

Centralised Traffic Control (CTC)

It is a chamber that acts as a control center for the tram system. The CTC allows, through a single agent, to supervise and remote control the service in real time.

- Control tram traffic and stopping points
- Viewing of video surveillance images
- Communication with drivers
- Supervision of electrical systems
- Supervision of traffic signalling systems

Picture 18: Computer recreation of the tram installation that would house the Workshops, Depots and CTC in the city of Salt. Source: tw.waw.pl

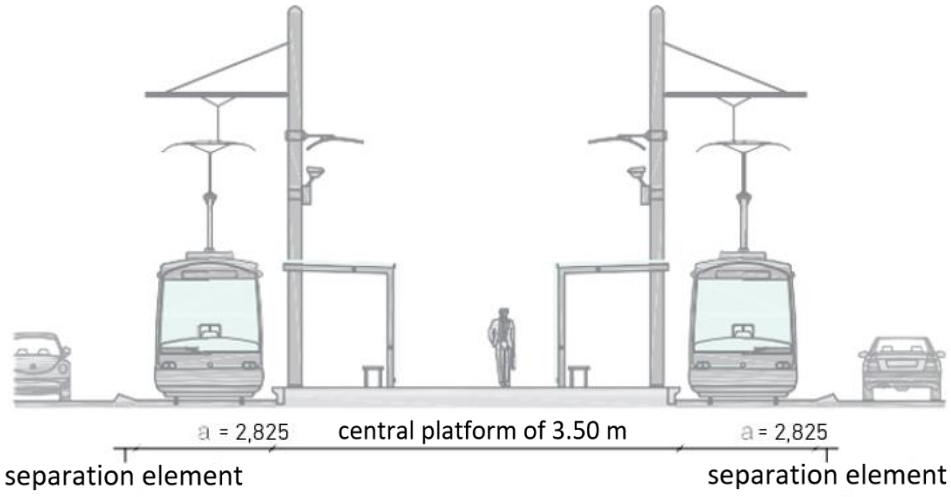
8.2 COMPATIBILITY CHECK

I proceed to assess the compatibility of the tram infrastructure with the width of the streets. The study also suggests the dimensions (width) of the curb, the possibility of introducing bike lanes, the number of traffic lanes for vehicles and the corresponding width.

The width of the streets has been obtained through plans of the Girona City Council and Google Maps, which is why this data may not be accurate.

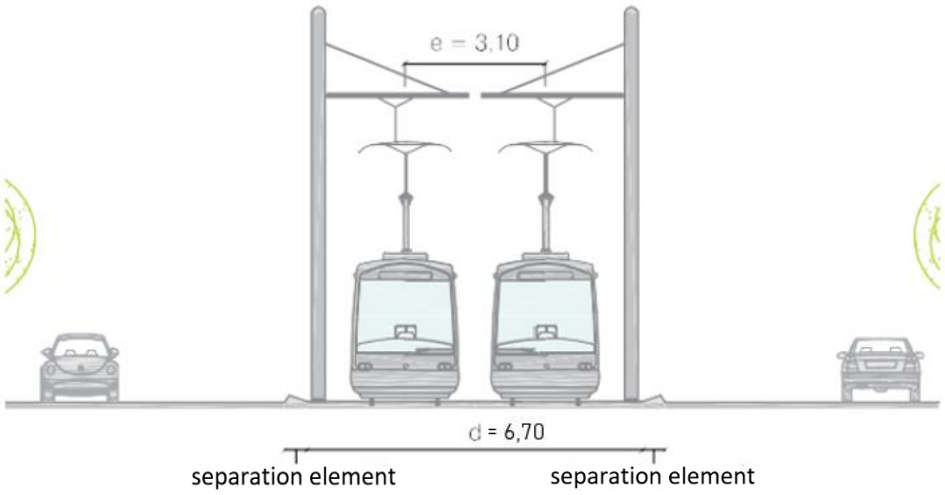
The width of the lines varies according to the section, consequently the location of the stops must be contemplated in the areas of maximum width, in order not to reduce the traffic lanes of vehicles.

The following structure is chosen: bidirectional platform with central platform (3.5 m) and side poles (a = 2,825 m x2)



Section 5: Section parameters proposed A1. Source: www.amb.cat

In the streets where its width is reduced, the following structure is chosen:



Section 6: Section parameters proposed A2. Source: www.amb.cat

8.2.1 Compatibility Table

The following table shows the width of the platforms between stop points and at stopping point, the platform, the length of the curb, the possibility of installing a bike lane and the number of lanes available for road traffic with the width corresponding to each lane.

L1: Espai Gironès-Salt-Girona-UdG Montilivi

Street	Street width (m)	Section platform width (m)	Width platform section at stopping point (m)	Stop (m)	Total Tram (m)	Pavement (sidewalk) (m)	Bike Lane	Bike Lane Width (m)	Traffic Lanes	Width of Lanes of Circulation (m)	COMPATIBILITY
Passeig dels Països Catalans	26,00	6,70	5,65	3,50	**9,15**	6,35	no		**3**	3,50	**yes**
Passeig d'Olot	28,50	6,70	5,65	3,50	**9,15**	6,00	yes	2,85	**3**	3,50	**yes**
Carrer Emili Grahit	28,50	6,70	5,65	3,50	**9,15**	6,00	yes	2,85	**3**	3,50	**yes**
Avinguda Lluís Pericot	34,00	6,70	5,65	3,50	**9,15**	8,00	yes	2,85	**4**	3,50	**yes**
Avinguda de Montilivi	20,00	6,70	5,65	3,50	**9,15**	4,85	no		**2**	3,00	**yes**

L2: Vilablareix-Eixample-Correus-Fontajau PROPOSAL I

Street	Street width (m)	Section platform width (m)	Width platform section at stopping point (m)	Stop (m)	Total Tram (m)	Pavement (sidewalk) (m)	Bike Lane	Bike Lane Width (m)	Traffic Lanes	Width of Lanes of Circulation (m)	COMPATIBILITY
Ctra. De Santa Coloma	35,00	6,70	5,65	3,50	**9,15**	4,85	no		**6**	3,50	**yes**
Carrer de Sarrià de Ter	16,05	6,70			**6,70**	3,35	no		**2**	3,00	**yes**
Espai viaducte	25,00	6,70	5,65	3,50	**9,15**	9,85	yes	3,00	**1**	3,00	**yes**
Carrer Berenguer Carnicer	28,00	6,70	5,65	3,50	**9,15**	4,85	no		**4**	3,50	**yes**
Passeig de la Devesa	50,00	6,70	5,65	3,50	**9,15**	10,00	yes	3,00	**4**	3,50	**yes**
Pont de la Barca	11,05	6,70			**6,70**	4,35	no				**yes**
Avinguda de França	16,05	6,70			**6,70**	3,35	no		**2**	3,00	**yes**
Rambla de Xavier Cugat	33,00	6,70	5,65	3,50	**9,15**	6,85	yes	3,00	**4**	3,50	**yes**

L2: Vilablareix-Eixample-Correus-Fontajau PROPOSAL II

Street	Street width (m)	Section platform width (m)	Width platform section at stopping point (m)	Stop (m)	Total Tram (m)	Pavement (sidewalk) (m)	Bike Lane	Bike Lane Width (m)	Traffic Lanes	Width of Lanes of Circulation (m)	COMPATIBILITY
Ctra. De Santa Coloma	35,00	6,70	5,65	3,50	**9,15**	4,85	no		**6**	3,50	**yes**
Carrer de Sarrià de Ter	16,05	6,70			**6,70**	3,35	no		**2**	3,00	**yes**
Carrer Barcelona	22,00	6,70	5,65	3,50	**9,15**	6,05	no		**2**	3,40	**yes**
Plaça Marquès de Camps	40,00	6,70	5,65	3,50	**9,15**	6,00	yes	3,00	**4**	3,50	**yes**
Ronda Ferran Puig	19,10	6,70			**6,70**	6,40	no	0,00	**2**	3,00	**yes**
Riu Güell	42,00	6,70	5,65	3,50	**9,15**	6,00	yes	3,00	**3**	3,50	**yes**
Carrer Berenguer Carnicer	28,00	6,70	5,65	3,50	**9,15**	4,85	no		**4**	3,50	**yes**
Passeig de la Devesa	50,00	6,70	5,65	3,50	**9,15**	10,00	yes	3,00	**4**	3,50	**yes**
Pont de la Barca	11,05	6,70			**6,70**	4,35	no				**yes**
Avinguda de França	16,05	6,70			**6,70**	3,35	no		**2**	3,00	**yes**
Rambla de Xavier Cugat	33,00	6,70	5,65	3,50	**9,15**	6,85	yes	3,00	**4**	3,50	**yes**

Table 16: Accounting Table. Source: Prepared by the Author

8.3 VEHICLE STOCK

There are three main tram manufacturers:

- Bombardier Inc.
- Grupo CAF, S.A.
- Alstom S.A.

The tram route does not pass through any historic center or monumental building, so that the infrastructure of the catenary would not damage the subsoil of the old town or visually contaminate the historic buildings. Consequently, the use of electrified or hybrid rails could be discarded.

According to the characteristics of the streets and transportation demand that the tram would fulfil, tram/light-metro would be the best option.

Light metro/tram operates on a platform segregated from the rest of the traffic and has an intermediate transport capacity between the regional and metropolitan scale.

It is proposed that the supplier of trams for the Girona Tram System be Alstom S.A., a French company manufacturing trains and rail signalling. The company has production facilities in La Rochelle (France) and Barcelona (Catalunya).

The specifications of the different models determine that the Alstom Citadis range is the one that best suits the system. These models have a standard and modular design, allowing greater capacity, comfort and flexibility with a lower maintenance cost and energy consumption.

Model Alstom Citadis	Length (m)	Width (m)	Nº of base modules	Capability
– **Compact**	25 - 30	2,4 - 2,65	3	120 - 140
– **205**	25	2,4	3	142
– **305**	32 - 37	2,4 - 2,65	5	202 - 238
– **405**	43 – 45	2,4 - 2,65	7	271 - 341

However, Alstom offers modularity and adaptability to fit the characteristics of each city.

An Alstom Citadis Model 205 would be requested with the following characteristics: 25m long and 2.4m wide with 3 base modules of a capacity of 140 passengers.

The acquisition cost of each unit mobile *Model Alstom Citades 205* with special modelling is of 2.500.000€.

Picture 19: Alstom tram compatible with Girona's tram system. Source: alstom.com

9. STUDY OF DEMAND

To analyse the potential users of the proposed tram system, it is necessary to generate a model of demand for public and private transport and at the same time apply the relevant modifications to refine the demand as much as possible.

The following hypotheses are assumed for implementation:

- The total number of daily urban journeys on weekdays in the non-motorised walking mode will continue the trend of recent years with 65% compared to the total.
- Continuity of the notable use of the bicycle in the study area, with 3% with respect to the total number of daily urban journeys on weekdays.
- Exponential growth in the use of public transport with the implementation of the tram, going from 17,610 daily trips to about 23,000.
- Substantial reduction in the use of private vehicles for intra-municipal travel. It is estimated that a reduction will take place thus avoiding traffic congestion in the centre and parking time.

The lay-out of the suggested routes corresponds to two axes perpendicular to the Girona-centre urban system with a commercial speed of around 30 km/h, with stops strategically placed in hundreds of interest every approximately 400 m.

9.1 TERRITORIAL COVERAGE

The area of study has been divided by estates in the city of Girona and by entity as a whole in the municipalities of Salt and Vilablareix.

The coverage area that the tram service would provide in the city of Girona would be 97%, with stops in all estates directly or in their delimitation except Montjuïc. The number of inhabitants covered directly would be 100,756.

The coverage of Salt is total thanks to its passage through the Passeig dels Països Catalans (32,138 inhabitants) and Vilablareix due to its stop at the beginning of the town (Ctra. of Santa Coloma (1,116 inhabitants)).

	Inhabitants 2020	%	Stop
Girona			
Center	9.916	9,58%	Yes
Eixample	44.784	43,25%	Yes
East	4.551	4,39%	Yes
Mas Xirgu	17	0,02%	Yes
Montjuïc	2.794	2,70%	
North	4.013	3,88%	Yes
West	9.834	9,50%	Yes
Saint Eugenia	17.507	16,91%	Yes
South	10.134	9,79%	Yes
TOTAL	103.550	100,00%	

	Inhabitants 2020	Section coverage	Number Covered Section
Girona	103.550	97%	100.756
Salt	32.138	100%	32.138
Vilablareix	1.116	100%	1.116

Table 18: Territorial coverage of Girona, Salt and Vilablareix. Source: prepared by the Author

9.2 CLIENT ACQUISITION FROM THE CURRENT TRANSPORT

Secondly, given the tram route and the locations of the 20 stops, it is considered that the following shares could be overtaken from current public transport:

- 100% of lines L3, L4, L8 and L9: 2,350,000 trips/year
- 85% of lines L5 and L11: 1,125,000 trips/year
- 70% of lines L2 and L7: 680,000 trips/year
- 50% of line L1: 415,000 trips/year
- Between 5% and 10% of lines L6, L10 and L12: 60,000 trips/year

The total acquisition of the passengers from the current bus lines would be around 75%, representing a total figure of about 4,600,000 trips/year, 12,744 trips/daily.

	trips 2019	travel estimate 2020	% recruitment	trips overtaken from TMG and TEISA
L1	804.267	821.586	50%	410.793
L2	699.360	714.420	70%	500.094
L3	1.299.297	1.327.276	100%	1.327.276
L4	693.836	708.777	100%	708.777
L5	950.736	971.209	85%	825.527
L6	781.906	798.743	5%	39.937
L7	241.938	247.147	70%	173.002
L8	217.269	221.947	100%	221.947
L9	82.058	83.825	100%	83.825
L10	102.490	104.697	10%	10.469
L11	329.045	336.130	85%	285.710
L12		3.802	10%	380
TOTAL	**6.202.202**	**6.339.559**		**4.587.737**

Table 19: Recruitment of the current public transport service. Source: prepared by the Author

9.3 POTENTIAL DEMAND

Finally, the demand for the tram for the years 2025-2050 is calculated in the two scenarios contemplated: optimistic (base case) and pessimistic.

— **Most likely scenario or base case**: This is the situation that is expected to occur most likely in the system. The hypotheses for the estimation of the variables involved in determining demand have been made trying to adjust to what is expected to happen on the time horizon of planning the investment project.

— **Pessimistic scenario**: In this situation, the variables that have used as a reference for scenario configuration take significantly lighter values that worsen the initial demand forecasts.

The implementation of the tram system usually presents a significant increase in usage quotas compared to the predecessor transport systems, as it has been seen in European cities. In addition, as it consolidates, the system attracts new passengers year after year.

The following is proposed:

- Base increase on the 12,744 daily travellers to improve the service by 75%.
- Year-on-year growth rate of 25% in the first 5 years of service.
- Moderate year-on-year growth rate of 15% between 2031-2040.
- Weak year-on-year growth rate of 10% between 2041-2050.

However, it is estimated that the total demand for the most likely (optimistic) scenario will be for the first year of operation of about 8.5M users (23,500 users/day) and that it would end up consolidating between 2030-2040 with about 12-15M passengers per year (between 30,000 and 38,000 users).

Moderate-weak year-on-year growth linked to population growth is assumed from 2031. By 2050, the service would end up taking on about 46,000 trips a day in the most likely scenario (42,000 in a pessimistic scenario).

Most likely scenario						
Year	Population AFTE Girona+Salt+Vilablareix	Base increase for service improvement	Growth rate	% on calculated demand	Total passengers/year	Users/day
2025	153.577	0,75		100%	8.484.658	23.568
2030	160.134		25%	130%	11.058.641	30.718
2040	174.100		15%	163%	13.826.581	38.407
2050	189.286		10%	195%	16.535.876	45.933
Pessimistic scenario						
Year	Population AFTE Girona+Salt+Vilablareix	Base increase for service improvement	Growth rate	% on calculated demand	Total passengers/year	Users/day
2025	151.350	0,75		100%	8.361.624	23.227
2030	155.522		25%	127%	10.740.142	29.834
2040	164.215		15%	154%	13.041.540	36.226
2050	173.397		10%	179%	15.147.826	42.077

Table 20: Most likely and pessimistic scenario of users for year and day in the new section service. Source: prepared by the Author

10. EXPLOITATION

Two two-way lines with 10 stops each are proposed. L1: Espai Gironès-Salt-Girona-UdG Montilivi, would have 5,171 km and L2: Vilablareix-Eixample-Correus-Fontajau would be 5,558 km long.

The service would be from East to West on L1: Espai Gironès in UdG Montilivi and from South to North on L2: Vilablareix in Fontajau.

10.1 RATES

In the following, I suggest a fare system for the Girona Tram Service. The following prices have been determined assuming that the price of the ticket and the ticket system determine the economic accessibility of the service for the population. The values are presented with VAT included, since it is the final price that the user sees.

At the same time, a percentage of free trips that can be awarded to certain sectors of the population is contemplated, such as citizens under ten years of age, retired, disabled or those who meet the required economic conditions.

The technical rate of the Tramway Public Transport System contemplates the cost of the passenger paid by the user plus the subsidy per passenger paid by the public administration.

See below my proposal of fare policy and the distribution of income by modality in the first financial year:

RATES	Single ticket	10 travel card	30 travel card	Monthly subscription	Free
VAT included price	1,40 €	9,90 €	22,50 €	42,50 €	0,00 €
VAT included price / trip	1,40 €	0,99 €	0,75 €	0,71 €	0,00 €
Percentage	27%	35%	14%	10%	14%

Vat travel subsidy included:	**0,46 €**
Technical rate of the area without VAT:	**1,36 €**
Annual rate increase:	**1,50%**

Table 24: Proposal for fare policy. Source: prepared by the Author

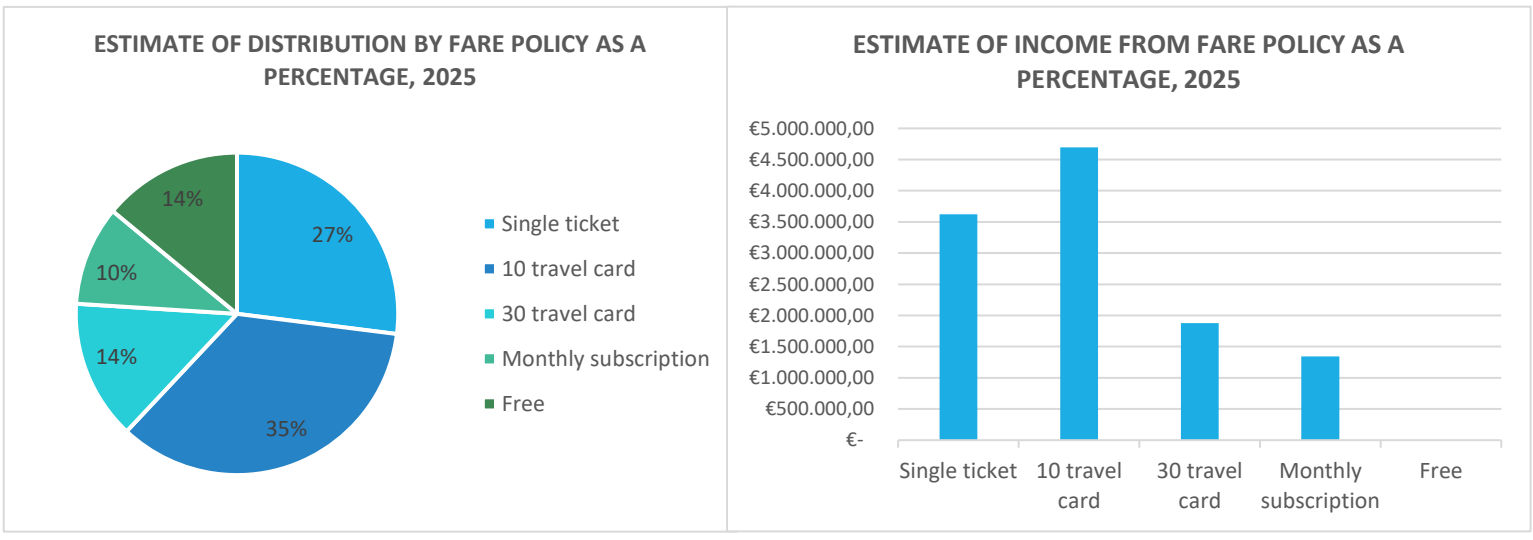


Table 21: Tariff policy estimates for the first year of operation Source: prepared by the Author

10.2 SERVICE FREQUENCIES

Tram service is proposed from 6:00 a.m. to 12:00 p.m. The asymmetry of demand depending on the time of day requires time slots depending on this intensity.

The frequency of passage of the convoys is established according to the current demand and frequencies of the bus service, adapted to the socioeconomic reality of the area and operational criteria.

Rush hour use is recommended on a working day from 7:00 a.m. to 9:00 p.m., from 2:00 p.m. to 3:00 p.m. and from 4:30 p.m. to 7:30 p.m. with a frequency of 10 minutes. The rest of the day (off-peak hours) with a frequency of 15 minutes.

On Saturdays a frequency of 20 minutes and on Sundays and holidays a frequency 30 minutes (45 mins for summer holidays) is recommended. There should be the possibility of creating night service for certain dates, such as the main festivities, with a frequency of 60 minutes.

		HOURS
Service	from 6 to 24	*18*
Rush hour	from 7 a.m. to 9 p.m.	*2*
	from 2 p.m. to 3 p.m.	*1*
	from 16:30 to 19:30	*3*
Off-peak hours	rest day	*12*

Step freq. (min)	L1: E. Gironès-UdGMontilivi	L2: Vilablareix-Fontajau
Rush hour working day	10	10
Off-peak working day	15	15
Saturday	20	20
Nocturnal	60	60
Festive	30	30
Summer holiday	45	45

The Lap Route Time is the time it takes to make the start - end of line route and is established by means of the following formula:

Moving Time + Stop Time + Security Time

The time at stop is the time, waiting at stop, necessary for the entry and exit of users, on average it is set in about 40 seconds.

Security Time is the additional time frame configured for any unforeseen events that may arise.

	L1: Espai Gironès-Salt-Girona-UdG Montilivi	L2: Vilablareix-Eixample-Correus-Fontajau
Length (km)	**5,171**	**5,558**
Route time start - end line (min)	**20**	**20**
Moving time	10	11
Time to stop	8	8
Security Time	2	1
Lap route time (min)	**40**	**40**

10.3 COMMERCIAL SPEED, VEHICLE STOCK AND MILEAGE

The commercial speed is calculated by dividing the length between the start and end of the line between the total journey time, including all the factors that determine the same.

The factors that determine commercial speed are:

- Opening and closing doors
- Alighting and disembarking
- Braking time and acceleration time
- Traffic, minimised through the implementation of dedicated platforms (segregation) and traffic light priority.

The commercial speed, applying the previous formula, would be of 25.9 km/h for line 1 and 27.8 km/h for line 2.

The quantity of the vehicle units needed in operation is the result of calculating the minimum value of service frequencies (10 min) divided the Lap Route Time (40 min).

Of the previous application, there are four trains for each line, eight in total. At the same time, a back-up of a train (reserve) is proposed for each line. See the following table:

	L1: Espai Gironès- UdG Montilivi	L2: Vilablareix-Fontajau	TOTAL
Trains needed in operation	4	4	8
Trains required (includes reserve)	5	5	10

In accordance with the above parameters, the mileage per hour, day and annual of the two lines is calculated. See in the following table the differences between the mileage of the service on weekdays (Monday to Friday), holidays and others.

Length per hour (km)	**L1**	**L2**
Working Rush Hour	62,052	66,696
working off-peak hour	41,368	44,464
Saturday	31,026	33,348
nocturnal	10,342	11,116
Holiday	20,684	22,232
Summer Bank Holiday	13,789	14,821

Length per day (km)	**L1**	**L2**
Working Rush Hour	372,312	400,176
working off-peak hour	496,416	533,568
Saturday	558,468	600,264
nocturnal	62,052	66,696
Holiday	372,312	400,176
Summer Bank Holiday	220,629	237,141

Length per year (km)	**days/year**	**L1**	**L2**	
Working	255	221.526	238.105	
Saturday	50	27.923	30.013	
Nocturnal	25	1.551	1.667	
Holiday	50	18.616	20.009	
Summer Bank Holiday	10	2.206	2.371	**ANNUAL TOTAL in km**
TOTAL (km)		**271.822**	**292.166**	**563.988**

11. BUDGET

The following point presents a detailed estimate of the investment necessary for the implementation of the tram, budgeting several items: route urbanisation, catenary, stops, mobile material, etc.

Macro adjusted economic units determined by the following documents have been used for their preparation:

I. L'ESTUDI DE VIABILITAT D'UN TRAMVIA INTERCOMARCAL A LES COMARQUES GIRONINES. (authorship: Diputació de Girona, 2008 https://www.cilma.cat/wp-content/uploads/Documents%20i%20informes/Tramvia%20intercomarcal/separata%20resum%20estudi%20tramvia%20novembre08.pdf).
II. ESTIMACIÓ DE LA INVERSIÓ D'INFRAESTRUCTURES I INSTAL·LACIONS TRAMVIÀRIES (authorship: Ajuntament de Saragossa, 2016 https://www.zaragoza.es/contenidos/tranvia/linea2/TOMOII.pdf)
III. BASE DE PREUS DE LA CONSTRUCCIÓ DEL GOVERN (https://infraestructures.gencat.cat/)
IV. DESPESES GENERALS D'ESTRUCTURA I BENEFICI INDUSTRIAL AL CONTRACTE DE SERVEIS. APLICACIÓ DELS PERCENTATGES ESTABLERTS (https://www.hacienda.gob.es/Documentacion/Publico/D.G.%20PATRIMONIO/Junta%20Consultiva/informes/Informes%202020/2019-040Gastosgrales.pdf)

In accordance with the current legislation, the Tender Base Budget is calculated by the sum of the following budgetary sections:

- Budget of Material Execution
- General Expenses (13% of the Material Execution Budget)
- Industrial Profit (6% of the Material Execution Budget)

The budget for the knowledge of the administration is prepared by means of the sum of the following sections:

- Tender Base Budget
- Budget of Expropriations and Compensation.

11.1 BUDGET FOR THE EXECUTION OF THE INFRASTRUCTURE AND TRAM NETWORK

11.1.1 Construction

This section takes into account the costs of previous actions and land movement, to prepare the terrain, surface costs, which include roads, grass and asphalt and urbanisation costs (sewage sanitation, outdoor lighting, urban furniture, etc.).

CONSTRUCTION PRICE BASE	€/m	Budget Execution
Preparatory activities and terrain works	520	5.579.080
Surface (track, grass and asphalt)	2.200	23.603.800
Urbanisation (Sewage sanitation, outdoor lighting, urban furniture, ...)	2.700	28.968.300

11.1.2 Electrification

This section assessed the electrical grid, which includes the poles and the contact airline (catenary), electronic security systems, communication elements and the necessary electrical substations.

The cost of each electrical substation is €2,000,000 and 5 of them are required, in accordance with the *Tranvías Manual, metros ligeros y sistemas en plataforma reservada* (Zamorano Martín, Clara). With regard to the tram communications system, a specific network of sensors and other elements is required at an approximate cost of € 7 M.

CONSTRUCTION PRICE BASE	€/m	Budget Execution
Electrical grid and tram systems	1.900	20.385.100
Overhead grid line - Catenary	930	9.977.970
	Ud	
Electrical substations	5	10,000,000
Communication Elements	1	7.000.000

11.1.3 Depots and Repair Shop

The railway infrastructure needs a depot and a repair shop in order to perform maintenance actions. The installation requires a minimum area of 7,200 square meters. The construction budget for this facility is €1,008,000.

CONSTRUCTION PRICE BASE	m2 required	Amount m2	Budget Execution
Construction of Depots and Repair Shop	7.200	140 €	1.008.000 €
Expropriations	7.200	30 €	216.000 €

11.1.4 Complementary works

This section assesses the interventions that, without being attributable to the project, are necessary for the proper functioning of the tram system.

In many cases, the implementation of this infrastructure becomes an opportunity to unleash projects already planned and not executed by public administrations and for private investors, such as:

Urbanisation project of the area of PMU 106/ pa 103, around the Shopping Center "el Corte Inglés" and crossing of C/Barcelona and Martí Sureda street in Girona.

Urbanisation project of the Urban Development Area 116 Barcelona-Avellaneda Clínica Girona street.

Urbanisation Project of Carrer Oriol Martorell i Codina, 32-34

Construction project for the splitting and extension of the exit branch of the C-65 at the junction with the N-IIa, in Girona

In the following link you can find all the projected actions:
https://terra.girona.cat/vu/actuacions_urbanisme/

11.1.5 Stop Points and Mobile Material

The construction cost of each stop is around €335,000 and this figure has been obtained from the documents mentioned above at prices by 2022. The acquisition cost of each mobile unit is € 2,500,000.

CONSTRUCTION PRICE BASE	Ud	Ud amount	Budget Execution
Stops	20	335.000 €	6.700.000 €
Vehicle Stock (cars 2.4 m wide and 25 m long)	10	2.500.000 €	25.000.000 €

11.1.6 Traffic restrictions, diversions and services affected, Unforeseen events, Health and Safety and Quality Control

Traffic restrictions, diversions and services affected, unforeseen events, health and safety and Quality Control are assessed on a percentage basis on the PRELIMINARY MATERIAL IMPLEMENTATION BUDGET.

	% above PRELIMINARY MATERIAL IMPLEMENTATION BUDGET
Traffic restrictions, diversions and services affected	2,5%
Unforeseen	5,5%
Health & Safety	1,0%
Quality Control	1,0%

11.2 BUDGET OF MATERIAL EXECUTION

The MATERIAL IMPLEMENTATION BUDGET is presented below in accordance with the above.

INVESTMENT BUDGET	
Game I: TRAM ROUTE EXECUTION BUDGET	
Preparatory activity and terrain works	5.579.080,00 €
Superstructure (track, grass and asphalt)	23.603.800,00 €
Signage and Safety Elements	5.900.950,00 €
Urbanisation (Sewage sanitation, outdoor lighting, urban furniture, ...)	28.968.300,00 €
Overhead grid line - Catenary	9.977.970,00 €
Electrical grid and tram systems	20.385.100,00 €
Complementary works	858.320,00 €
SUBTOTAL I	95.273.520,00 €
Item II: BUDGET FOR THE EXECUTION OF THE INFRASTRUCTURE AND TRAM NETWORK	
Stops	6.700.000 €
Construction of depots and repair workshop	1.008.000 €
Vehicle stock (cars 2.4 m wide and 25 m long)	25.000.000 €
Electrical substations	10.000.000 €
Communication Elements	7.000.000 €
SUBTOTAL II	49.708.000,00 €
PRELIMINARY MATERIAL EXECUTION BUDGET	144.981.520,00 €
Traffic restrictions and detours	3.624.538,00 €
Unforeseen	7.973.983,60 €
Health & Safety	1.449.815,20 €
Quality Control	1.449.815,20 €
I. BUDGET OF MATERIAL EXECUTION	**159.479.672,00 €**

The percentages of Industrial Benefit (6%) and General Expenditure (13%), resulting in the BASE BID BUDGET WITHOUT VAT, are applied below, in accordance with current legislation:

I. BUDGET OF MATERIAL EXECUTION	**159.479.672,00 €**
Industrial profit (6%)	9.568.780,32 €
General Expenses (13%)	20.732.357,36 €
II. TOTAL BASE BID BUDGET WITHOUT VAT	**189.780.809,68 €**

The Value Added Tax (VAT) of 21 percentage points is applied below, resulting in the BASE BID BUDGET WITH VAT:

II. TOTAL BASE BID BUDGET WITHOUT VAT	**189.780.809,68 €**
VAT (21%)	39.853.970,03 €
III. TOTAL BASE BID BUDGET WITH VAT	**229.634.779,71 €**

Below is the value of expropriations in the BASE BUDGET OF TENDER WITH VAT, resulting in the BUDGET FOR KNOWLEDGE OF THE ADMINISTRATION:

III. TOTAL BASE BID BUDGET WITH VAT	**229.634.779,71 €**
Expropriations	216.000,00 €
IV. TOTAL BUDGET FOR KNOWLEDGE OF THE ADMINISTRATION	**229.850.779,71 €**

12. OPERATING COSTS

Operating costs are ordinary expenses, attributable to operation and maintenance, which are necessary for the normal operation of the tram service. According to the characteristics of the service, one can group them by:

- Personnel Costs
- Maintenance, cleaning and repair costs
- Energy Costs
- Technical Assistance Costs and Security Elements
- Other Costs

For its preparation, economic units provided by *Sociedad Concesionaria Tramvia de Murcia* have been used for its own consultation.

12.1 PERSONNEL COSTS

The following table shows the dimensional estimation of the necessary personnel and the corresponding cost for the normal operation of the service.

AREA		nº of staff	Base salary + Supplement	Total Salaries and Annual Salaries
Management		1	40.000	40.000
Head of Traffic		1	35.000	35.000
Drivers		48	33.400	1.603.200
Command		5	33.400	167.000
Administration technician		3	23.000	69.000
Maintenance of vehicle stock	Head of Workshop	1	33.000	33.000
	Mechanical	2	29.000	58.000
	Electric	1	28.000	28.000
	Traction	1	28.000	28.000
Total Maintenance of Mobile Material		5	118.000	147.000
Facilities Maintenance Staff		4	20.000	80.000
Auxiliary personnel	Wash units	1	19.000	19.000
	Cleaning facilities	1	19.000	19.000
	Inspectors	2	27.000	54.000
	Safety	4	24.000	96.000
Total Auxiliary Staff		8	89.000	188.000
TOTAL		**75**	**391.800**	**2.329.200**

Table 25: Personnel Costs. Source: Prepared by the Author

12.2 MAINTENANCE, CLEANING AND REPAIR COSTS

These are the expenses attributed to the conservation of mobile material, roads and other elements of the system in order to maintain its normal use. A cost analysis/annual route of 563,988 km has been carried out to detail an average price per km.

Maintenance, cleaning and repair costs: 3,63€/km.

12.3 ENERGY COSTS

These are the expenses attributed to electricity consumption and the traction of units and facilities. A cost analysis/annual route ratio of 563,988 km has been carried out to detail an average price per km.

Energy Costs: 0,83 €/km.

12.4 COSTS OF TECHNICAL ASSISTANCE AND SECURITY ELEMENTS

These are the expenses attributed to the technological and logistical support of the tram system and the network safety components. A cost analysis/annual route ratio of 563,988 km has been carried out to detail an average price per km.

Technical Assistance Costs and Security Elements: 0,48€/km.

12.5 OTHER COSTS

They comprise the rest of the expenses, of a very diverse nature, that are not strictly linked to the previous items. A cost analysis/annual route ratio of 563,988 km has been carried out to detail an average price per km.

Other costs: 0,90€/km.

12.6 TOTAL OPERATING COST PER KILOMETRE

The following table contains the different operating costs, according to typology, of the Girona Tramway service per kilometre. The total cost of the service per kilometre is 8.25€.

In parallel with the cost per kilometre, vehicle insurance costs must be borne. Annually it would mean an endowment of € 60,000.

OPERATING COSTS - Girona Tramway

Staff €/km	Maintenance, cleaning and repair	Energy €/km	Technical Assistance and Security Elements	Other Costs	Total Cost/Km
2,41	3,63	0,83	0,48	0,90	8,25

Insurance €/veh	Total €
6.000,00	60.000,00

Table 26: Total Operating Cost. Source: Prepared by the Author

13. INVESTMENT ANALYSIS

A capital cost (cost of the financial resources necessary to carry out an investment) of 5% is assumed.

Current interest rates range from 2%-2,5%. The 3% differential is considered as that amount that should be required of a project with similar characteristics. At the same time, a higher capital cost is not assumed taking into account that it is an investment made from the public sector, that does not seek financial profitability itself, but rather a social return.

13.1 NPV (NET PRESENT VALUE)

Net Present Value (NPV) is a dynamic financial indicator that allows us to assess and determine the feasibility and profitability of an investment project.

It is determined by updating the project's future revenue and expenditure flows, minus the initial investment. NPV allows to know the possible profitability through the following mathematical formula:

$$VAN = -I_0 + \sum_{t=1}^{n} \frac{F_t}{(1+k)^t}$$

Where:

Ft are the flows of money in each period t (see point 13.3 and 13.4)
I0 is the investment made at the initial moment (t = 0); (I_0 = 164.996.809,68 €)
n is the number of time periods (n = 25)
k is the type of discount required for the investment (k = 5.00 %)

This formula uses the values of updated cash flows (inputs and outputs) by discounting them at a certain interest rate. Results are expressed in units of monetary value.

13.2 IRR (INTERNAL RATE OF RETURN)

Internal Return Rate (IRR) is the interest rate or profitability offered by an investment, i.e. it is that "r" interest rate that makes the net present value (NPV) equal to 0.

It is determined by the following mathematical formula:

$$VAN = -I_0 + \sum_{t=1}^{n} \frac{F_t}{(1+TIR)^t} = -I_0 + \frac{F_1}{(1+TIR)} + \frac{F_2}{(1+TIR)^2} + \cdots + \frac{F_n}{(1+TIR)^n} = 0$$

Where:

Ft are the flows of money in each period t (see point 13.3 and 13.4)
I0 is the investment made at the initial moment (t = 0); (I_0 = 164.996.809,68 €)
n is the number of time periods (n = 25)

13.3 INVESTMENT ANALYSIS IN MOST LIKELY SCENARIO

	INVESTMENT		OPERATING COSTS						
YEAR	Infrastructure	Mobile material	Staff and Business Structure	Maintenance, cleaning and repair	Energy €/km	Technical Assistance and Security Elements	Other Costs	FARE INCOME	BALANCE
2023	- 82.498.404,84 €								- **82.498.404,84 €**
2024	- 82.498.404,84 €	-25.000.000							- **107.498.404,84 €**
2025			-1.360.000	-2.047.276	-468.110	-270.714	-507.589	11.541.964	**6.888.275,14 €**
2026			-1.387.200	-2.088.221	-477.472	-276.128	-517.741	14.766.775	**10.020.012,78 €**
2027			-1.414.944	-2.129.986	-487.021	-281.651	-528.096	15.113.997	**10.272.299,27 €**
2028			-1.443.243	-2.172.585	-496.762	-287.284	-538.657	15.469.590	**10.531.058,23 €**
2029			-1.472.108	-2.216.037	-506.697	-293.030	-549.431	15.833.646	**10.796.344,14 €**
2030			-1.501.550	-2.260.358	-516.831	-298.890	-560.419	16.206.055	**11.068.006,51 €**
2031			-1.531.581	-2.305.565	-527.168	-304.868	-571.628	19.075.401	**13.834.592,10 €**
2032			-1.562.213	-2.351.676	-537.711	-310.965	-583.060	19.524.238	**14.178.612,92 €**
2033			-1.593.457	-2.398.710	-548.465	-317.185	-594.721	19.983.465	**14.530.927,55 €**
2034			-1.625.326	-2.446.684	-559.435	-323.528	-606.616	20.453.435	**14.891.846,58 €**
2035			-1.657.832	-2.495.618	-570.623	-329.999	-618.748	20.934.638	**15.261.817,32 €**
2036			-1.690.989	-2.545.530	-582.036	-336.599	-631.123	21.426.947	**15.640.670,06 €**
2037			-1.724.809	-2.596.440	-593.676	-343.331	-643.746	21.931.123	**16.029.121,01 €**
2038			-1.759.305	-2.648.369	-605.550	-350.198	-656.620	22.447.046	**16.427.003,83 €**
2039			-1.794.491	-2.701.337	-617.661	-357.202	-669.753	22.975.109	**16.834.665,90 €**
2040		-25.000.000	-1.830.381	-2.755.363	-630.014	-364.346	-683.148	23.515.314	- **7.747.938,07 €**
2041			-1.866.989	-2.810.471	-642.615	-371.632	-696.811	26.475.473	**20.086.956,14 €**
2042			-1.904.328	-2.866.680	-655.467	-379.065	-710.747	27.098.377	**20.582.089,23 €**
2043			-1.942.415	-2.924.014	-668.576	-386.646	-724.962	27.735.719	**21.089.106,01 €**
2044			-1.981.263	-2.982.494	-681.948	-394.379	-739.461	28.388.135	**21.608.589,41 €**
2045			-2.020.888	-3.042.144	-695.587	-402.267	-754.251	29.055.963	**22.140.826,84 €**
2046			-2.061.306	-3.102.987	-709.498	-410.312	-769.336	29.739.551	**22.686.111,93 €**
2047			-2.102.532	-3.165.046	-723.688	-418.519	-784.722	30.439.088	**23.244.579,74 €**
2048			-2.144.583	-3.228.347	-738.162	-426.889	-800.417	31.154.927	**23.816.529,29 €**
2049			-2.187.475	-3.292.914	-752.925	-435.427	-816.425	31.887.942	**24.402.775,61 €**
2050			-2.231.224	-3.358.773	-767.984	-444.135	-832.754	32.638.006	**25.003.136,27 €**
SUM	- 164.996.809,68 €	- 50.000.000,00 €						595.811.924,40 €	**224.121.206,07 €**

Table 27: Initial investment, operating costs and rate income 2023 - 2025 in the most likely scenario. Source: Prepared by the Author

Consumer Price Index (CPI)	2,00%
Capital cost (Ke)	5,00%

NPV	**15.522.740,59 €**
IRR	**5,45%**

15.522.740,59; NPV > 0, the investment project is acceptable. The updated value of future investment collections and payments, at the discount rate, would generate benefits.

5,45%; IRR > k, the investment project is acceptable. The internal performance rate obtained is higher than the minimum rate of return required on investment.

13.4 INVESTMENT ANALYSIS IN A PESSIMISTIC SCENARIO

	INVESTMENT		OPERATING COSTS						
YEAR	Infrastructure	Mobile material	Staff and Business Structure	Maintenance, cleaning and repair	Energy €/km	Technical Assistance and Security Elements	Other Costs	FARE INCOME	BALANCE
2023	- 82.498.404,84 €								- **82.498.404,84 €**
2024	- 82.498.404,84 €	-25.000.000							- **107.498.404,84 €**
2025			-1.360.000	-2.047.276	-468.110	-270.714	-507.589	11.374.595	**6.720.906,63 €**
2026			-1.387.200	-2.088.221	-477.472	-276.128	-517.741	14.510.374	**9.763.611,38 €**
2027			-1.414.944	-2.129.986	-487.021	-281.651	-528.096	14.808.359	**9.966.660,99 €**
2028			-1.443.243	-2.172.585	-496.762	-287.284	-538.657	15.112.313	**10.173.781,31 €**
2029			-1.472.108	-2.216.037	-506.697	-293.030	-549.431	15.422.652	**10.385.349,94 €**
2030			-1.501.550	-2.260.358	-516.831	-298.890	-560.419	15.739.306	**10.601.257,88 €**
2031			-1.531.581	-2.305.565	-527.168	-304.868	-571.628	18.471.879	**13.231.069,51 €**
2032			-1.562.213	-2.351.676	-537.711	-310.965	-583.060	18.851.233	**13.505.607,26 €**
2033			-1.593.457	-2.398.710	-548.465	-317.185	-594.721	19.238.541	**13.786.003,33 €**
2034			-1.625.326	-2.446.684	-559.435	-323.528	-606.616	19.633.722	**14.072.132,99 €**
2035			-1.657.832	-2.495.618	-570.623	-329.999	-618.748	20.036.930	**14.364.109,88 €**
2036			-1.690.989	-2.545.530	-582.036	-336.599	-631.123	20.448.327	**14.662.049,85 €**
2037			-1.724.809	-2.596.440	-593.676	-343.331	-643.746	20.868.202	**14.966.200,11 €**
2038			-1.759.305	-2.648.369	-605.550	-350.198	-656.620	21.296.729	**15.276.686,78 €**
2039			-1.794.491	-2.701.337	-617.661	-357.202	-669.753	21.733.949	**15.593.505,40 €**
2040		-25.000.000	-1.830.381	-2.755.363	-630.014	-364.346	-683.148	22.180.168	- **9.083.083,85 €**
2041			-1.866.989	-2.810.471	-642.615	-371.632	-696.811	24.899.428	**18.510.911,24 €**
2042			-1.904.328	-2.866.680	-655.467	-379.065	-710.747	25.410.985	**18.894.697,23 €**
2043			-1.942.415	-2.924.014	-668.576	-386.646	-724.962	25.932.751	**19.286.138,22 €**
2044			-1.981.263	-2.982.494	-681.948	-394.379	-739.461	26.465.558	**19.686.012,07 €**
2045			-2.020.888	-3.042.144	-695.587	-402.267	-754.251	27.008.833	**20.093.696,70 €**
2046			-2.061.306	-3.102.987	-709.498	-410.312	-769.336	27.563.427	**20.509.987,78 €**
2047			-2.102.532	-3.165.046	-723.688	-418.519	-784.722	28.129.571	**20.935.063,00 €**
2048			-2.144.583	-3.228.347	-738.162	-426.889	-800.417	28.707.000	**21.368.601,49 €**
2049			-2.187.475	-3.292.914	-752.925	-435.427	-816.425	29.296.611	**21.811.445,04 €**
2050			-2.231.224	-3.358.773	-767.984	-444.135	-832.754	29.898.314	**22.263.444,64 €**
SUM	- 164.996.809,68 €	- 50.000.000,00 €	- 45.792.431,78 €				- 17.090.981,03 €	563.039.755,47 €	**191.349.037,14 €**

Table 28: Initial investment, operating costs and rate income 2023 - 2025 in the pessimistic scenario. Source: Prepared by the Author

Consumer Price Index (CPI)	2,00%
Capital cost (Ke)	5,00%

NPV	**1.259.261,25 €**
IRR	**4,88%**

1.259.261,25; NPV > 0, the investment project is acceptable. The updated value of future investment collections and payments, at the discount rate, would generate benefits.

4,88%; IRR > k, the investment project is acceptable. The internal performance rate obtained is higher than the minimum rate of return required on investment.

14. SOCIAL EVALUATION OF THE PROJECT: BENEFITS AND SOCIAL COSTS

The awarding of public resources must fulfil, in addition to economic and financial criteria, to social and environmental criteria, that is, it must generate for the general public. This section will evaluate the social benefits and social costs attributable to the project.

The impact on citizens and companies that usually have the implementation of this mode of transport is usually very positive.

14.1 ENVIRONMENT

The tram transport system provides important benefits to the environment, including the absence of polluting emissions, low noise levels, reduction of energy consumption, improved urban environmental quality, re-introduction of vegetation in the adjacent areas and urban and landscape regeneration.

Experts highlight the visibility of the tram as an opportunity for the modernisation of the streets around the tram system, while reversing the comfort and quality of life of citizens in urban areas, which were previously reduced by the presence of vehicles and pollution.

Thus, a tram system provides an immediate improvement of the environment.

14.2 SOCIAL EQUITY

Generally, transport systems that include tram systems increase mobility in their areas of influence, which translates into greater accessibility to transport and territory, as well as to centres where citizens carry out their work, study, culture and leisure activities.

The tram offers a higher quality transport service for areas with large populations dependent on transport (Salt and Vilablareix) and makes both public transport and walking attractive options for the population. In addition, it creates significant quality of life benefits for people who visit, work and live around the tram corridor.

Thus, it improves speed, promotes public health, activates the development of the main traffic arteries main ones, extends access to public services and expand housing options.

Picture 21: Computer recreation in the space occupied by the current viaduct
Source: pinterest.es

14.3 ECONOMY

Trams are ideal for connecting workers, residents and tourism with workplaces, shops, restaurants and entertainment centres in different urban centres.

The multiple Girona-Salt-Vilablareix connection would allow, together with the high frequency of passage, the economic development of a estate or centre.

In contrast to other transport systems, trams being smaller allow them to be highly integrated with the nearby urban environment. At the same time, these systems have the perception of long-term investments, which attracts private investment.

Recent studies show that trams are associated with an increase in retail sales, development, growth of environmental values and increased tourism, benefiting owners, businesses and public institutions.

» Development and economic activity.

A tram system has the potential to stimulate investment activity in urban renewal and residential and commercial development projects, often in areas that were previously inaccessible or unfeasible.

The longevity, durability and attractiveness of the light rail infrastructure image send a positive message to planners and developers.

» Tourism.

Good transport systems have an "emblematic" value that is attractive to tourists, as well as to travellers and residents. While bus routes are difficult for both domestic and international tourists.

Tram networks are perceived as simple and reliable, because the routes are permanent and visible. Transport is a key element in the visitor experience, and an efficient public transport system can significantly improve a city's reputation among travellers. In addition, a strong image of a tram can be incorporated into tourism marketing campaigns and information material.

15. FINANCING PROPOSALS

This last section addresses, by way of synthesis, the management plan and the deposit of the system, since there are countless public-private combinations.

Please keep in mind that public sector intervention is necessary to make the project viable and allow accessibility to goods, services and jobs for all those who do not have private mobility options.

In this sense, the economic contribution by the administration must include:

- **In the initial phase**: a subsidy or the full payment of the initial investment (infrastructure and mobile material).

  The implementation of the tram system requires an initial investment of € 164,996,809.68 for the infrastructure and € 25,000,000 for mobile material.

  In the case of a subsidy, the greater the contribution in the form of a smaller share capital, the lower the bank debt to be assumed by the concessionary company, consequently an investment sufficiently profitable to attract the private sector investors.

- **In the operating phase**: a fare subsidy of € 0.46 per trip (VAT included) that would be paid to the company responsible for the service, being the technical rate of the area of € 1.36.

It proposes the establishment of a public company that would take charge of the exploitation of the system and commission the construction of the infrastructure.

In this context, a means of collaboration between the private sector would be chosen for the implementation of the infrastructure and mobile material and the public sector, responsible for the management of resources and exploitation. The public company would ensure a quality service to citizens and its accessibility to the service.

In parallel with this final project, it would be necessary to study the possibility of financing the project with the Next Generation EU Funds, as the project is part of the four European pillars of the fund: a greener, more digital, more cohesive and inclusive and more egalitarian territory.

It would also have repercussions in the five strategic areas: entrepreneurship, growth, digitisation and innovation, support for trade and internationalisation.

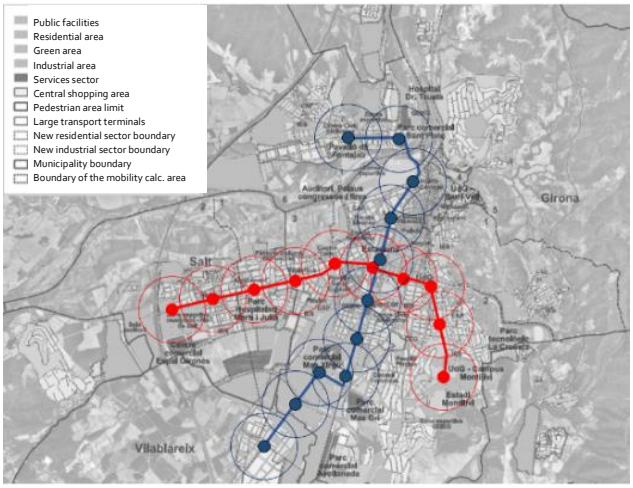
16. CONCLUSIONS

Once the implementation plan has been developed, and having analysed all the variables that affect the creation of the tram system, the results can be interpreted and the conclusions can be drawn.

This proposal exploits the potential of a sustainable collective means of transport that have the least possible impact on the environment and the environment. The tram represents a model of urban mobility, safe, fast, comfortable and accessible while stands out for the absence of polluting emissions, low sound levels, reduction of energy consumption, and integration with the environment.

In addition, the construction of the infrastructure represents an opportunity for the modernisation of the streets around the tram system, while reversing the levels of comfort and quality of life of citizens in urban areas, which were previously reduced by the presence of vehicles and pollution.

Following functional and efficiency criteria, I conclude that the route must be distributed throughout the urban area. It has proposed the implementation of two lines, one that crosses the city from west to east (L1: Espai Gironès – Salt - Girona - UdG Montilivi), and the other making its journey from north to south (L2: Vilablareix - Eixample - Correus - Fontajau), so that both had a stopping point at the Station to allow transfer.



The location of the stops has been determined by three lines of analysis. The first fulfils the following criteria: resident population density, work centres, areas of interest, commercial areas and public facilities. The second takes into account the alighting and disembarking incidents at the TMG stops in the city of Girona to establish patterns of current users. And the third uses the isochronous system, a map that defines the accessible area from a point within a certain time frame.

It is concluded after obtaining the mobility study that:

- The total demand for the most likely (optimistic) scenario is the first year of exploitation of about 8.5M users and that would end up consolidating with about 12-15M passengers per year, reaching 16.5M users by 2030.
- From 2031 onwards, moderate-weak year-on-year growth is assumed linked to the increase in population, by 2050 the service would end up assuming about 46,000 trips a day.

The implementation of dedicated platforms (segregation of other vehicles) is chosen with the aim of guaranteeing safety and punctuality. In accordance with the specificities of the streets, a two-way platform with a central platform of 3.50 m and side poles is proposed.

Operating costs, attributable to the operation and maintenance of the tram service, have been grouped into the following categories: Personnel Costs (€2.41/km), Maintenance Costs, Cleaning and Repair Costs (€3.63/km), Energy Costs (€0.83/km), Technical Assistance Costs and Safety Elements (€0.48/km) and Other Costs (0.90 €/km) resulting in the Total Cost of the Service per kilometre of 8,25€. At the same time, vehicle insurance costs, an investment of €60,000, would have to be borne.

On the other hand, I take into account an intervention of the public sector, which is necessary to make the project viable and allow accessibility to goods, services and jobs for all those who do not have private mobility options.

In this sense, the economic contribution by the administration must include:

- In the initial phase: a subsidy or the full payment of the initial investment (infrastructure and mobile material). The implementation of the tram system requires an initial investment of € 164,996,809.68 for the infrastructure and € 25,000,000 for mobile material.
- In the operating phase: a fare subsidy of € 0.46 per trip (VAT included) that would be paid to the company responsible for the service, being the technical rate of the area of € 1.36.

The economic and financial analysis resolves that the project is viable. The internal return rate obtained is higher than the minimum rate of return required on investment (5.45% > 5%) and the updated value of future investment collections and payments, at the discount rate it would generate profits (NPV = €15,522,740.59).

Finally, the tram would have the potential to stimulate investment activity in urban renewal and residential and commercial development projects, often in areas that were previously inaccessible or unfeasible while recent studies link trams to an increase in retail sales, development, growth of environmental values and increased tourism, benefiting owners, businesses and public institutions.

Consequently, this Plan for the Implementation of a Tram System would allow the quality deficit of current public transport to be corrected in addition to decongesting the traffic of the Urban nuclei and connecting the municipalities of Salt and Vilablareix with the urban nucleus of the city of Girona, as well as it would address all the elements described in the National plan for the implementation of the 2030 Agenda in Catalonia in relation to sustainable mobility and urban reorganisation.

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ADDITIONAL DOCUMENTATION

A. Estimation of Population Growth - Girona

	Escenari més probable	Escenari pessimista
Taxa de creixement anual (previsió)	0,85%	0,55%
ETCA % sobre Població resident	9,27%	9,27%

ETCA = No resident present + Resident absent

	Escenari més probable, 2050			Escenari pessimista, 2050		
Girona	Població resident	Total ETCA	Població ETCA	Població resident	Total ETCA	Població ETCA
2021	104.247	9.663	113.910	103.940	9.635	113.575
2022	105.133	9.745	114.878	104.514	9.688	114.202
2023	106.026	9.828	115.854	105.091	9.741	114.832
2024	106.927	9.912	116.839	105.671	9.795	115.466
2025	107.835	9.996	117.831	106.254	9.849	116.103
2026	108.751	10.081	118.832	106.841	9.904	116.745
2027	109.675	10.166	119.841	107.431	9.958	117.389
2028	110.607	10.253	120.860	108.024	10.013	118.037
2029	111.547	10.340	121.887	108.620	10.069	118.689
2030	112.495	10.428	122.923	109.220	10.124	119.344
2031	113.451	10.516	123.967	109.823	10.180	120.003
2032	114.415	10.606	125.021	110.429	10.236	120.665
2033	115.387	10.696	126.083	111.039	10.293	121.332
2034	116.367	10.787	127.154	111.652	10.350	122.002
2035	117.356	10.878	128.234	112.268	10.407	122.675
2036	118.353	10.971	129.324	112.888	10.464	123.352
2037	119.359	11.064	130.423	113.511	10.522	124.033
2038	120.373	11.158	131.531	114.138	10.580	124.718
2039	121.396	11.253	132.649	114.768	10.638	125.406
2040	122.427	11.348	133.775	115.402	10.697	126.099
2041	123.467	11.445	134.912	116.039	10.756	126.795
2042	124.516	11.542	136.058	116.680	10.816	127.496
2043	125.574	11.640	137.214	117.324	10.875	128.199
2044	126.641	11.739	138.380	117.972	10.936	128.908
2045	127.717	11.839	139.556	118.623	10.996	129.619
2046	128.802	11.939	140.741	119.278	11.057	130.335
2047	129.896	12.041	141.937	119.937	11.118	131.055
2048	131.000	12.143	143.143	120.599	11.179	131.778
2049	132.113	12.246	144.359	121.265	11.241	132.506
2050	133.235	12.350	145.585	121.934	11.303	133.237

Source: prepared by the Author

B. Estimation of Population Growth - Salt

	Escenari més probable	Escenari pessimista
Taxa de creixement anual (previsió)	0,80%	0,52%
ETCA % sobre Població resident	2,43%	2,43%

ETCA = No resident present + Resident absent

	Escenari més probable, 2050			Escenari pessimista, 2050		
Salt	Població resident	Total ETCA	Població ETCA	Població resident	Total ETCA	Població ETCA
2021	30.632	744	31.376	30.547	742	31.289
2022	30.877	750	31.627	30.705	746	31.451
2023	31.124	756	31.880	30.864	749	31.613
2024	31.372	762	32.134	31.024	753	31.777
2025	31.622	768	32.390	31.185	757	31.942
2026	31.874	774	32.648	31.347	761	32.108
2027	32.128	780	32.908	31.510	765	32.275
2028	32.385	786	33.171	31.673	769	32.442
2029	32.644	793	33.437	31.837	773	32.610
2030	32.905	799	33.704	32.002	777	32.779
2031	33.168	805	33.973	32.168	781	32.949
2032	33.433	812	34.245	32.335	785	33.120
2033	33.700	818	34.518	32.503	789	33.292
2034	33.969	825	34.794	32.672	793	33.465
2035	34.240	832	35.072	32.841	798	33.639
2036	34.513	838	35.351	33.011	802	33.813
2037	34.789	845	35.634	33.182	806	33.988
2038	35.067	852	35.919	33.354	810	34.164
2039	35.347	858	36.205	33.527	814	34.341
2040	35.629	865	36.494	33.701	818	34.519
2041	35.914	872	36.786	33.876	823	34.699
2042	36.201	879	37.080	34.052	827	34.879
2043	36.490	886	37.376	34.229	831	35.060
2044	36.781	893	37.674	34.406	836	35.242
2045	37.075	900	37.975	34.584	840	35.424
2046	37.371	908	38.279	34.763	844	35.607
2047	37.669	915	38.584	34.943	849	35.792
2048	37.970	922	38.892	35.124	853	35.977
2049	38.273	930	39.203	35.306	857	36.163
2050	38.579	937	39.516	35.489	862	36.351

Source: prepared by the Author

C. Estimation of Population Growth Vilablareix

	Escenari més probable	Escenari pessimista
Taxa de creixement anual (previsió)	0,90%	0,59%
ETCA % sobre Població resident	4,90%	4,90%

ETCA = No resident present + Resident absent

	Escenari més probable, 2050			Escenari pessimista, 2050		
Vilablareix	Població resident	Total ETCA	Població ETCA	Població resident	Total ETCA	Població ETCA
2021	3.089	151	3.240	3.079	150	3.229
2022	3.116	152	3.268	3.097	151	3.248
2023	3.144	153	3.297	3.115	152	3.267
2024	3.172	155	3.327	3.133	153	3.286
2025	3.200	156	3.356	3.151	154	3.305
2026	3.228	158	3.386	3.169	155	3.324
2027	3.257	159	3.416	3.187	156	3.343
2028	3.286	160	3.446	3.205	156	3.361
2029	3.315	162	3.477	3.223	157	3.380
2030	3.344	163	3.507	3.241	158	3.399
2031	3.374	165	3.539	3.259	159	3.418
2032	3.404	166	3.570	3.278	160	3.438
2033	3.434	168	3.602	3.297	161	3.458
2034	3.464	169	3.633	3.316	162	3.478
2035	3.495	171	3.666	3.335	163	3.498
2036	3.526	172	3.698	3.354	164	3.518
2037	3.557	174	3.731	3.373	165	3.538
2038	3.589	175	3.764	3.392	166	3.558
2039	3.621	177	3.798	3.411	167	3.578
2040	3.653	178	3.831	3.430	167	3.597
2041	3.685	180	3.865	3.450	168	3.618
2042	3.718	182	3.900	3.470	169	3.639
2043	3.751	183	3.934	3.490	170	3.660
2044	3.784	185	3.969	3.510	171	3.681
2045	3.818	186	4.004	3.530	172	3.702
2046	3.852	188	4.040	3.550	173	3.723
2047	3.886	190	4.076	3.570	174	3.744
2048	3.920	191	4.111	3.590	175	3.765
2049	3.955	193	4.148	3.611	176	3.787
2050	3.990	195	4.185	3.632	177	3.809

Source: prepared by the Author

D. Potential Demand and Annual Rate Revenue, Most Likely Scenario

Escenari més probable, 2050

	Població ETCA Girona + Salt + Vilablareix	Increment base per millora del servei	Taxa creixement interanual	% sobre demanda calculada	Total passatgers/any	Usuaris/dia	INGRESSOS TARIFARIS (€) (IVA no inclòs)
2025	153.577	0,75		100%	8.484.658	23.568	11.541.963,70 €
2026	154.866		25%	126%	10.694.840	29.708	14.766.775,11 €
2027	156.165		25%	127%	10.784.547	29.957	15.113.996,85 €
2028	157.477		25%	128%	10.875.152	30.209	15.469.589,76 €
2029	158.801		25%	129%	10.966.586	30.463	15.833.646,30 €
2030	160.134		25%	130%	11.058.641	30.718	16.206.054,71 €
2031	161.479		15%	151%	12.824.253	35.623	19.075.401,26 €
2032	162.836		15%	152%	12.932.023	35.922	19.524.238,27 €
2033	164.203		15%	154%	13.040.587	36.224	19.983.465,41 €
2034	165.581		15%	155%	13.150.024	36.528	20.453.435,19 €
2035	166.972		15%	156%	13.260.493	36.835	20.934.637,70 €
2036	168.373		15%	158%	13.371.757	37.144	21.426.946,85 €
2037	169.788		15%	159%	13.484.133	37.456	21.931.123,34 €
2038	171.214		15%	160%	13.597.382	37.771	22.447.046,20 €
2039	172.652		15%	162%	13.711.585	38.088	22.975.109,12 €
2040	174.100		15%	163%	13.826.581	38.407	23.515.314,01 €
2041	175.563		10%	181%	15.337.046	42.603	26.475.473,27 €
2042	177.038		10%	182%	15.465.901	42.961	27.098.376,70 €
2043	178.524		10%	184%	15.595.716	43.321	27.735.719,23 €
2044	180.023		10%	185%	15.726.668	43.685	28.388.134,90 €
2045	181.535		10%	187%	15.858.755	44.052	29.055.963,24 €
2046	183.060		10%	188%	15.991.978	44.422	29.739.551,05 €
2047	184.597		10%	190%	16.126.249	44.795	30.439.087,64 €
2048	186.146		10%	192%	16.261.568	45.171	31.154.927,35 €
2049	187.710		10%	193%	16.398.198	45.551	31.887.941,64 €
2050	189.286		10%	195%	16.535.876	45.933	32.638.005,62 €

Source: prepared by the Author

E. Potential Demand and Annual Rate Revenue, Pessimistic Scenario

Escenari pessimista, 2050

	Població ETCA Girona+Salt+Vil ablareix	Increment base per millora del servei	Taxa creixement interanual	% sobre demanda calculada	Total passatgers/any	Usuaris/dia	INGRESSOS TARIFARIS (€) (IVA no inclòs)
2025	151.350	0,75		100%	8.361.624	23.227	11.374.595,19 €
2026	152.177		25%	124%	10.509.141	29.192	14.510.373,71 €
2027	153.007		25%	125%	10.566.460	29.351	14.808.358,57 €
2028	153.840		25%	125%	10.623.985	29.511	15.112.312,84 €
2029	154.679		25%	126%	10.681.926	29.672	15.422.652,10 €
2030	155.522		25%	127%	10.740.142	29.834	15.739.306,08 €
2031	156.370		15%	146%	12.418.509	34.496	18.471.878,67 €
2032	157.223		15%	147%	12.486.253	34.684	18.851.232,61 €
2033	158.082		15%	148%	12.554.472	34.874	19.238.541,19 €
2034	158.945		15%	149%	12.623.009	35.064	19.633.721,60 €
2035	159.812		15%	150%	12.691.864	35.255	20.036.930,27 €
2036	160.683		15%	150%	12.761.037	35.447	20.448.326,64 €
2037	161.559		15%	151%	12.830.607	35.641	20.868.202,43 €
2038	162.440		15%	152%	12.900.574	35.835	21.296.729,15 €
2039	163.325		15%	153%	12.970.858	36.030	21.733.948,62 €
2040	164.215		15%	154%	13.041.540	36.226	22.180.168,24 €
2041	165.112		10%	170%	14.424.055	40.067	24.899.428,37 €
2042	166.014		10%	171%	14.502.853	40.286	25.410.984,70 €
2043	166.919		10%	172%	14.581.913	40.505	25.932.751,44 €
2044	167.831		10%	173%	14.661.584	40.727	26.465.557,56 €
2045	168.745		10%	174%	14.741.431	40.948	27.008.833,10 €
2046	169.665		10%	175%	14.821.801	41.172	27.563.426,90 €
2047	170.591		10%	176%	14.902.696	41.396	28.129.570,90 €
2048	171.520		10%	177%	14.983.853	41.622	28.706.999,55 €
2049	172.456		10%	178%	15.065.621	41.849	29.296.611,06 €
2050	173.397		10%	179%	15.147.826	42.077	29.898.313,98 €

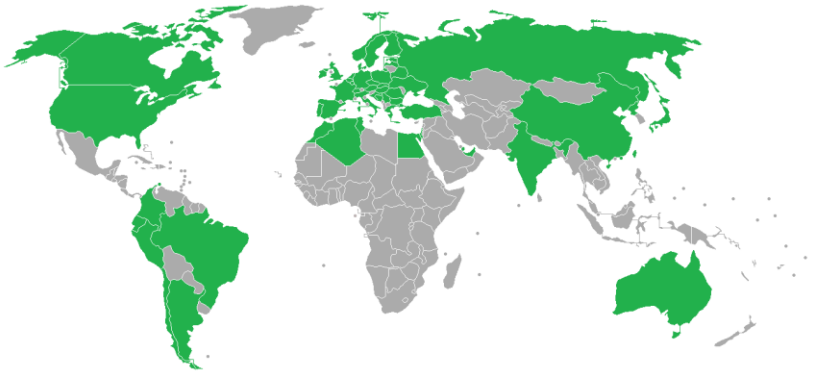
Source: prepared by the Author

ANNEX

PLAN OF IMPLEMENTATION OF A TRAM SYSTEM IN THE URBAN AREA OF GIRONA

I. ANNEX: Networks of trams in the world

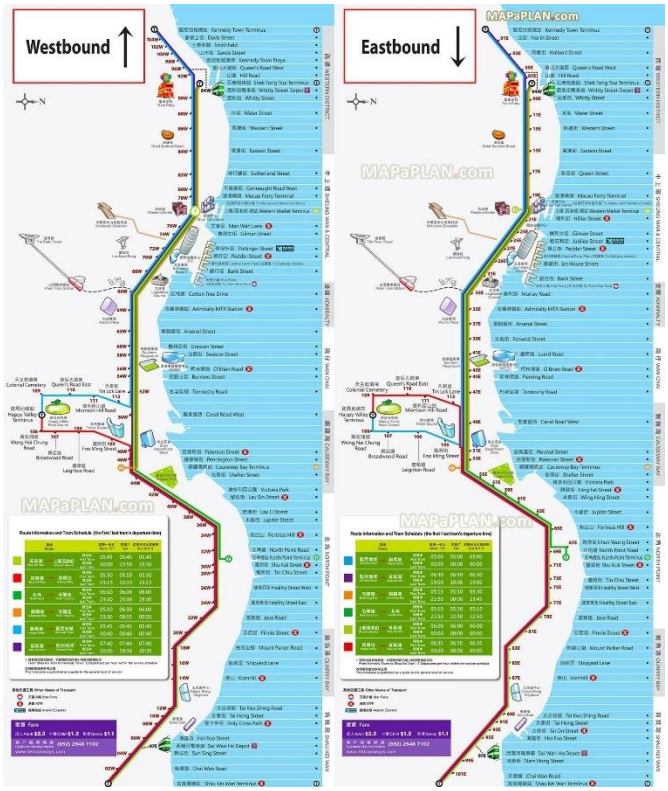
In green, countries with tram networks



In green, countries with tram networks.

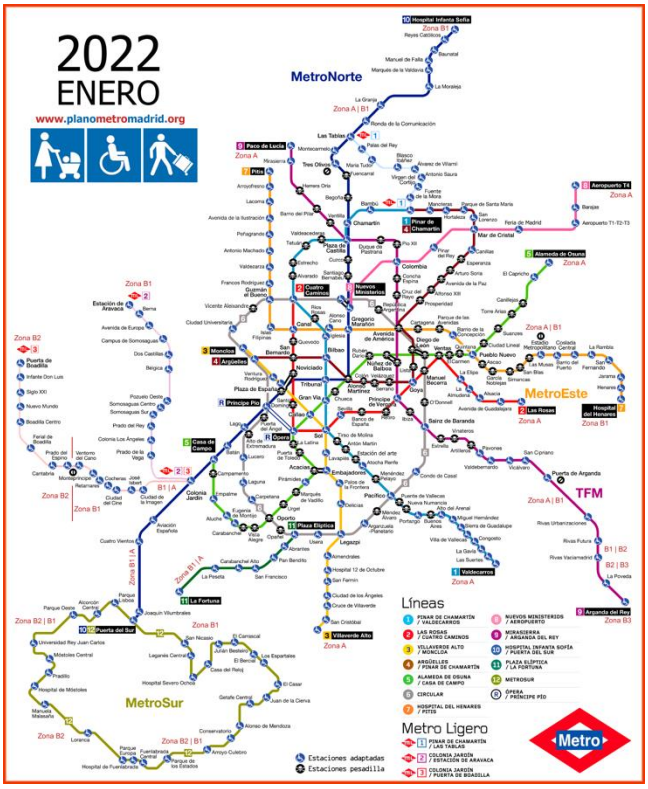
Source: https://es.wikipedia.org/wiki/Tranv%C3%ADa#/media/Archivo:World_Tram_Systems.png

II. ANNEX: Hong Kong Tram Map: tram lines and stations



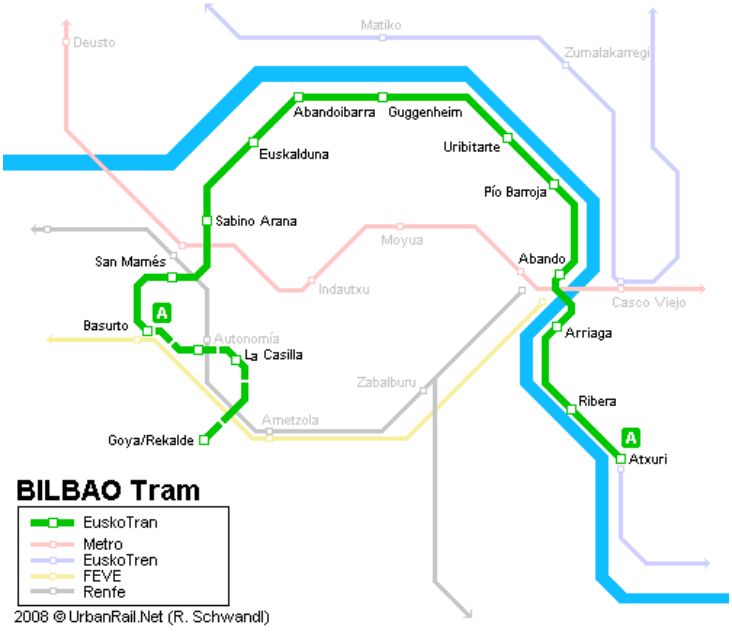
Source: https://hongkongmap360.com/hong-kong-tram-map#.Ye_TfurMK5c

III. ANNEX: Madrid 2022 metro map



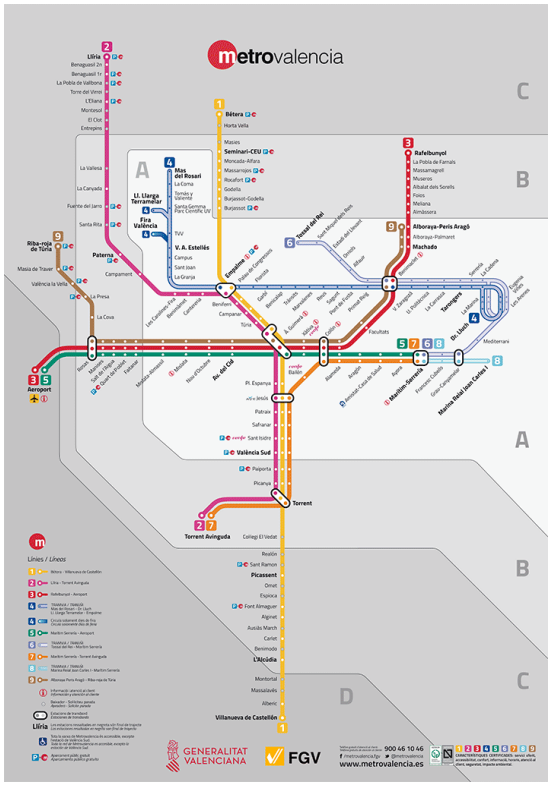
Source: https://www.planometromadrid.org/

IV. ANNEX: Bilbao Tram Map



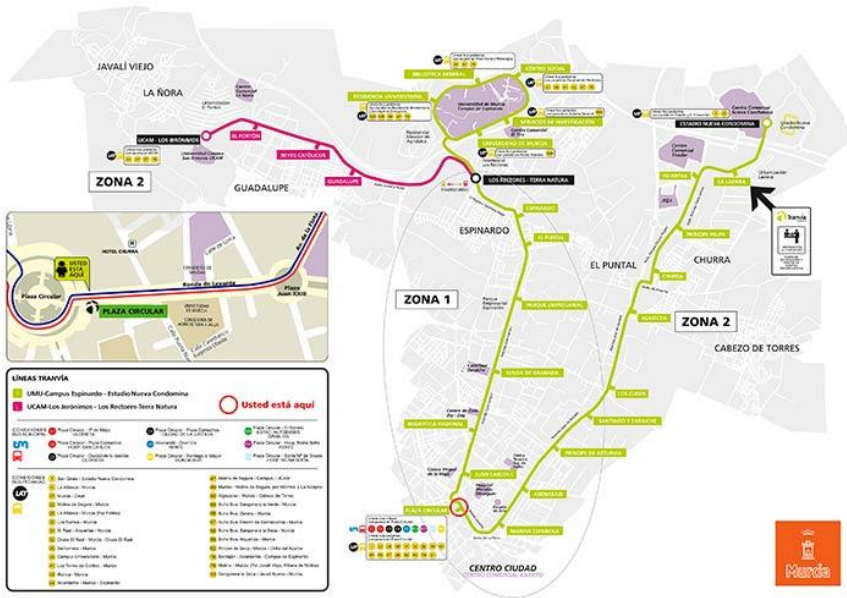
Source: https://www.orangesmile.com/guia-turistica/bilbao/mapa-tranvias.htm

V. ANNEX: Valencia 2022 tram (lines and map)



Source: https://www.enterat.com/servicios/horarios-tranvia-valencia.php

VI. ANNEX: Murcia 2022 tram (lines and map)

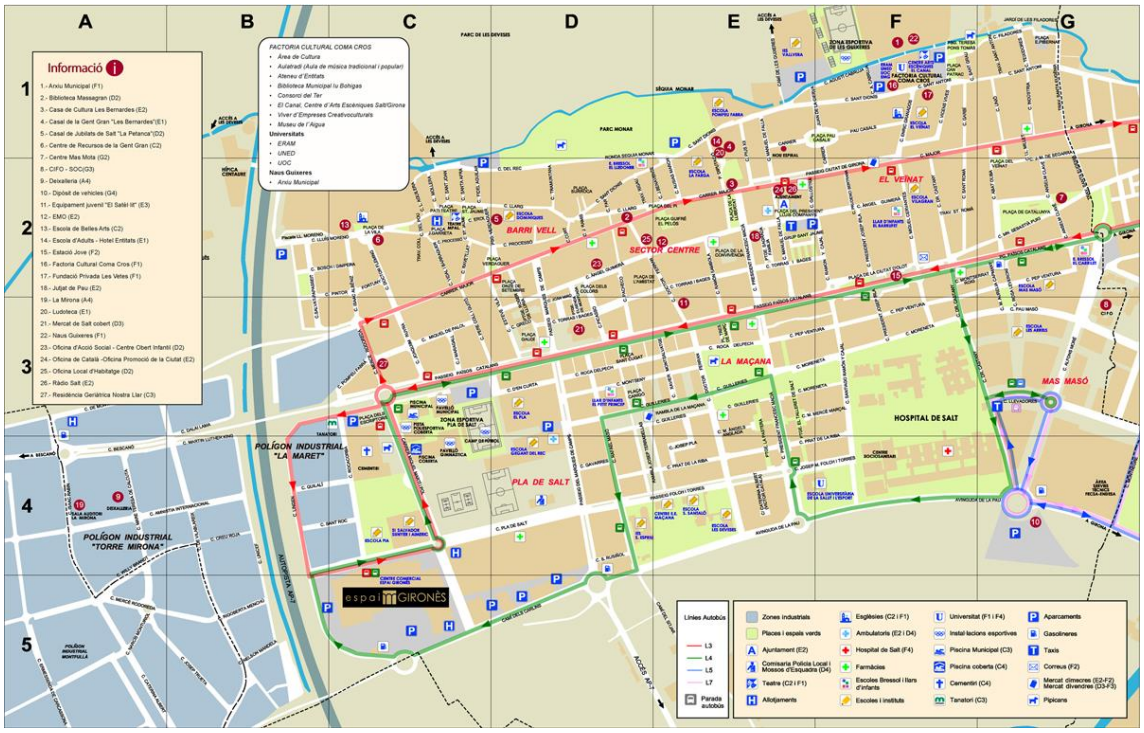


Source: https://www.enterat.com/servicios/horarios-tranvia-murcia.php

VII. ANNEX: Map of the city of Girona

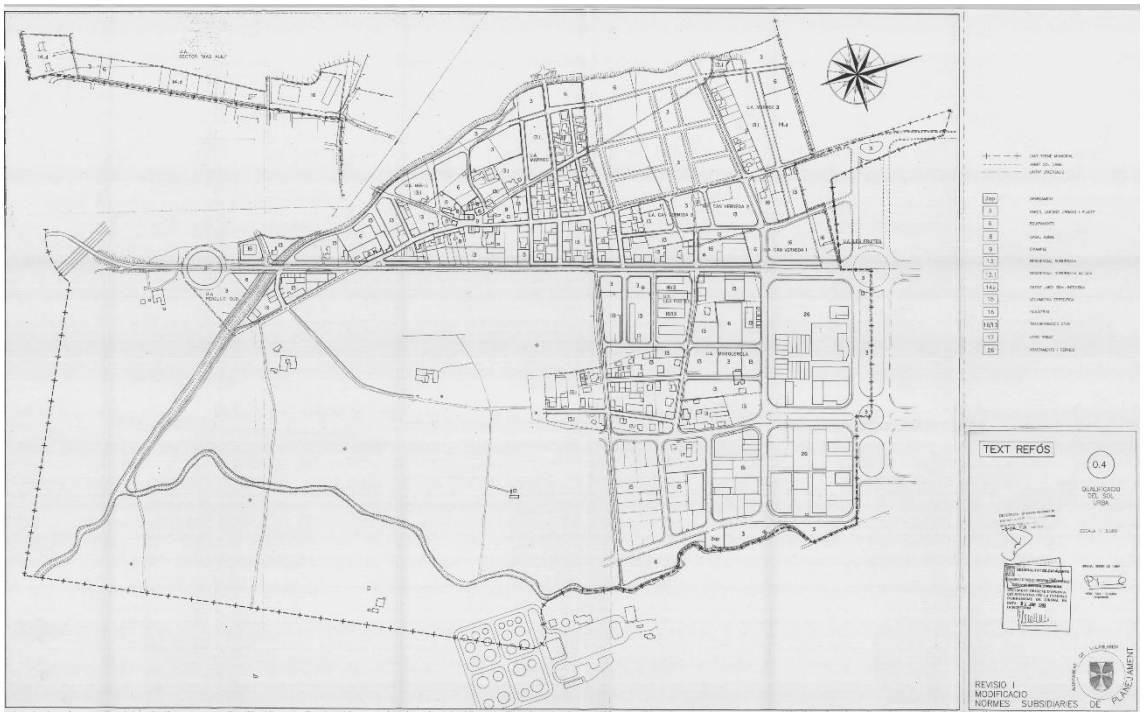
Source: https://www.gironanoticies.com/noticia/42538-lajuntament-de-girona-edita-de-nou-el-planol-de-la-ciutat.htm

VIII. ANNEX: Map of the city of Salt



Source:https://viusalt.cat/informacio-salt-girona-costa-brava/mapes-planols-de-salt/zagctanalisis_territorialcapescarrererplanol_cadcarrerer/

IX. ANNEX: Map of Vilablareix



Source: https://www.vilablareix.cat/taxonomy/term/19

X. ANNEX: Municipality in figures - Girona (Gironès)

Girona	
Codi	170792
Comarca	Gironès
Població (2021)	101.932
Superfície (km²)	39,12
Densitat (hab./km²)	2.605,6
Altitud (m)	70

Població a 1 de gener. Per sexe i edat quinquennal
Girona. 2020

	Homes	Dones	Total
De 0 a 4 anys	2.528	2.358	**4.886**
De 5 a 9 anys	2.918	2.729	**5.647**
De 10 a 14 anys	3.131	2.937	**6.068**
De 15 a 19 anys	3.161	2.970	**6.131**
De 20 a 24 anys	3.199	3.058	**6.257**
De 25 a 29 anys	3.498	3.505	**7.003**
De 30 a 34 anys	3.330	3.634	**6.964**
De 35 a 39 anys	3.761	3.980	**7.741**
De 40 a 44 anys	4.403	4.572	**8.975**
De 45 a 49 anys	3.967	4.197	**8.164**
De 50 a 54 anys	3.533	3.641	**7.174**
De 55 a 59 anys	3.057	3.359	**6.416**
De 60 a 64 anys	2.512	3.043	**5.555**
De 65 a 69 anys	2.146	2.560	**4.706**
De 70 a 74 anys	1.772	2.172	**3.944**
De 75 a 79 anys	1.233	1.647	**2.880**
De 80 a 84 anys	786	1.240	**2.026**
De 85 a 89 anys	600	1.141	**1.741**
De 90 a 94 anys	222	625	**847**
De 95 a 99 anys	42	165	**207**
100 anys o més	10	27	**37**
Total	**49.809**	**53.560**	**103.369**

Estimacions de població ETCA i de població estacional ETCA
Girona

	Població estacional ETCA					
	no resident present	resident absent	total	Població resident	Població ETCA	Població ETCA (%)
2020	11.669	-6.463	5.206	103.369	108.575	105,0
2019	20.168	-10.361	9.807	101.852	111.659	109,6
2018	19.817	-10.496	9.321	100.266	109.587	109,3
2017	19.586	-9.914	9.672	99.013	108.685	109,8
2016	18.146	-9.448	8.698	98.255	106.953	108,9
2015	17.951	-9.044	8.907	97.586	106.493	109,1

Unitats: Persones en equivalència a temps complet anual (ETCA).
Font: Idescat. Estimacions de població estacional (base 2016).
Nota: Població ETCA (%) = Població ETCA / Població resident x 100.

Estimacions de població vinculada ETCA i taxa de vinculació
Girona

	Població resident	Població vinculada no resident ETCA	Població vinculada ETCA	Taxa de vinculació ETCA (%)
2020	103.369	11.669	115.038	111,3
2019	101.852	20.168	122.020	119,8
2018	100.266	19.817	120.083	119,8
2017	99.013	19.586	118.599	119,8
2016	98.255	18.146	116.401	118,5
2015	97.586	17.951	115.537	118,4

Unitats: Persones en equivalència a temps complet anual (ETCA).
Font: Idescat. Estimacions de població estacional (base 2016).

Llars. Per nombre i tipus de nucli (agregat)
Girona

	Sense nucli		Amb nucli				
	unipersonals	2 persones o més	parella sense fills	parella amb fills	pare o mare amb fills	dos nuclis o més	Total
2011	10.305	1.339	8.857	12.460	4.412	872	**38.245**

Creixement per mil habitants
Girona

	Taxa bruta de creixement total	Taxa bruta de creixement natural	Taxa bruta de creixement migratori	Correccions estadístiques
2020	-9,70	1,16	-10,81	-0,05
2019	13,05	1,68	11,42	-0,05
2018	10,98	2,22	8,78	-0,02
2017	8,79	3,25	5,57	-0,03
2016	7,54	3,49	4,04	..
2015	4,40	3,70	0,70	..
2014	1,40	4,53	-3,13	..
2013	-3,04	4,53	-7,57	..
2012	-3,59	4,62	-8,22	..
2011	2,46	5,48	-3,03	..
2010	4,19	6,62	-2,43	..
2009	0,88	7,54	-6,66	..
2008	14,34	7,48	6,86	..
2007	22,02	6,48	15,54	..
2006	37,62	6,70	30,93	..
2005	38,15	5,76	32,39	..
2004	36,44	7,02	29,43	..
2003	37,60	6,08	31,52	..
2002	41,83	5,51	36,32	..
2001	31,99	4,52	27,47	..
2000	24,54	4,86	19,68	..

Població ocupada resident i llocs de treball localitzats per sexe
Municipi: Girona. 2011

	Homes	Dones	Total
Residents ocupats a dins	**11.489**	**14.755**	**26.245**
▼ **No residents ocupats a dins**	**10.954**	**10.784**	**21.738**
▼ **Residents ocupats a fora**	**7.439**	**5.424**	**12.863**
Residents ocupats a diversos municipis	**2.740**	**899**	**3.639**
Llocs de treball localitzats	**22.444**	**25.539**	**47.983**
Població ocupada resident	**21.669**	**21.079**	**42.747**
Diferència lloc localitzats - residents	**775**	**4.461**	**5.236**

Unitats: persones que es desplacen
Font: Idescat, a partir del Cens de població i habitatges 2011 de l'INE.
(1) Llocs de treball localitzats: Residents ocupats a dins + No residents ocupats a dins
(2) Població ocupada resident: Residents ocupats a dins + Residents ocupats a fora + Residents ocupats a diversos municipis

Alumnes residents i llocs d'estudi localitzats. Ensenyaments no universitaris
Girona

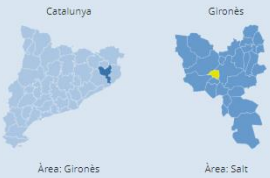
	Curs 2020/21	Curs 2019/20	Curs 2018/19	Curs 2017/18	Curs 2016/17	Curs 2015/16	Curs 2014/15	Curs 2013/14	Curs 2012/13	Curs 2011/12
Residents que estudien al municipi	16.680	16.745	16.665	16.655	16.370	16.320	16.060	15.650	15.935	15.600
No residents que estudien al municipi	6.275	6.325	6.285	6.015	5.840	5.560	5.685	5.535	5.595	5.585
No consta residència i estudien al municipi	5	50	45	45	40	55	70	660	10	40
Residents que estudien a fora del municipi	1.160	1.125	1.120	1.025	1.075	970	890	870	870	895
Llocs d'estudi localitzats (1)	22.960	23.120	22.995	22.715	22.250	21.935	21.815	21.845	21.540	21.220
Alumnes residents (2)	17.840	17.870	17.785	17.675	17.450	17.290	16.950	16.520	16.805	16.495

Unitats: Alumnes.
Font: Idescat, a partir de les dades de la matrícula del Departament d'Educació.
Nota: Els resultats estan arrodonits a valors múltiples de 5. Per aquesta raó algun total pot no coincidir amb la suma de la seva desagregació.
(1) Llocs d'estudi localitzats = Residents que estudien al municipi + No residents que estudien al municipi + No consta residència i estudien al municipi.
(2) Alumnes residents = Residents que estudien al municipi + Residents que estudien a fora del municipi.

Source: https://www.idescat.cat/emex/?id=170792

XI. ANNEX: Municipality in figures - Salt (Gironès)

Salt	
Codi	171557
Comarca	Gironès
Població (2021)	32.230
Superfície (km²)	6,64
Densitat (hab./km²)	4.853,9
Altitud (m)	83



Població a 1 de gener. Per sexe i edat quinquennal Salt. 2020			
	Homes	**Dones**	**Total**
De 0 a 4 anys	1.088	1.019	**2.107**
De 5 a 9 anys	1.206	1.065	**2.271**
De 10 a 14 anys	1.165	1.031	**2.196**
De 15 a 19 anys	1.004	838	**1.842**
De 20 a 24 anys	1.091	880	**1.971**
De 25 a 29 anys	1.196	975	**2.171**
De 30 a 34 anys	1.161	1.089	**2.250**
De 35 a 39 anys	1.439	1.231	**2.670**
De 40 a 44 anys	1.669	1.289	**2.958**
De 45 a 49 anys	1.432	1.007	**2.439**
De 50 a 54 anys	1.092	964	**2.056**
De 55 a 59 anys	952	827	**1.779**
De 60 a 64 anys	713	749	**1.462**
De 65 a 69 anys	583	650	**1.233**
De 70 a 74 anys	448	501	**949**
De 75 a 79 anys	282	388	**670**
De 80 a 84 anys	209	298	**507**
De 85 a 89 anys	134	253	**387**
De 90 a 94 anys	46	123	**169**
De 95 a 99 anys	10	35	**45**
100 anys o més	0	6	**6**
Total	**16.920**	**15.218**	**32.138**

Població estrangera a 1 de gener. Per sexe i edat quinquennal. 2020 Salt				
	Homes	**Dones**	**Total**	**% sobre la població**
De 0 a 4 anys	546	504	1.050	8,32
De 5 a 9 anys	509	440	949	7,52
De 10 a 14 anys	380	334	714	5,66
De 15 a 19 anys	407	291	698	5,53
De 20 a 24 anys	555	412	967	7,67
De 25 a 29 anys	694	545	1.239	9,82
De 30 a 34 anys	662	631	1.293	10,25
De 35 a 39 anys	847	668	1.515	12,01
De 40 a 44 anys	885	575	1.460	11,58
De 45 a 49 anys	656	407	1.063	8,43
De 50 a 54 anys	407	299	706	5,60
De 55 a 59 anys	276	169	445	3,53
De 60 a 64 anys	128	108	236	1,87
De 65 anys i més	119	159	278	2,20
Total	**7.071**	**5.542**	**12.613**	**100,00**
%	56,06	43,94	100,00	

Font: Idescat, a partir del Padró continu de l'INE.

Estimacions de població ETCA i de població estacional ETCA
Salt

	Població estacional ETCA					
	no resident present	resident absent	total	Població resident	Població ETCA	Població ETCA (%)
2020	1.541	-1.986	-445	32.138	31.693	98,6
2019	2.507	-3.254	-747	31.362	30.615	97,6
2018	2.615	-3.191	-576	30.622	30.046	98,1
2017	2.542	-2.993	-451	29.836	29.385	98,5
2016	2.358	-2.858	-500	29.404	28.904	98,3
2015	2.257	-2.767	-510	29.342	28.832	98,3

Unitats: Persones en equivalència a temps complet anual (ETCA).
Font: Idescat. Estimacions de població estacional (base 2016).
Nota: Població ETCA (%) = Població ETCA / Població resident x 100.

Estimacions de població vinculada ETCA i taxa de vinculació
Salt

	Població resident	Població vinculada no resident ETCA	Població vinculada ETCA	Taxa de vinculació ETCA (%)
2020	32.138	1.541	33.679	104,8
2019	31.362	2.507	33.869	108,0
2018	30.622	2.615	33.237	108,5
2017	29.836	2.542	32.378	108,5
2016	29.404	2.358	31.762	108,0
2015	29.342	2.257	31.599	107,7

Unitats: Persones en equivalència a temps complet anual (ETCA).
Font: Idescat. Estimacions de població estacional (base 2016).

Llars. Per nombre i tipus de nucli (agregat)
Salt

	Sense nucli		Amb nucli				
	unipersonals	2 persones o més	parella sense fills	parella amb fills	pare o mare amb fills	dos nuclis o més	Total
2011	2.235	359	2.059	4.207	1.139	277	**10.276**

Creixement intercensal de la població, per components. 2001-2011
Salt

	Naixements	Defuncions	Creixement natural	Saldo migratori	Creixement total
2001-2011	4.716	1.871	2.845	5.347	8.192

Font: Idescat.
Nota: El Cens 2011 inclou dades provinents d'enquesta. Els resultats han estat convenientment arrodonits i es mostren sense decimals. Per aquesta raó algun total pot no coincidir amb la suma de la seva desagregació per sexe, edat o territori.

Creixement intercensal de la població, per components en taxa. Mitjana anual 2001-2011
Salt

	Natalitat	Mortalitat	Creixement natural	Creixement migratori	Creixement total
2001-2011	18,62	7,39	11,23	21,11	32,34

Unitats: Taxes per mil habitants.
Font: Idescat.

Creixement intercensal de la població

CAT COM MUN

Creixement total. 2011	8.192
Creixement total (mitjana anual) (taxa per 1.000 habitants). 2001-2011	32,34
Creixement natural (mitjana anual) (taxa per 1.000 habitants). 2001-2011	11,23
Creixement migratori (mitjana anual) (taxa per 1.000 habitants). 2001-2011	21,11

Població ocupada resident i llocs de treball localitzats
Municipi: Salt. 2011

	Total
Residents ocupats a dins	**4.594**
▾ No residents ocupats a dins	**3.910**
▾ Residents ocupats a fora	**4.652**
Residents ocupats a diversos municipis	**955**
Llocs de treball localitzats	**8.504**
Població ocupada resident	**10.201**
Diferència lloc localitzats - residents	**-1.697**

Unitats: persones que es desplacen
Font: Idescat, a partir del Cens de població i habitatges 2011 de l'INE.
(1) Llocs de treball localitzats: Residents ocupats a dins + No residents ocupats a dins
(2) Població ocupada resident: Residents ocupats a dins + Residents ocupats a fora + Residents ocupats a diversos municipis

Població que estudia resident i llocs d'estudi localitzats
Municipi: Salt. 2011

	Total
Residents que estudien a dins	**5.908**
No residents que estudien a dins	**1.037**
Residents que estudien a fora	**1.230**
Residents que estudien a diversos municipis	**159**
Llocs d'estudi localitzats	**6.945**
Alumnes residents	**7.298**
Diferència lloc localitzats - residents	**-353**

Unitats: persones que es desplacen
Font: Idescat, a partir del Cens de població i habitatges 2011 de l'INE.
(1) Llocs d'estudi localitzats: Residents que estudien a dins + No residents que estudien a dins
(2) Alumnes residents: Residents que estudien a dins + Residents que estudien a fora + Residents que estudien a diversos municipis

Alumnes residents i llocs d'estudi localitzats per nivell d'estudis. Ensenyaments no universitaris
Salt. Curs 2020/2021

	Educació infantil 2n cicle	Educació primària	Educació secundària obligatòria	Batxillerat	Cicles formatius de grau mitjà	Cicles formatius de grau superior	Total
Residents que estudien al municipi	1.085	2.280	1.330	175	150	65	**5.085**
No residents que estudien al municipi	40	90	80	30	375	375	**995**
No consta residència i estudien al municipi	0	15	35	0	0	0	**50**
Residents que estudien a fora del municipi	80	200	175	95	200	125	**875**
Llocs d'estudi localitzats (1)	1.130	2.385	1.445	205	525	440	**6.130**
Alumnes residents (2)	1.170	2.485	1.505	270	350	190	**5.965**

Unitats: Alumnes.
Font: Idescat, a partir de les dades de la matrícula del Departament d'Educació.
Nota: Els resultats estan arrodonits a valors múltiples de 5. Per aquesta raó algun total pot no coincidir amb la suma de la seva desagregació.
(1) Llocs d'estudi localitzats = Residents que estudien al municipi + No residents que estudien al municipi + No consta residència i estudien al municipi.
(2) Alumnes residents = Residents que estudien al municipi + Residents que estudien a fora del municipi.

Source: https://www.idescat.cat/emex/?id=171557

XII. ANNEX: Municipality in figures - Vilablareix (Gironès)

Vilablareix	
Codi	172155
Comarca	Gironès
Població (2021)	3.225
Superfície (km²)	6,17
Densitat (hab./km²)	522,7
Altitud (m)	114

Població a 1 de gener. Per sexe i edat quinquennal
Vilablareix. 2020

	Homes	Dones	Total
De 0 a 4 anys	98	90	**188**
De 5 a 9 anys	117	98	**215**
De 10 a 14 anys	91	95	**186**
De 15 a 19 anys	81	65	**146**
De 20 a 24 anys	73	73	**146**
De 25 a 29 anys	68	68	**136**
De 30 a 34 anys	70	102	**172**
De 35 a 39 anys	137	135	**272**
De 40 a 44 anys	142	159	**301**
De 45 a 49 anys	99	121	**220**
De 50 a 54 anys	102	115	**217**
De 55 a 59 anys	102	85	**187**
De 60 a 64 anys	107	93	**200**
De 65 a 69 anys	89	93	**182**
De 70 a 74 anys	59	66	**125**
De 75 a 79 anys	46	32	**78**
De 80 a 84 anys	17	18	**35**
De 85 a 89 anys	11	28	**39**
De 90 a 94 anys	6	9	**15**
De 95 a 99 anys	2	1	**3**
100 anys o més	0	0	**0**
Total	**1.517**	**1.546**	**3.063**

Creixement intercensal de la població

CAT COM MUN

Creixement total. 2011	396
Creixement total (mitjana anual) (taxa per 1.000 habitants). 2001-2011	17,75
Creixement natural (mitjana anual) (taxa per 1.000 habitants). 2001-2011	4,48
Creixement migratori (mitjana anual) (taxa per 1.000 habitants). 2001-2011	13,27

Població estrangera a 1 de gener. Per sexe i edat quinquennal. 2020
Vilablareix

	Homes	Dones	Total	% sobre la població
De 0 a 4 anys	<4	0	<4	4,41
De 5 a 9 anys	<4	0	<4	1,47
De 10 a 14 anys	<4	<4	<4	2,94
De 15 a 19 anys	<4	<4	<4	2,94
De 20 a 24 anys	<4	<4	5	7,35
De 25 a 29 anys	<4	5	7	10,29
De 30 a 34 anys	<4	5	7	10,29
De 35 a 39 anys	9	8	17	25,00
De 40 a 44 anys	<4	7	8	11,76
De 45 a 49 anys	<4	<4	4	5,88
De 50 a 54 anys	<4	<4	<4	2,94
De 55 a 59 anys	<4	<4	<4	2,94
De 60 a 64 anys	<4	<4	<4	4,41
De 65 anys i més	<4	<4	5	7,35
Total	**30**	**38**	**68**	**100,00**
%	44,12	55,88	100,00	

Font: Idescat, a partir del Padró continu de l'INE.

Alumnes residents i llocs d'estudi localitzats per nivell d'estudis. Ensenyaments no universitaris
Vilablareix. Curs 2020/2021

	Educació infantil 2n cicle	Educació primària	Educació secundària obligatòria	Batxillerat	Cicles formatius de grau mitjà	Cicles formatius de grau superior	Total
Residents que estudien al municipi	105	200	130	30	0	0	**465**
No residents que estudien al municipi	5	5	380	85	0	0	**470**
No consta residència i estudien al municipi	0	0	0	0	0	0	**0**
Residents que estudien a fora del municipi	20	40	15	15	15	20	**120**
Llocs d'estudi localitzats (1)	110	205	510	110	0	0	**935**
Alumnes residents (2)	125	240	150	40	15	20	**585**

Unitats: Alumnes.
Font: Idescat, a partir de les dades de la matrícula del Departament d'Educació.
Nota: Els resultats estan arrodonits a valors múltiples de 5. Per aquesta raó algun total pot no coincidir amb la suma de la seva desagregació.
(1) Llocs d'estudi localitzats = Residents que estudien al municipi + No residents que estudien al municipi + No consta residència i estudien al municipi.
(2) Alumnes residents = Residents que estudien al municipi + Residents que estudien a fora del municipi.

Llocs d'estudi localitzats per lloc de residència de l'alumne. Ensenyaments no universitaris
Vilablareix

	Alumnes que resideixen al mateix municipi	Alumnes que resideixen a la resta de la comarca	Alumnes que resideixen a la resta de Catalunya	Alumnes que resideixen fora de Catalunya	No consta residència de l'alumne	Total llocs d'estudi localitzats
Curs 2020/21	465	460	15	0	0	**935**
Curs 2019/20	430	435	10	0	0	**880**
Curs 2018/19	410	400	10	0	0	**820**
Curs 2017/18	390	385	5	0	0	**785**
Curs 2016/17	355	365	5	0	0	**725**
Curs 2015/16	335	330	5	0	0	**675**
Curs 2014/15	305	335	5	0	0	**645**
Curs 2013/14	300	310	10	0	0	**620**
Curs 2012/13	280	275	5	0	0	**560**
Curs 2011/12	250	210	5	0	0	**460**

Unitats: Alumnes.
Font: Idescat, a partir de les dades de la matrícula del Departament d'Educació.
Nota: Els resultats estan arrodonits a valors múltiples de 5. Per aquesta raó algun total pot no coincidir amb la suma de la seva desagregació.

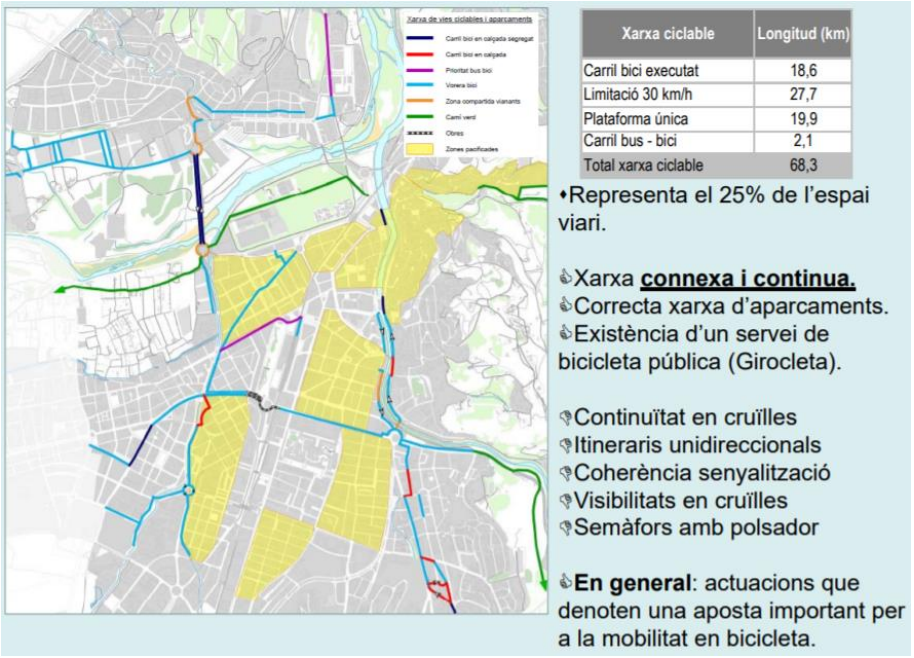
Alumnes residents i llocs d'estudi localitzats. Ensenyaments no universitaris
Vilablareix

	Curs 2020/21	Curs 2019/20	Curs 2018/19	Curs 2017/18	Curs 2016/17	Curs 2015/16	Curs 2014/15	Curs 2013/14	Curs 2012/13	Curs 2011/12
Residents que estudien al municipi	465	430	410	390	355	335	305	300	280	250
No residents que estudien al municipi	470	450	410	395	370	340	340	320	280	210
No consta residència i estudien al municipi	0	0	0	0	0	0	0	0	0	0
Residents que estudien a fora del municipi	120	125	110	100	115	110	110	115	140	170
Llocs d'estudi localitzats (1)	935	880	820	785	725	675	645	620	560	460
Alumnes residents (2)	585	555	520	490	465	445	415	415	420	415

Unitats: Alumnes.
Font: Idescat, a partir de les dades de la matrícula del Departament d'Educació.
Nota: Els resultats estan arrodonits a valors múltiples de 5. Per aquesta raó algun total pot no coincidir amb la suma de la seva desagregació.
(1) Llocs d'estudi localitzats = Residents que estudien al municipi + No residents que estudien al municipi + No consta residència i estudien al municipi.
(2) Alumnes residents = Residents que estudien al municipi + Residents que estudien a fora del municipi.

Source: https://www.idescat.cat/emex/?id=172155

XIII. ANNEX: Bicycle Network



Xarxa ciclable	Longitud (km)
Carril bici executat	18,6
Limitació 30 km/h	27,7
Plataforma única	19,9
Carril bus - bici	2,1
Total xarxa ciclable	68,3

- Representa el 25% de l'espai viari.

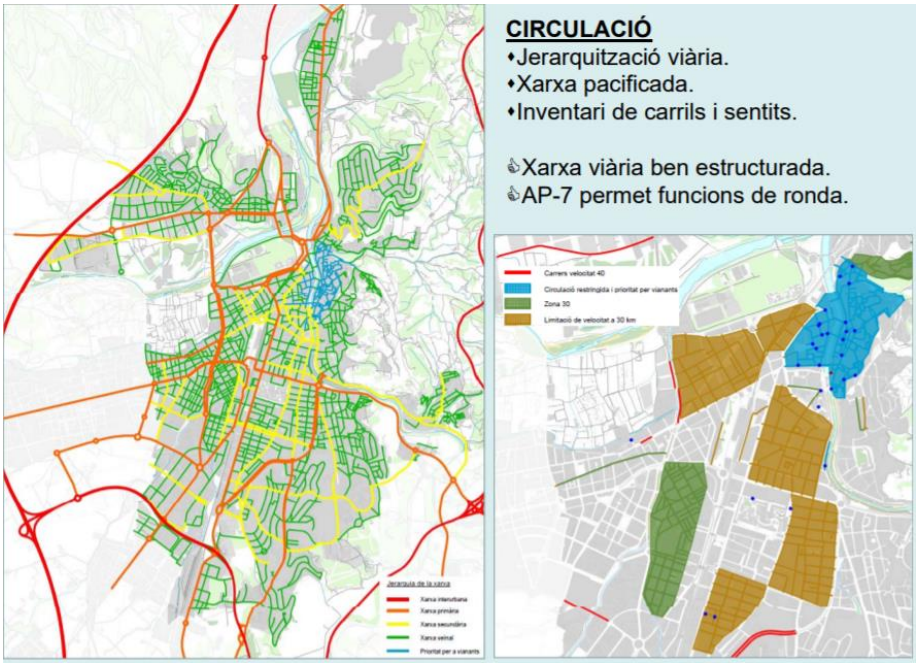
- Xarxa **connexa i continua.**
- Correcta xarxa d'aparcaments.
- Existència d'un servei de bicicleta pública (Girocleta).

- Continuïtat en cruïlles
- Itineraris unidireccionals
- Coherència senyalització
- Visibilitats en cruïlles
- Semàfors amb polsador

- **En general**: actuacions que denoten una aposta important per a la mobilitat en bicicleta.

Source:https://web.girona.cat/documents/20147/271997/3_2014-11-05-PMU-GRN-Doc4-Sintesi-v20.pdf

XIV. ANNEX: Motorised private transport network



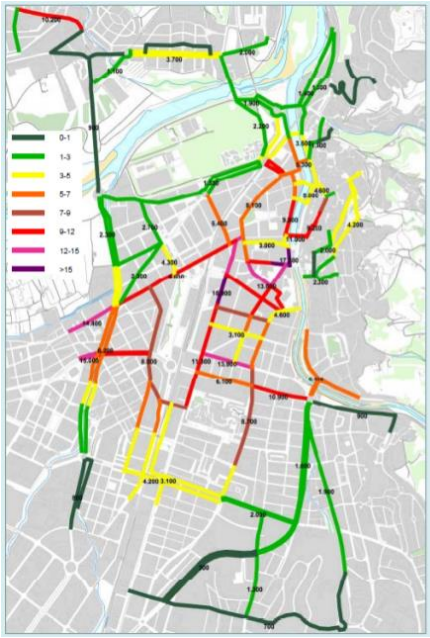
CIRCULACIÓ

- Jerarquització viària.
- Xarxa pacificada.
- Inventari de carrils i sentits.

- Xarxa viària ben estructurada.
- AP-7 permet funcions de ronda.

Source:https://web.girona.cat/documents/20147/271997/3_2014-11-05-PMU-GRN-Doc4-Sintesi-v20.pdf

XV. ANNEX: Mobility on foot



AFORAMENTS

- 10 punts de llarga durada → patró diari
- 86 punts de curta durada→ mallar el territori

- Temps mitjà de desplaçament : 16 minuts

- Els eixos amb major flux de circulació vianants es troben dins aquest 55% de vials que disposen de "voreres còmodes"

ENQUESTES

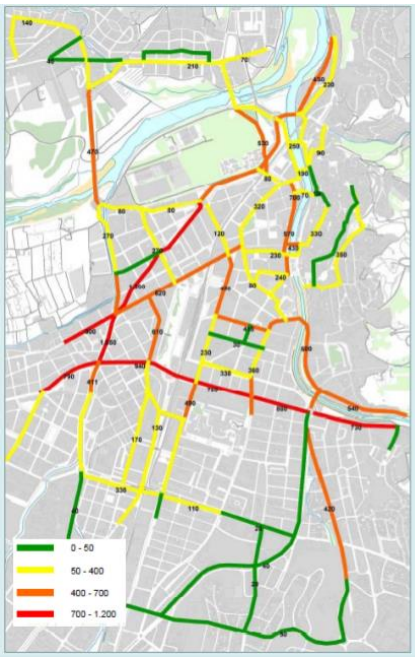
- Suficients passos de vianants

- Necessitar d'augmentar el nombre de guals
- Velocitat adequada dels vehicles motoritzats

Valoració global usuaris (0-10): 6,7 punts

Source:https://web.girona.cat/documents/20147/271997/3_2014-11-05-PMU-GRN-Doc4-Sintesi-v20.pdf

XVI. ANNEX: Mobility by bicycle



AFORAMENTS

- 10 punts de llarga durada → patró diari
- 5 aforaments automàtics → patró setmanal
- 86 punts de curta durada→ mallar el territori

- Temps mitjà de desplaçament : 20 minuts

Mapa de trànsit → Demanda notable
(5% modes no motoritzats)

APARCAMENTS

- Ocupació mitjana: 20%

- No hi ha aparcaments saturats

ENQUESTES

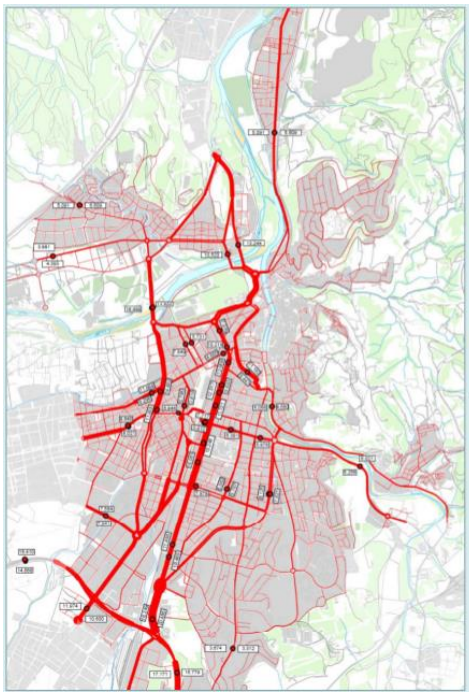
- Comoditat

- Sensació d'inseguretat fora dels carrils bici

Valoració global usuaris (0-10): 6,3 punts

Source:https://web.girona.cat/documents/20147/271997/3_2014-11-05-PMU-GRN-Doc4-Sintesi-v20.pdf

XVII. ANNEX: Mobility in private transport



AFORAMENTS: CIRCULACIÓ

- 33 aforaments de llarga durada → patró diari.
- 24 seccions d'aforaments direccionals→ → comportament d'interseccions.

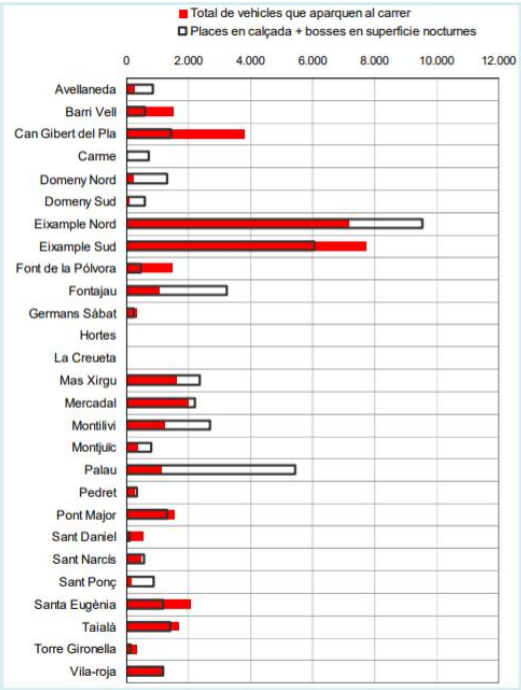
- Vies amb més trànsit: av. Barcelona, c/ Riu Güell, Gran Via Jaume I, Sta. Eugènia, ponts sobre el Ter, accessos per Pedret i Emili Grahit.

- El 48% del trànsit es concentra en les vies principals(21% de la xarxa).

ENQUESTES/OBSERVACIÓ

- Baix trànsit de pas en vies principals (6%).
- Ús del casc en motocicletes (100%).

- Manca d'ús del cinturó (5%).
- Ús del telèfon mòbil (2%).



APARCAMENT NOCTURN

- Grau d'ocupació: 70-80-90%.

- Important volum de vehicles de fora Girona que aparquen en le municipi.

- Existeixen sectors amb dèficit d'aparcament (Barri Vell, Can Gibert del Pla, Eixample Sud, Font de la Pólvora i Santa Eugènia).

APARCAMENT DIÜRN

- Grau d'ocupació:
  95% en places no regulades.
  91% en places regulades (zona blava).
  70% en places de C/D.

- Grau de rotació:
  3veh/plaça en places no regulades.
  6veh/plaça en places regulades (zona blava).
  6veh/plaça en places C/D.

Source:https://web.girona.cat/documents/20147/271997/3_2014-11-05-PMU-GRN-Doc4-Sintesi-v20.pdf

PLAN OF IMPLEMENTATION OF A TRAM SYSTEM IN THE URBAN AREA OF GIRONA

FINAL DEGREE PROJECT
Universitat de Girona – Faculty of Business and Economic Sciences

Abstract

This Final Degree Project presents a preliminary study on the implementation of a tram system in the urban area of Girona.

Specifically, it is proposed to improve the quality the current public transport as well as to decongest the traffic of urban centres and connect the municipalities of Salt and Vilablareix with the urban nucleus of the city of Girona in an efficient way.

Consequently, a preliminary study of the tram is carried out and relevant comparisons are carried out with other transport systems. As a result, it is concluded that the tram allows to reduce CO2 emissions from 183 g/vkm (traveller per kilometre) to 26.4 g/vkm.

Introduction

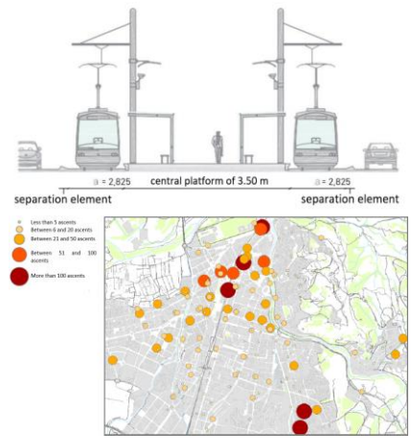
This proposal exploits the potential of a sustainable collective means of transport that have the least possible impact on the environment and the environment.

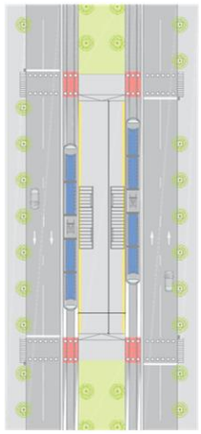
The tram represents a model of urban mobility, safe, fast, comfortable and accessible while stands out for the absence of polluting emissions, low sound levels, reduction of energy consumption, and integration with the environment.

In addition, the construction of the infrastructure represents an opportunity for the modernisation of the streets around the tram system, while reversing the levels of comfort and quality of life of citizens in urban areas, which were previously reduced by the presence of vehicles and pollution.

RATES (VAT included)	Single ticket	T10 card	T30 card	Tmonthly card	Free
price	1,40 €	9,90 €	22,50 €	42,50 €	0,00 €
price / trip	1,40 €	0,99 €	0,75 €	0,71 €	0,00 €

Methods and Materials





The location of the stops has been determined by three lines of analysis: The first fulfils the following criteria: resident population density, work centres, areas of interest, commercial areas and public facilities.

The second takes into account the alighting and disembarking incidents at the TMG stops in the city of Girona to establish patterns of current users.

And the third uses the isochronous system, map that defines the accessible area from a point within a certain time frame.

The implementation of dedicated platforms is chosen with the aim of guaranteeing safety and punctuality. In accordance with the specificities of the streets, a two-way platform with a central platform of 3.50 m and side poles is proposed.

Results

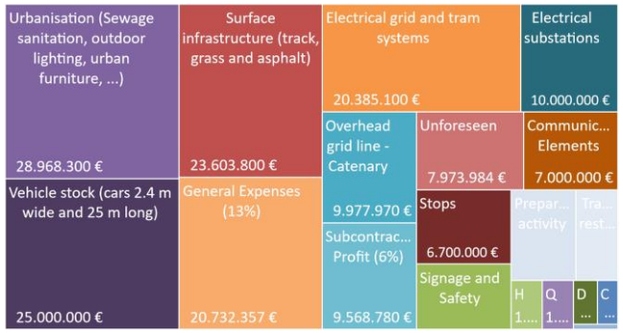
Following functional and efficiency criteria, It has proposed the implementation of two lines

L1: Espai Gironès - Salt – Girona -UdG Montilivi
L2: Vilablareix - Eixample - Correus - Fontajau

It is concluded after obtaining the mobility study that:

- The total demand for the most likely (optimistic) scenario is the first year of exploitation of about 8.5M users and that would end up consolidating with about 12-15M passengers per year, reaching 16.5M users by 2030.
- From 2031 onwards, moderate-weak year-on-year growth is assumed linked to the increase in population, by 2050 the service would end up assuming about 46,000 trips a day.

BOX 1. BUDGET OF MATERIAL EXECUTION



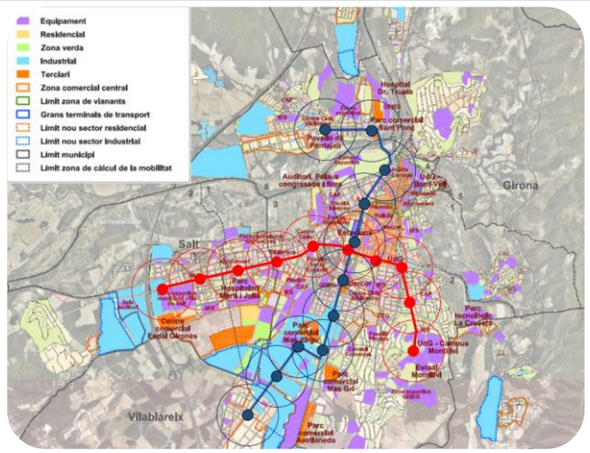
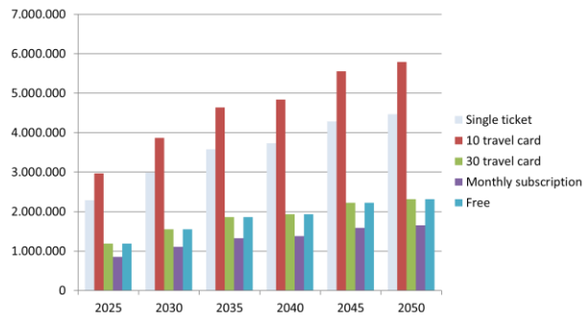
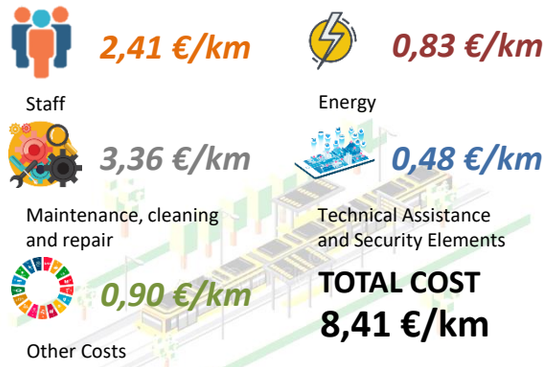


CHART 1. ANNUAL USERS FOR FARE POLICY 2025 - 2050.



Operating Costs



** A cost analysis/annual route ratio of 563,988 km has been carried out to detail an average price per km.*

Conclusions

The economic and financial analysis resolves that the project is viable.

The internal return rate obtained is higher than the minimum rate of return required on investment (5.45% > 5%) and the updated value of future investment collections and payments, at the discount rate it would generate profits € 15,522,740.59 (NPV).

In this sense, the economic contribution by the administration must include:

- In the initial phase: a subsidy or the full payment of the initial investment (infrastructure and mobile material). Amount of € 164,996,809.68 for the infrastructure and € 25,000,000 for mobile material.
- In the operating phase: a fare subsidy of € 0.46 per trip (VAT included), being the technical rate of the area of € 1.36.

Future Directions

The tram would have the potential to stimulate:

- ✓ Investment activity in urban renewal and residential and commercial development projects
- ✓ Increase in retail sales, development, growth of environmental values
- ✓ Increased tourism, benefiting owners, businesses and public institutions.

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CALL: **ABRIL 2022**

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