Escola Politècnica Superior d'Enginyeria de Vilanova i la Geltrú

UNIVERSITAT POLITÈCNICA DE CATALUNYA

Final Report

08.06.2021

Project 3 : Fuzz Sensoring

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I. Abstract

Traffic congestion is a significant problem that affects smoothness in transportation in many cities around the world. It is unavoidable due to increasing numbers of vehicles and overuse of roads in large and growing metropolises. Although several policies are implemented to reduce traffic congestion, such as improvement of public transport, car and motorcycle restriction on several roads, and an even-odd license plate policy, the major problem involves getting data in order to predict and avoid traffic. Information can be collected from many sources such as city traffic sensors, GPS, as well as, from many application programming interfaces (API) provided by different companies. The project involves gathering sources and information about traffic congestion in order to create guidelines that can be essential in creating a traffic map of Vilanova i la Geltrú in the future. Eventually, the guidelines to the city of Vilanova i la Geltrú are provided, consisting of analysis of traffic inside the city, IoT management, choices of APIs, effective selection of sensors, and cost analysis to vastly improve traffic flow.

Key words: traffic congestion, API, GPS, sensors, Data

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1. Introduction

There is no doubt that we are witnessing an era of profound economic and social change driven by the advancement of technology. The technological revolution is transforming the way we live, work and interact. We live in a hyper-connected society. For the first time in history, billions of people are continuously connected through their mobile devices. This event leaves a digital footprint, generating a massive amount of data.

This technological revolution, known as the fourth industrial revolution, causes a continuous confluence of new technologies, such as artificial intelligence, the internet of things, robotization, autonomous vehicles, or nanotechnology. Cities need data to solve their problems. Many factors contribute to traffic flow, including driver behavior, urban topology, transit rules, driving conventions, infrastructure, and demand. Here the project is focused on one factor: traffic data.

The project required not only careful planning and analysing of each step but also stating the problem definition. Presentation of the team members and a description of the project stating the problem definition is presented in section 2. Section 3 focuses on traffic management, the types, and the importance of effective management. Furthermore, the section compares traffic management strategies in different countries and cities. The traffic situation related to Vilanova i la Geltrú is described in section number 4. In addition, the work involves theoretical background related to available technology and data sources used for traffic information like GPS, API and sensors contained respectively in section 5, 6 and 7. Solutions about getting data about traffic in Vilanova i la Geltru are presented in section 8. Based on all research, the final product, in the form of guidelines with instructions and ideas about managing traffic, is attached in section 9 and 10. Section 9 includes comparison and final proposition of using API and sensors for Vilanova i la Geltrú. Whereas, section 10 is focused on the possibility of mixing data while using the concept of IoT system. The last three sections include conclusions, bibliography and appendices related to the project.

2. Project “Fuzz Sensoring”

2.1. Group Introduction

'Fuzz Sensoring' was carried out by five international students participating in the European Project Semester (EPS) 2021 from various study fields with different experiences. Team members are presented in the table below (tab.1.), where figure 1 depicts countries of each student's origin. This project is a collaboration between Universitat politècnica de Catalunya EPSEVG and local company Neàpolis.

Name	Nationality	University	Field of Study
Youssra Benaddi	Morocco	EPSEVG	Mechanical Engineering
Sean Johnston	Scottish	Glasgow Caledonian University	Mechanical Systems Engineering
Fraz Muhammad	Spanish	EPSEVG	Industrial Electronics
Paul Vilain	French	ESIReims	Packaging Engineer
Justyna Zasada	Polish	Technical University of Lodz	Mechanical Engineering

Tab.1. Team members.

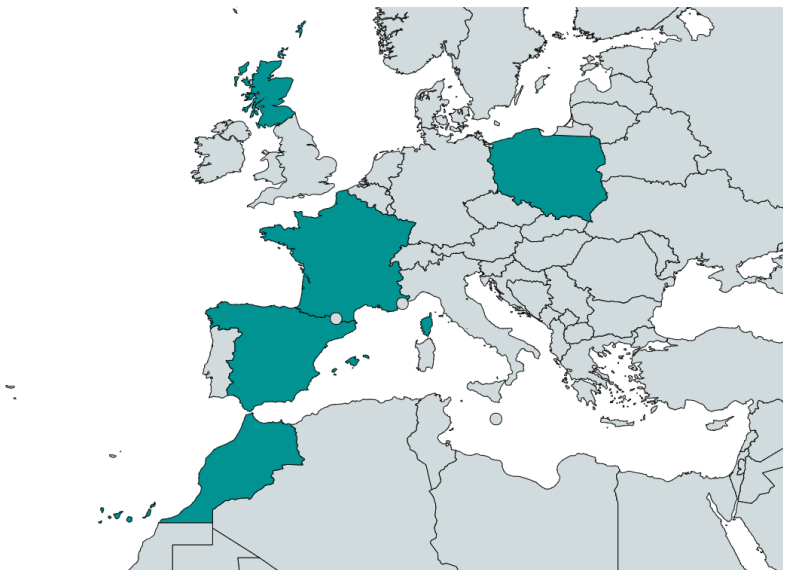


Fig.1. Nationalities of group members.

2.2. Description of the project

The aim is to improve the current state of traffic management in Vilanova. Thus, it is essential to use traffic APIs and sensors to provide traffic data of the city. However, we are also going to work under the assumption we are limited to a set few. Once research has been conducted, guidelines will be set to support the choice of API's and what kind of set of sensors are needed to improve the city of Vilanova. A task also is to discover effective ways to achieve data where none is gained through APIs and sensor use.

2.3. Problem Definition

To know the project's direction, it was critical to brainstorm about the most prominent challenges and questions we would encounter along with our project. After going back and forth, we found that the main queries are:

- How many API can we get traffic data? Which one is the best one for Vilanova? Are they free, or do they have a cost? To what extent IoT technologies (Internet of things) can help tackle traffic issues in cities?
- Make a useful inference with the current sensors and add potentially more sensors to be appropriate to the needs of the city. In addition, propose the location of said sensors.
- Carry out a study on the current traffic situation in Vilanova and find out critical points.
- Calculate the price of each API for traffic data and the cost of implantation of sensors in the city.
- Create a proposition on how to improve the current state of Traffic in Vilanova.

2.4. Purpose and Scope of the Guidelines:

In order to facilitate the assessment of present and future traffic demands, for the development of need-based infrastructure accurate information and continuous monitoring of traffic by appropriate methods is necessary. Implementing authorities must therefore ensure that sufficient and appropriate data is available to undertake necessary planning, design, construction and maintenance of the country's road network, which is aimed at meeting the prevailing traffic flow, future traffic growth and loading without considerable deterioration in the quality of service.

2.5. Work breakdown structure

This structure helps to see the full overview of the project, step by step to reach the final work. As we can see, at the bottom we will start with a deep study of APIs and sensors. The next step will be to study and research Vilanova traffic management and how to improve it. The last step will be to design a programmable system to display useful traffic information to make traffic decisions (this part will be future work).

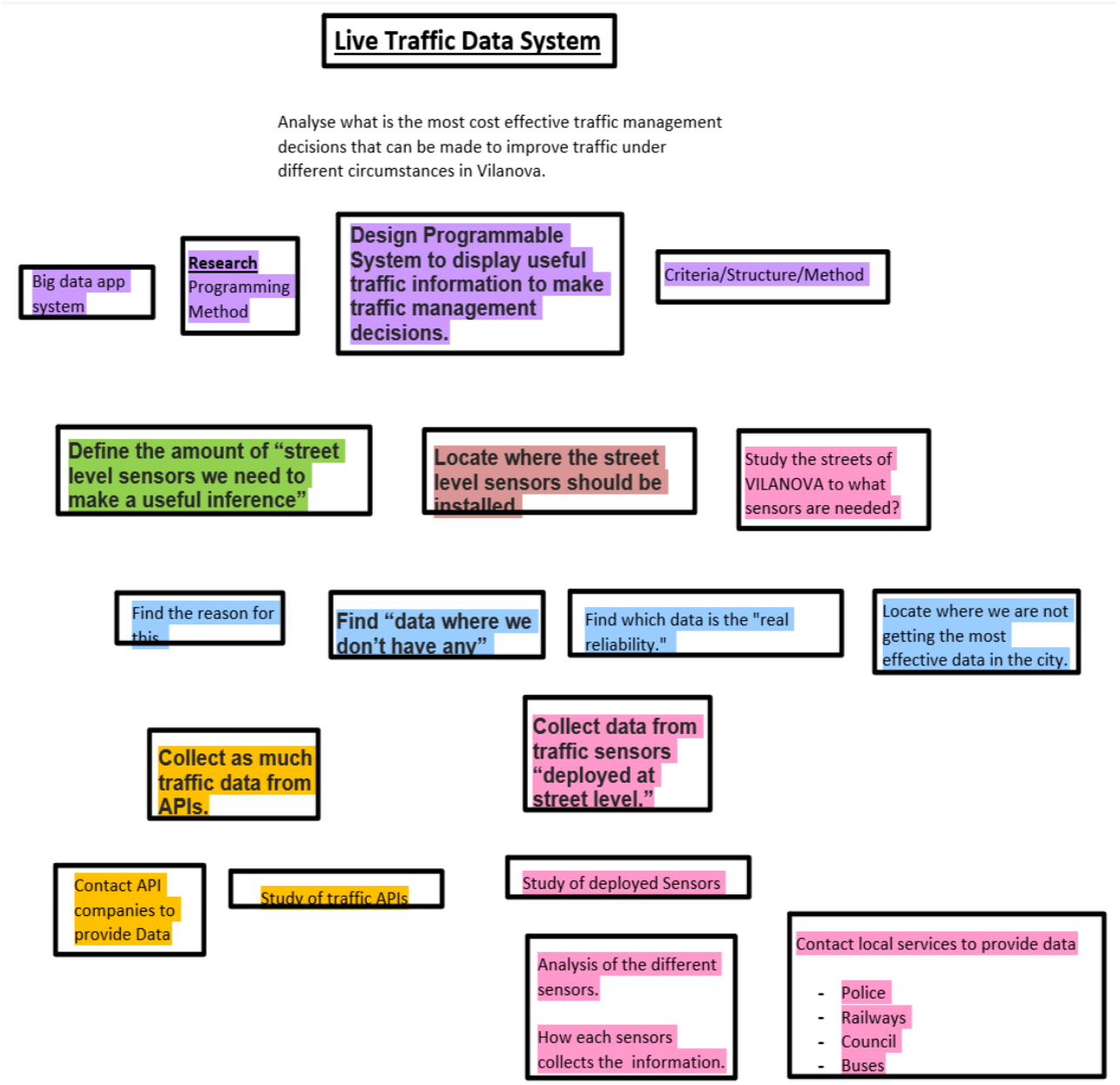


Fig.2. Graph showing work breakdown structure.

3. Study of traffic management

3.1. What is traffic management?

Traffic Management is the procedure designed to improve the state of traffic. It stems from improving safety, efficiency, security and the environment. It is a predominately complicated system with many sources of information to deal with and take into account. The issue is to make the best possible traffic management decisions to get the best outcomes in all aspects of improvement.

The areas to consider are;

- **Automobiles and Pedestrians** - Quality of vehicles, the understanding of human behaviour, understanding travel times/rush hours.
- **Lorries/trucks(deliveries/transports) and smaller vehicles** - Analysing the influence each type of vehicles have over each other.
- **Vehicle parking** - Employees, tourists, and the distribution of products & services.
- **For Road maintenance** - Road resurfacing, filling potholes and repainting of road lanes/signs.
- **Civil Engineering project**s - Building of structures, Testings/Visits, impact it has on the city.
- **Speed Restriction** - Finding the best speed on every road that conveys safety and provides the quickest times.
- **Populations** - Understanding the busiest places and keeping up to date with the current and future state of the population.
- **Density of the city** - How compact the urban areas are and the impact it has on having little confined places to travel.
- **Roads Systems** - Understanding how a city operates via one way roads, complex roads, roundabouts and traffic lights.

3.1.1. Why is it so important?

Safety

The critical issue of traffic management is the safety of the people (drivers/pedestrians.) To increase safety it is pivotal to ensure that people can get from point A to B as smoothly and easily as possible with risk of failure kept to minimum. Hence, avoiding accidents at all costs.

In the event of national emergencies, no matter how big or small, the advice of traffic managers are used to guide people to safety hence how important traffic management is.

Efficiency

Traffic has the capability of consuming and wasting time for every individual. Solving this problem will increase productivity for all parties, which in the long run improves the economy.

Cities are becoming increasingly popular all over the planet. According to the UN, an estimate of 68% of its population in 2050 will be living in 'urban' areas. Thus there will be more roads and more cars to handle in densely populated places. As a result, there will be more traffic to handle; hence the demand for traffic management improvement to be more fluid and quick as possible increases.

To summarise the benefits of a good traffic management system the following are key areas of development. Firstly, improvement of traffic guidance and traffic flow, which will result in reduction of the risk of accidents. What is more, traffic can be cleared without any irregularities and should be managed smarter and savvier. Excess expenditure of the government on traffic police needs to be reduced. Time of the commuters on the road should be saved and traditional methods of traffic management systems replaced. All factors would influence the usage of the fuel, which can be saved up to 70% compared to normal timer-based traffic control.

Environment

This is a huge factor, especially in the world today with vehicles all over the world. Considering there are 1 billion cars to this date. With a majority of them polluting the air with carbon dioxide, further damaging our planet. Thus why traffic management is pivotal in reducing the time cars are spent on the road.

3.2. How traffic can be managed

There are many ways to reduce traffic jams in the busiest urban areas, improve tariff management and reduce polluting gas emissions. We will explain a few in summary ways below.

- **Public transport**

Traffic jams at rush hour are the antagonists of the streets of urban areas, so to avoid the pollution and problems that this fact generates, changing personal vehicles for public transport is a good measure.

- **Intelligent traffic control systems**

Traffic control through smart devices is no longer a utopia to become a reality. There are many advantages that smart traffic lights bring, which allows a reduction in waiting times for drivers.

- **Real-time information**

Among the many reasons to bet on smart mobility in cities, the fact that everything is controlled through technology in real-time is one of the main advantages, since in this way drivers will know the roads on which the circulation is complicated by accidents, works or traffic jams and it will be possible to deviate its route. Next, we can see some of the examples:

Google Maps

It provides many functions like location services, address search, navigation (in different means of transport), traffic status, street view, business listings, indoor maps, etc. One of the most useful functions of Google Maps and yet the most fascinating is the ability to inform the user of the traffic expected ahead on their journey.

Route monitoring from TomTom

TomTom Route Monitoring is a simple and cost-efficient way to see detailed travel times, speeds and traffic delays on strategic routes. Real-time analytics can then be shared easily with drivers on Variable Message Signs (VMS) or web and mobile applications, broadcasting effective decisions with a positive impact on traffic conditions.

In Catalonia, the following authorities are in charge of managing all this :

- **The Servei Català de Trànsit (SCT)**

Is an agency under the Generalitat de Catalunya in charge of designing and implementing road safety policies in Catalonia. The basic road network is reproduced on a Google Maps map focused in Catalonia, which allows different levels of zooming and searching by visualizing this information in map, satellite or relief format.

- **DGT (Dirección General de Tráfico)**

Has various tools for the measurement and detection of traffic conditions. An example of this are the hundreds of cameras and sensors distributed along the main roads of Spain, through which they can detect fluidity in circulation. In addition, the DGT also has various maps showing: traffic conditions, traffic incidents, planned intervention forecasts on the road network, as well as lists of black spots and possible special restrictions on certain types of vehicle.

3.3. How traffic is managed in different countries

- **United Kingdom**

In the UK, The Urban Traffic Management Control (UTMC) system is applied for managing traffic. This system is designed to allow the different applications used within modern traffic management systems to communicate and share information. This allows previously disparate data from multiple sources such as Automatic Number Plate Recognition cameras, Variable Message Signs, car parks, traffic signals, air quality monitoring stations and meteorological data, to be amalgamated into a central console or database. The idea behind UTMC is to maximise road network potential to create a more robust and intelligent system that can be used to meet current and future management requirements.

- **Pittsburgh, USA**

On the other hand, Pittsburgh deployed Rapid Flow Technology's Surtrac system at 50 intersections across the city. This decentralized system uses a combination of video detection and radar to detect vehicle traffic and adjust signals in real-time using artificial intelligence-driven software. Results from the implementation have been substantial: travel times have been reduced by 26 per cent, wait times at intersections are down 41 percent and vehicle emissions have been reduced by 21 percent.

Advanced traffic management systems also enable the development of smart intersections, which are emerging as one of the essential data-driven backbones needed to solve core city challenges.

Similar to the platform capabilities offered by intelligent street lighting, layers of additional services can be added to advanced traffic management systems, such as public transport prioritization and communications with connected vehicles.

For example, in early 2018, Dallas partnered with Ericsson to upgrade the city's traffic management system. In addition to adjusting traffic signals across hundreds of intersections in real-time, the system will be connected to local transit systems. This connection is anticipated to enable a bus rapid transit route to be prioritized through targeted greenlight timing.

- **Barcelona, Spain**

Parking management and traffic control cameras are two aspects Barcelona has tried to improve urban mobility with intelligent technology. The sensors at parking spots and video with analytics provide real-time data on parking availability, which are transmitted through the city's WiFi

infrastructure, linking devices belonging to the end-user and local authorities. Traffic control cameras are connected by fibre optics to the transport authority to monitor traffic in real-time, providing the control centre means to increase or reduce the frequency of green lights according to the traffic conditions.

3.3.1. Comparison

Analysing all traffic management in different cities, the most important aspect is focused on modern technology like sensors, cameras and advanced artificial intelligence software, in order to provide real time data. The aim is to apply smart cities solutions, involving adaptive traffic signals, pedestrian safety, ease of parking and air quality monitoring. These technologies will allow cities to respond faster to traffic conditions, cutting down on congestion and reducing costs.

4. Traffic management in Vilanova i la Geltrú

Vilanova i la Geltrú is the capital of the Garraf region, located halfway between the main metropolitan areas of Catalonia (40 km from Barcelona and 45 from Tarragona). With a population of 35,714 in 1970, currently in 2021, it now has a population of 67,533 and that represents a growth of almost 50%. The increase in population also means an increase in traffic, to understand traffic management. A study of Vilanova was conducted to better understand the underlying problems of the city.

Neighborhoods

Vilanova i la Geltru It is divided into 18 neighbourhoods called *'barris'* (fig.2)

- ➔ L'Aragai / L'Armanyà
- ➔ Barri de Mar / Can Marquès
- ➔ Casernes / Centre Vila
- ➔ Collada / Fondo Somella
- ➔ La Geltrú / Masia Nova
- ➔ Molí Vent / Nucli Antic
- ➔ Sardana / Prat Vilanova
- ➔ Ribes Roges / Sant Joan
- ➔ Santa Maria / Tacó

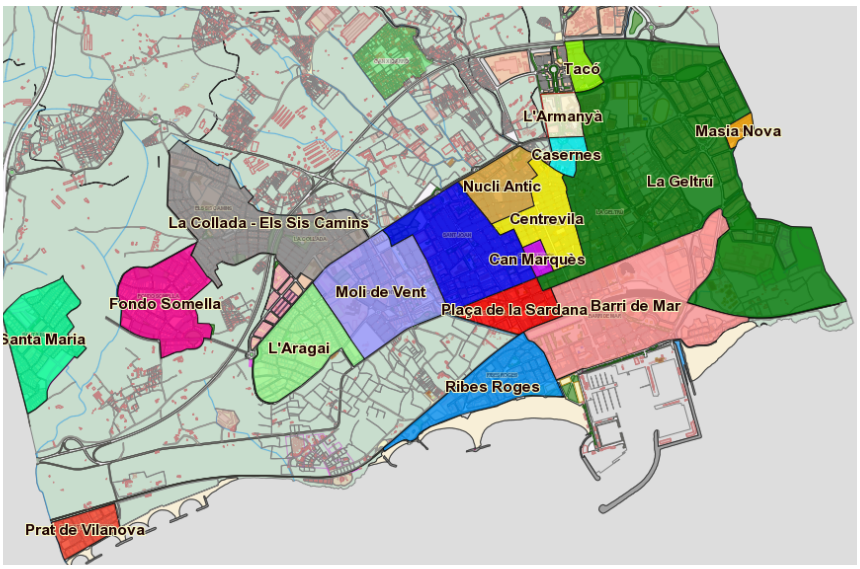


Fig.2. Map of Vilanova i la Geltrú- neighborhoods division.

Different zones

In the above map (fig.3), we can observe the distribution of the city in three different areas:

- Residential use (in grey colour)
- Commercial use (in Salmon colour)
- Industrial use (in blue colour)

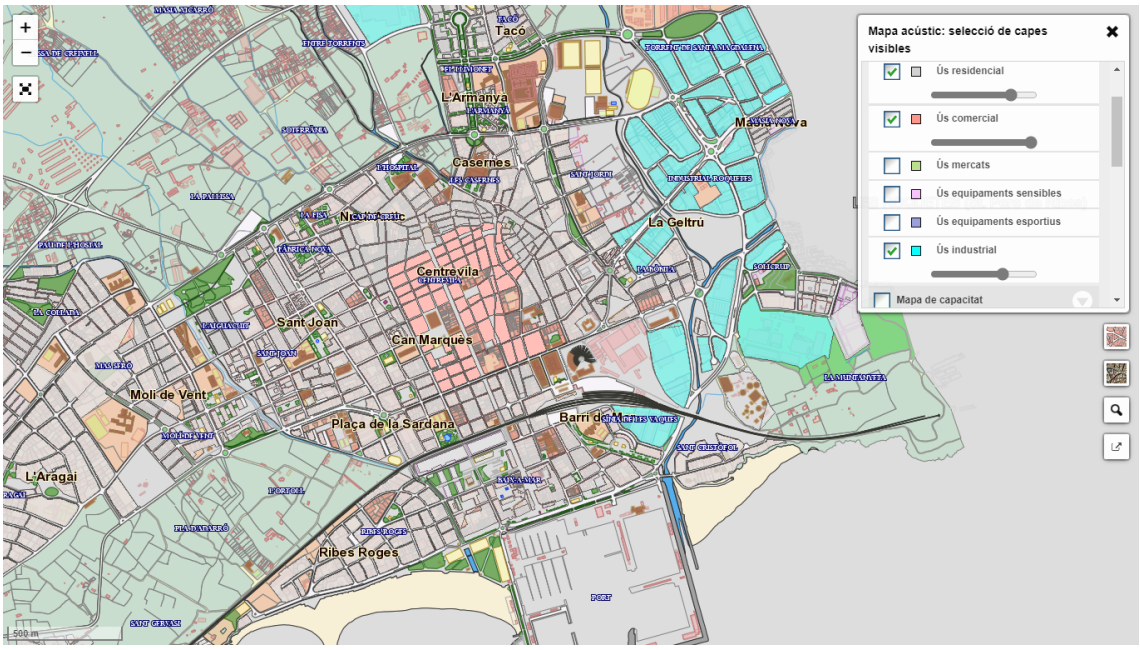


Fig.3. Map of Vilanova i la Geltrú- zones division.

Streets distribution

Vilanova, being a small and highly concentrated city. One of the consequences that the traffic management in Vilanova suffers nowadays is that many of its streets have gone from being two-way

to just one, this is because the city council prioritizes the transfer on foot and by bicycle over the private vehicle. This has many benefits, such as improving the fitness of the people and reducing the number of cars on the road to reduce air pollution, however this may be their intention but as a result it has caused more traffic . Only a few roads or avenues are two-way such as: Carrer de l'Aigua, Av de Jaume Balmes, Rambla de l'Exposició, Av de Francesc Macià y entre otras. The distribution of the streets are presented in the figure below (fig.4).

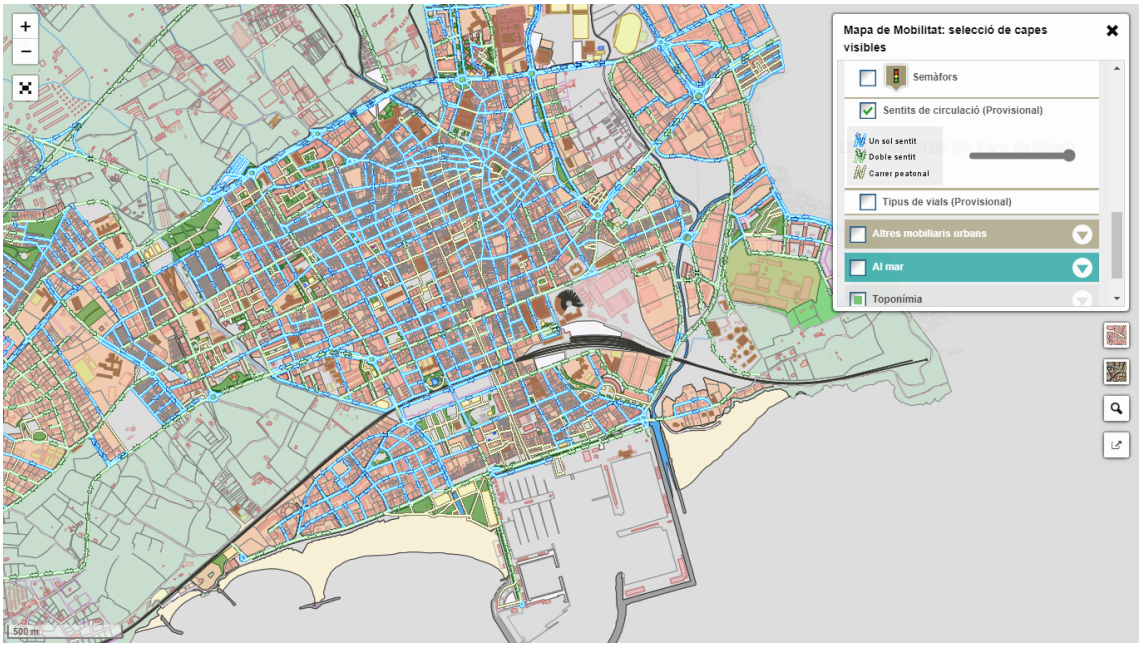


Fig.4. Map of Vilanova i la Geltrú- streets distribution.

A clear example is that if we compare the real-time traffic that Google Maps offers us (Fig. 5), we can see the areas most affected by congestion are the streets that are only one-way. For example, the center of Vilanova and the Ronda Iberica, which has recently gone from being a double lane to just one.

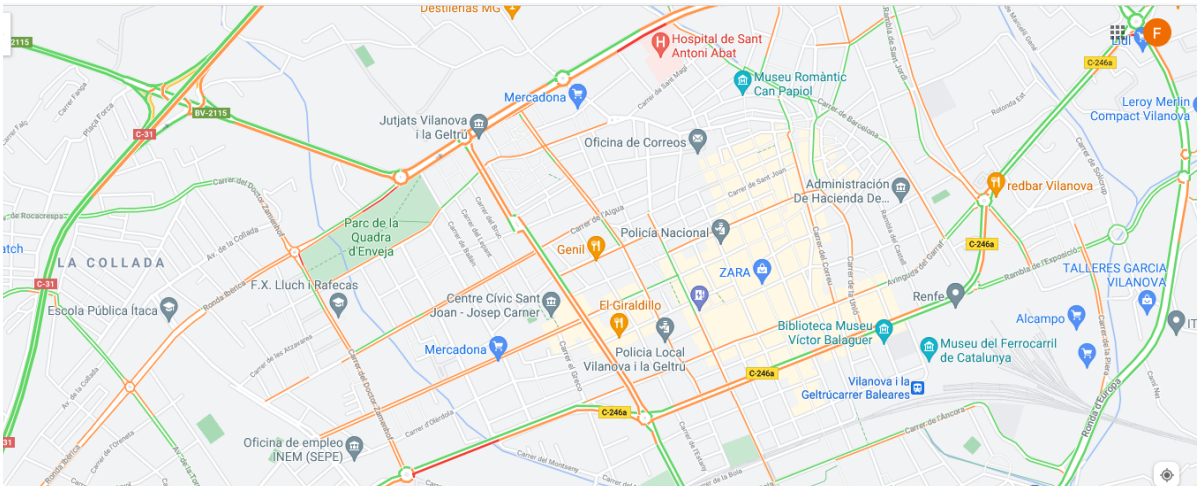


Fig. 5. Map of Vilanova i la Geltrú with real-time traffic (01-06-21 at 08:10)

Main streets

The main streets of the city are those that are connected and that enter the city directly from the surrounding cities such as Sitges, Vilafranca del Penedes, Cubelles and the one that goes to the Pantano (fig.5).

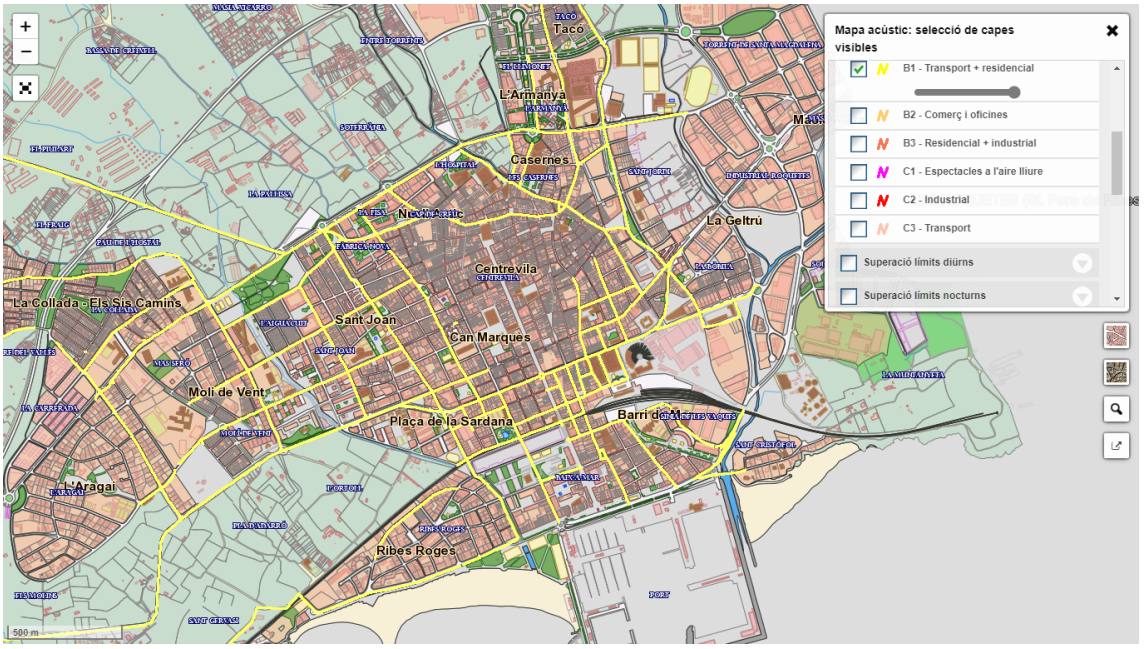


Fig.5. Map of Vilanova i la Geltrú- main streets.

4.1. The current state of traffic management and it's data sources.

Traffic

There are four significant roads to enter Vilanova i la Geltrú. We estimate that 95% of Vilanova i la Geltru traffic enters through these roads (fig.6) and these roads are the critical point of the Vilanova traffic system.

From Cubelles road: Blue dot

- Avinguda de cubelles (intersection with Carrer del Doctor Zembenhof and Carrer Ortoll)

From Pantano road: Black dot

- Ronda Ibérica (BV-2115)

From Sitges road: Green dot

- Avinguda d'Eduard Toldrà (intersection with Ronda Europa)

From Vilafranca del Penedes road: Orange dot

- Ronda Europa (C-15)

As you can see below the 4 points are located outside the urban area of Vilanova. Hence being 4 major points to enter and leave the city. This will be an ideal place to focus sensors as we will gain the most information of traffic status from these 4 highly concentrated parts of the city.

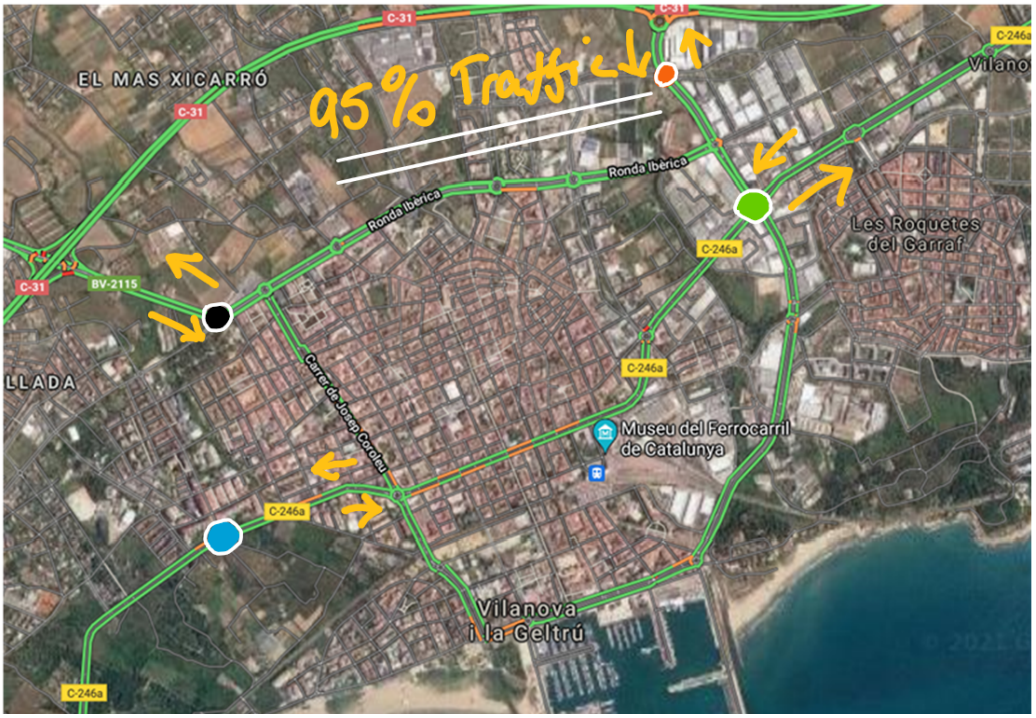


Fig.6. Map of Vilanova i la Geltrú- roads entering the city.

Most cities use sensors to know the traffic in real-time. Vilanova i la Geltrú is not a highly advanced city in technology, as there is a shortage of sensors in the city. There are only three traffic sensors in the entire town, and these three do not use highly advanced technology because you cannot obtain real-time data with them. To use their data, a person has to physically extract data with a memory card and then connect it to the computer to see the data.

We cannot know exactly which streets are busiest or where there is the most traffic with that information. To see this information, we are going to analyze the acoustic capacity map. This information is provided by Vilanova i la Geltrú City Council.

The objective of the map of the acoustic noise level of Vilanova i la Geltrú is to define the limit levels of noise emission for each street of Vilanova i la Geltrú by the criteria contemplated in the Reial Decret 1367/2007, Decret 245/2005 i al Decret 176/2009.

The territory is divided into different zones where a limit level of noise emission is assigned to it for each zone. The acoustic zoning of the region is based on the predominant land use and transport infrastructures or equipment.

4.1.1. Map of exceeding limit levels

In the below map (fig.7 and fig.8), the differences between the sound level measured or assigned to each street on the acoustic map can be represented. Thus, the different maps for exceeding the limit levels are extracted.

Map of exceeding diurnal limit levels

Fig.7. Map of Vilanova i la Geltrú- sound sensors reading during the day.

We can observe (fig.7) that exceeding noise levels between 1 and 3 dBA (in yellow colour) and between 3 and 5 dBA (in orange colour) occur in important traffic streets like Ronda Ibèrica, carrer de Josep Coroleu, Av de Jaume Blames, Carrer de l'Arquitecte Gaudi(tren), Rambla de Josep Antoni Vidal, Av d'Eduard Toldrà, Av del Pendes, Carrer de la Providència, Carrer del Palmera, Rambla de l'Exposicio.

Map of exceeding nighttime limit levels.

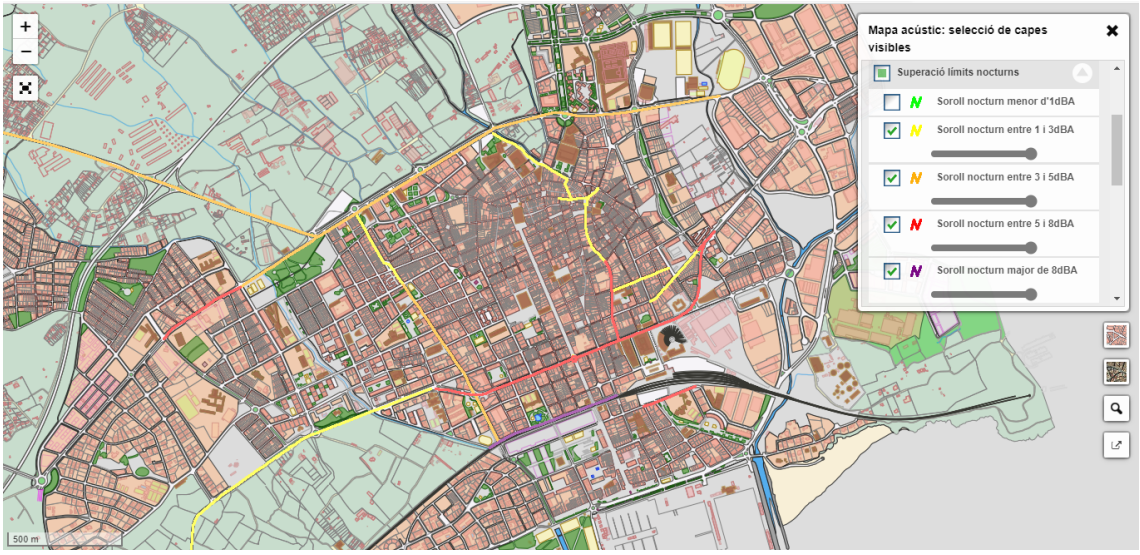


Fig.8. Map of Vilanova i la Geltrú- sound sensors reading during the night.

It is observed (Fig.8) that noise heard by the sensor exceeds considerably in the nighttime, exceeding the levels between 1 and 3 dBA (in yellow colour) are given in some streets. With 3 and 5 dBA (in orange colour) being heard in the traffic distribution streets, 5 and 8 dBA (in red colour) in the important traffic crossings, and the superior 8 dBA (in purple color) in the streets affected by the train station.

Some of the streets affected are: BV-2115, Ronda Ibèrica, carrer de Josep Coroleu, Av. De Cubelles, Av de Jaume Blames, Rambla de l'Exposicio, Av del Garraf, Carrer de la Providencia, carrer de la Unio, carrer del Palmera,Plaça Llarga and carrer de la Pastera.

4.1.2. Traffic patterns/jams

Traffic jams or congestion are a situation that affects people when many people decide to take the car at the same time, and they all travel on the same roads: to go to work, to go to university, to go to pick up the children from school, etc.

With these factors, the road network is not prepared to withstand such a high volume of traffic. According to a study carried out by the 'Infotransit' department of the RACC, the hours with the most retentions are the following:

The most conflicting hours are first thing in the morning, between 7:30 and 9:30, and in the afternoon, between 6:00 p.m. and 8:00 p.m.il

Tab.2. Intensity of traffic jams during the week in Barcelona.

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
12:00 AM	8%	7%	7%	8%	8%	9%	7%
	6%	6%	8%	11%	7%	8%	6%
02:00 AM	8%	6%	7%	10%	7%	8%	8%
	7%	6%	8%	8%	7%	7%	8%
04:00 AM	7%	4%	5%	5%	5%	5%	6%
	4%	1%	1%	2%	2%	2%	3%
06:00 AM	4%	6%	7%	7%	7%	6%	2%
	3%	31%	31%	31%	30%	28%	4%
08:00 AM	3%	40%	39%	39%	38%	34%	4%
	5%	32%	29%	28%	29%	24%	7%
10:00 AM	9%	23%	21%	21%	21%	19%	11%
	12%	24%	23%	23%	23%	22%	16%
12:00 PM	14%	25%	23%	24%	24%	23%	19%
	13%	23%	21%	23%	22%	23%	18%
02:00 PM	9%	20%	20%	21%	22%	31%	12%
	6%	19%	20%	22%	23%	33%	8%
04:00 PM	8%	21%	22%	24%	25%	28%	10%
	11%	31%	31%	32%	37%	31%	14%
06:00 PM	15%	36%	34%	37%	44%	27%	19%
	17%	26%	24%	27%	35%	22%	20%
08:00 PM	16%	16%	15%	18%	22%	18%	18%
	9%	9%	9%	10%	12%	13%	14%
10:00 PM	5%	4%	4%	5%	5%	7%	8%
	6%	6%	6%	7%	8%	6%	7%

4.1.3. Pacification plan for the center of Vilanova i la Geltrú

From 2021, the new pacification plan, known as "In the centre, the people", will be progressively implemented to deter drivers from using the centre to cross the city because 70 to 80% of the vehicles passing through are not destined for the centre. The objectives of this plan are:

- Prioritizing the use of this space for people.
- Reducing the presence of motor vehicles.
- Improving upload and download management.
- Encouraging mobility on foot and by bicycle.
- Reducing vehicle emissions.
- Improving pedestrian safety.
- Achieving a more comfortable and attractive public space for recreation, walking, socializing and shopping.

This action plan will be carried out in the following areas:

- To the south, between av. d'Antoni Vidal and de Tomàs Ventosa.
- To the west, between rambla de Salvador Samà and c. del Pare Garí.
- To the north, between c. de Tarragona, de Sant Magí and de l'Hospital.
- To the east, enter c. de la Unió and del Raval de la Pastera.

Fig.9. Map of Vilanova i la Geltrú- pacification plan.

5. Data sources used for traffic information.

5.1. What data sources can be used in Vilanova to manage traffic better?

Today we have many tools that can help us collect information, such as smartphones, cameras, traffic sensors, fuzzy systems with the benefit of being simultaneously connected to the Internet to produce live information.

A comparative study of existing smartphone-based traffic monitoring systems shows that cell phone location can and is used as an effective means of traffic monitoring in large metropolises around the world. It is also clear that any system of this type must be a "collective source" that can be used in Vilanova, where a large number of users will contribute information to the system and obtain the results at the same time. Therefore, the use of location data from mobile phones forms a

considerable number of motorists together with the functions already available in the API of traffic platforms.

GPS-based traffic monitoring system, data is also a good solution for a couple of reasons:

1. Eliminate the need for physical infrastructure on the road.
2. Use smartphones that are an existing technology.
3. By collecting user data, you eliminate the hassle of creating and maintaining an entirely different set of assets to provide the information needed.

But the methods based on the location of the vehicle (Floating Car Data) in comparison with the previous ones are the best ones, which are a cost-effective and promising solution to deal with some limitations of fixed detectors. Even if the idea of collecting device data "in the vehicle" via cell phones or GPS is not very new, the market for CDF is only now growing worldwide with a wide range of applications and benefits. This would not only improve traffic management, but also help meet the growing demand for drivers who are willing to pay service providers as long as they have access to relevant information in real time - will there be any congestion on my usual route today? ? How to avoid it? If not, how long will it last? Etc. These questions require that the traffic data be accurate, reliable, timely and as complete as possible.

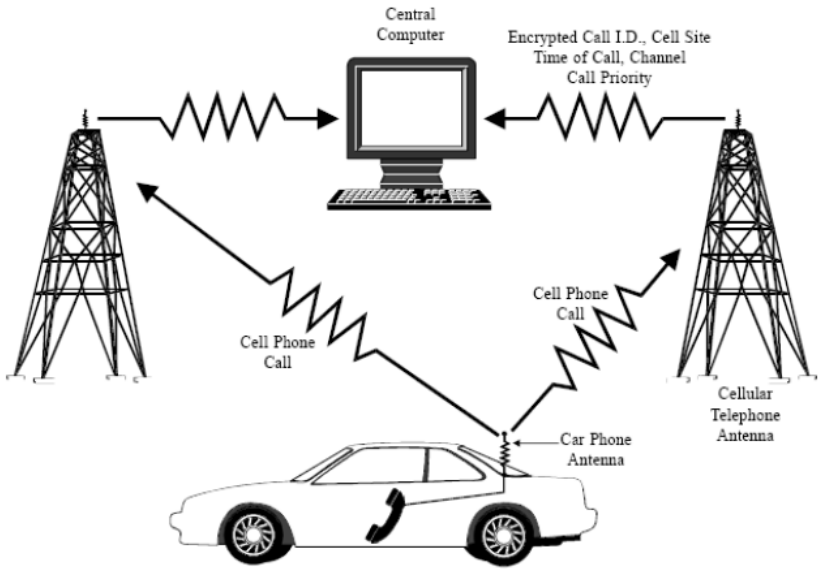


Fig.10. Communication from cellular phones.

5.2. GPS

With it being established that GPS is fundamental in improving traffic management. Further research was needed to better understand the science and mechanics behind this technology.

What is a GPS?

A large part of the data currently generated in cities is geolocated by some Global Navigation Satellite System (GNSS). GNSS are constellations of satellites coordinated to position devices anywhere on the globe. The GPS (Global Positioning System) system is the GNSS of the United States of America, the most widely used globally. Another system is the GLONASS of the Russian Federation, and with different levels of development, the BEIDOU of China, the IRNSS of India, the QZSS of Japan and the GALILEO of the European Union should also be mentioned.

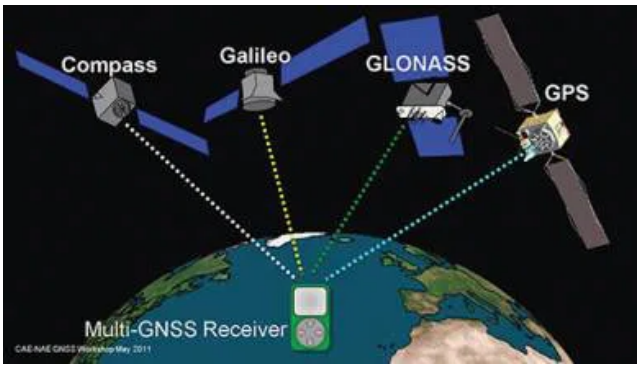


Fig.11. General view of some GNSS.

With the growing incorporation of technology, transport services and the launch of new shared mobility services, the amount of GPS log data generated increases exponentially. New shared mobility services (bicycles, electric scooters, electric cars, electric scooters, etc.) are spreading rapidly.

On the other hand, the connected car is increasingly spreading, and shortly, the use of autonomous vehicles will become widespread in our cities. Connected vehicles are currently generating a large amount of data sent to their owners through apps and to manufacturers through the internet. The data is obtained through GPS locators installed in the connected cars.

Fig.12. Public bicycles - Biking.

GPS records contain at least data about the user (user identifier) and the geographic (latitude, longitude and altitude) and temporal (year, month, day, minute and second) coordinates of the place and time when a record is made. Therefore, it is point data. The locations of people or vehicles over time are stored as sequences of points, making it possible to infer information about trips.

6. Application Programming Interface (APIs)

6.1. What are APIs ?

Informally speaking, an API is, first of all, an interface, a concept that all of us are familiar with. A typical example of an often-used interface is the mobile phone interface that many of us use to interact with web applications—an API interface exchanges data and services and exchanges this information between two computers instead of humans. Thus, an API is a programming interface that links computers via two software programs: an application running on a provider computer and one or more applications running on a client computer.

APIs are instrumental in today's world, although what they are and how they function is not widely understood. To use an analogy, it may be helpful to think of a customer in a restaurant. The customer looks at a menu, makes a decision and places their order with a waiter. The customer is not part of relaying the order to the kitchen or preparing the food, nor do they need to know how it is carried out. However, the customer does know that 'a' process will happen when the order is placed and hopes to receive what they have ordered as a result of this process. An API essentially performs the function of the waiter; it connects with other procedures, albeit digitally and across networks or servers.

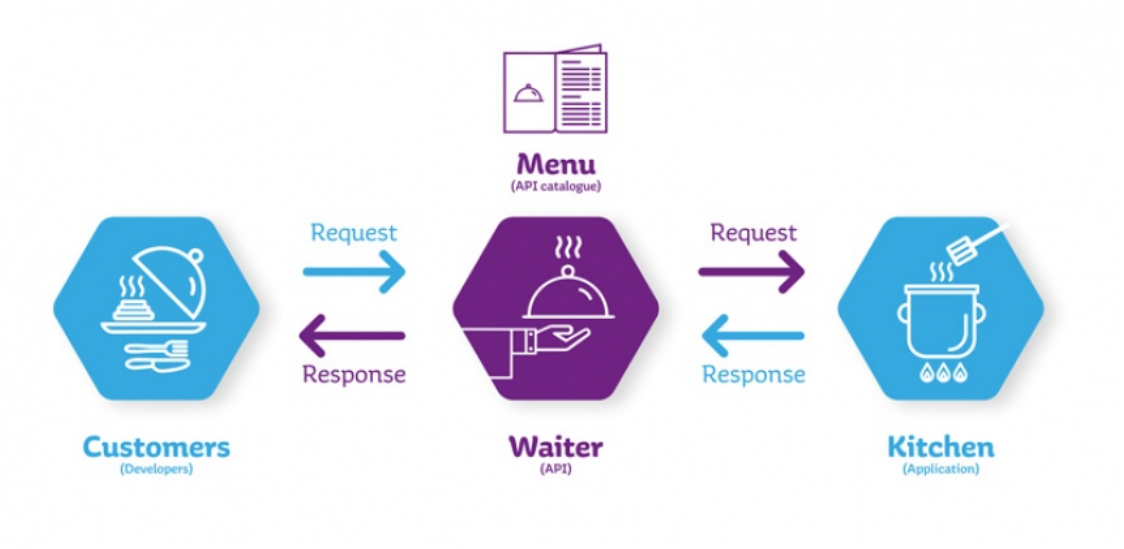


Fig.13. Restaurant Analogy Graphic.

With the support of computers and servers, this method is used enormously worldwide, from large corporations to small companies in domains such as social media, banking, security, consumer goods, and last but not least, traffic management.

Companies known for their API's

- Facebook/Twitter(Social Media)
- Paypal(Banking)
- Skyscanner(Travel booking)
- BBC Weather (Weather station)
- Google traffic/WAZE/TomTom (Traffic information)

6.1.1. What information does traffic APIs provide?

Traffic APIs focus on Traffic data. One of the more significant sources of data information is from smartphone locationing systems. Nowadays, a large percentage of people use a smartphone. In America, studies have shown that 85% of Americans own a smartphone. With this ability to detect where a person is, further traffic information can be produced.

Since a large majority of the population own a smartphone, it is easy to analyze human behaviour when travelling, for example.

- How people travel from one place to another.
- How people react to traffic jams
- When people choose to travel

Thus being able to understand the traffic behaviour.

Looking at Spains phone data information in Figure.30 and comparing it to the predicted population of Spain currently, which is 46,771,053 (05/2021). It indicates that roughly 85% of the people of Spain are smartphone owners. Hence, it would be highly cost-effective to understand the traffic of Vilanova using the service of a traffic API such as Google Maps. Since the implementation of traffic sensors all over the city would yet be very effective in managing traffic better, but extremely expensive. In-depth research on costing is found in heading 6.2.1. For APIs and 7.3 for sensors.

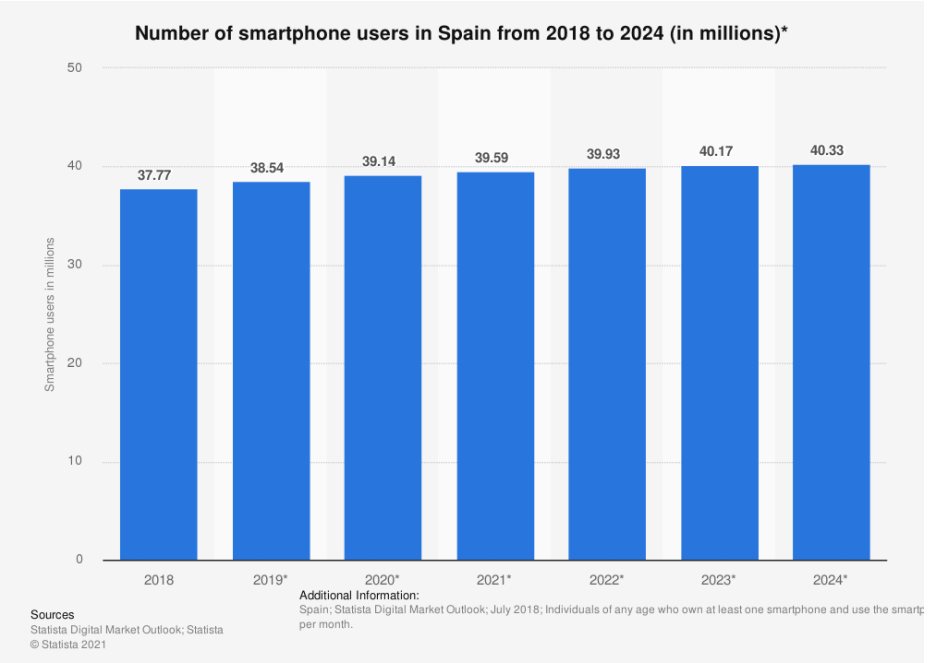


Fig.14. Total Smartphone Users - Spain.

Comparative Study of Different Google APIs for Congestion Tracking:

Google provides a live traffic status in several forms. The status can be represented by different color tracks in their map services or in the form of estimated time of arrival (ETA) at the destination according to the congestion between the origin and destination. In this paper, we are concerned with the live traffic data for the desired route, which can be extracted both ways from the respective APIs.

Google Maps provides numerous JavaScript APIs, which have a vast variety of API functionalities for map editing, one of which is the traffic layer API that gives the option to observe live traffic in four colors. With the help of the traffic layer API of Google Maps, we retrieved a map which has a lot of cluttered clusters, like water bodies, parks, building structures, local roads, etc. Google

provides the 'MapTypeStyleFeatureType' object specification and 'MapTypeStyleElementType' object specification to manipulate the map. So, Google gives the user the choice to edit roadmaps and manage the data, providing a good platform for a developer to experiment with the API. Google JavaScript API response data can be leveraged to extract congestion information by removing clutter and being left with color-coded traffic information on the map. Afterward, image processing is required to get the data on color pixel count, where clutter has certainly created a lot of distortion in the output. However, removing the clutter and reverse engineering the image to get the congestion status will create an error expected to be only about 2–3%, as the 'R, G, B' values of particular color pixels are not fixed and fall within a range.

To get the estimated time of travel/arrival, there is an API called 'Google Maps Distance Matrix API' which provides the travel distance and time for a matrix of origins and destinations. For calculating the ETA, the 'best_guess' traffic model of the API can be used to specify the assumptions to use when calculating time in traffic. This model setting affects the value returned, after using a mixture of historical traffic conditions and live traffic, in the 'duration_in_traffic' field. Live traffic becomes more important the closer the 'departure_time' is to real time. The best estimation of travel time is predicted by extrapolating historical (time-of-day and day-of-week) traffic data to the future. This makes it easier to predict how long it will take to get somewhere. As defined, a delay in excess of that which is normally incurred under light or free-flow travel conditions can be taken as congestion. So, unacceptable congestion is travel time or delay in excess of an agreed-upon norm. These norms may vary due to the type of transportation facility and mode, geographic location, and time of the day. So, the travel time estimate is the better way to map the congestion while also being a very common congestion measurement parameter in the transportation research community. Also, Google ensures and approves of this type of data for non-commercial research usage.

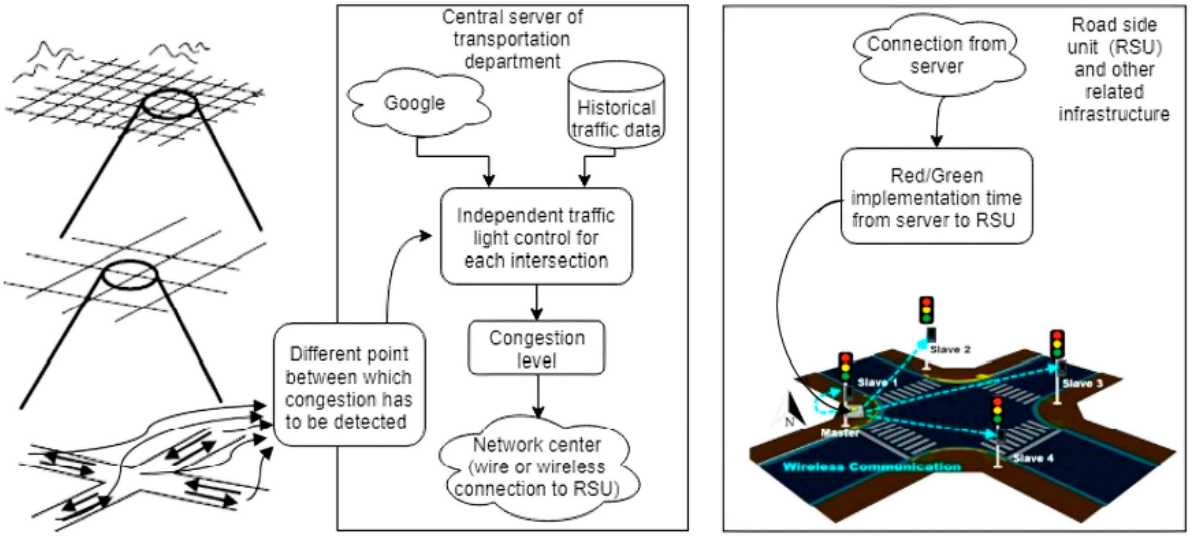


Figure 1. Proposed interconnected network.

Cycle time and split time infrastructure knowledge-based data for congestion statuses, have to be loaded into the system. In order to deploy a change in the cycle time for a given road intersection, a small network of microcontrollers is needed. The central microcontroller server pulls the calculated data of the implementation time of each slave. After that, wirelessly, it transmits the decided cycle time and corresponding implementation time to each slave microcontroller. Each slave resides in each traffic light of an intersection. Further, the central microcontroller server is connected to the internet, as shown in Figure 1, and the slave microcontrollers are placed clockwise from the geographical north, starting from slave '1', so that the user can predict an upcoming slave in their path. This will help the user's device application to know the particular slave number for which Data 2018, 3, 67 8 of 19 an associated time must be fetched from the server. Otherwise, the user's device application may also ping their approaching direction with the request, and the server itself will provide the required data. As discussed, the Google API does not publish its live congestion status data explicitly in digital form but mapping the response of the estimated travel time is possible. To map it, we followed a three-way process:

1. The origin is set at the central coordinates of the crossing with traffic light infrastructure, and the destination points are set to an appropriate distance on each track joined to the intersection.
2. All the differences 'D' (D = Estimated times to arrival provided by Google API − Averaged estimated time to arrival, grabbed by Google or provided by a road authority of each road lane) of each lane joining the intersection are added in accordance with the weight factor of each road to calculate the congestion value.
3. The calculated value is compared, as mentioned in Table 1, with the maximum congestion

value for the same hour from the previous week.

6.1.2. How is it used to help provide traffic management decisions?

Generally, the roads' improvement is made by installing road equipment (signalling, radars, etc.) that can be expensive and long to set up.

Fortunately, the growth of intelligent transport systems (ITS) such as connected vehicles, driving assistants (GPS, radar warning devices, etc.) and smartphones has revolutionised traffic management.

Hence it has helped to solve the limit of roadside sensors. The idea of collecting real-time traffic data from in-vehicle devices through mobile phones or GPS is quite popularly known as probe car (floating car). Raw data of geolocalisation sent anonymously to a central processing centre. After being collected and analysed, helpful information can be redistributed to the drivers on the road in real-time.
The use of the Floating Car Data makes it possible to respond to the various road safety issues and the improved reduction of congestion.

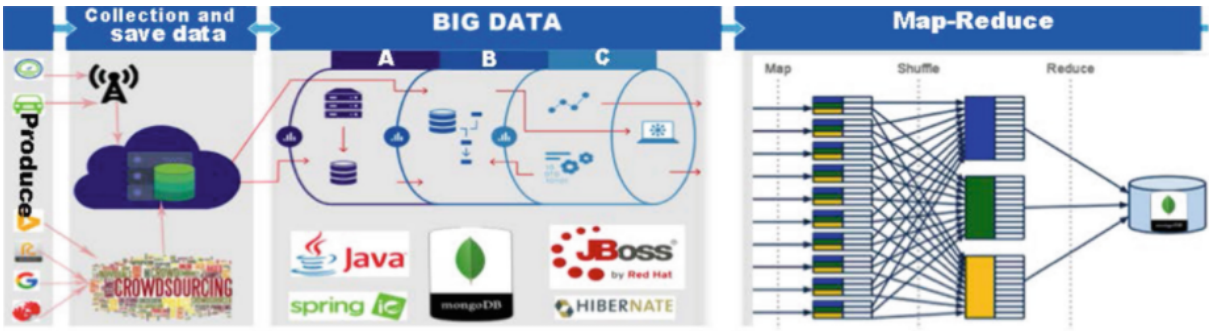


Fig.15. Using API for reduction of congestion.

6.1.3. Benchmarking Analysis

With the unrivalled amount of information that can be received from traffic APIs. It, therefore, leaves a firm question on what Traffic APIs are the best. The biggest well-known companies in this field are Google, Waze, TomTom, Ontonomo, HERE and Servei Català de Trànsit. 'HERE', however, to current knowledge, does not work in Spain.

6.2. The battle of the APIs

6.2.1. Google Traffic

Google Traffic is a feature on Google Maps that displays real-time traffic conditions on major roads and highways. Google Traffic can be viewed at the Google Maps website or by using the Google Maps application on a handheld device.

Early versions of Google Maps provided information to users about how long it would take to travel a particular road based on the historical data. This information was not real-time and far from accurate. In 2004 Google acquired ZipDash, a company specializing in real-time traffic analysis. In 2007, Google integrated ZipDash's technology into Google Maps, offering traffic data based on information gathered anonymously from cellular phone users.

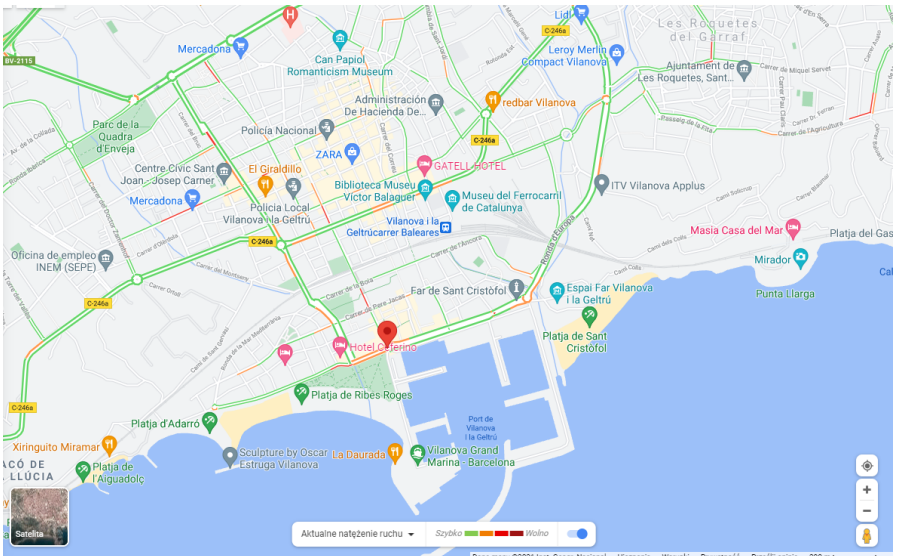


Fig.16. Google maps- Vilanova i la Geltrú.

<u>Process</u>

Google Traffic works by analyzing the GPS-determined locations transmitted to Google by many mobile phone users.

By calculating the speed of users along the length of the road, Google can generate a live traffic map. Google processes the incoming raw data from mobile phone device locations and excludes anomalies such as people at a standstill and postal vehicles that make frequent stops. When a

threshold of users in a particular area is noted, the overlay along roads and highways on the Google map changes colour.

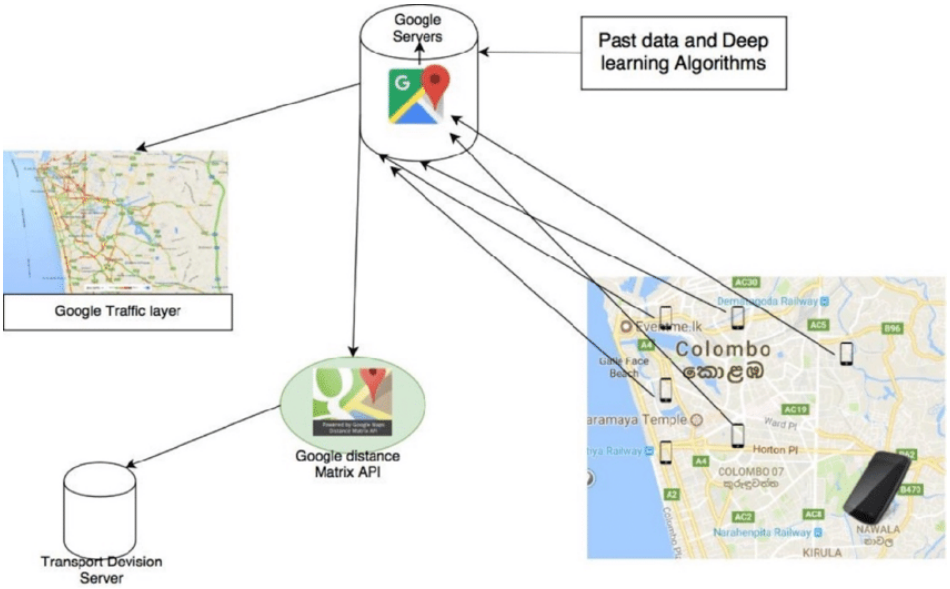


Fig.17. Google maps- traffic scheme.

<u>Service</u>

Google provides.

- Assurance of high-quality data from 99% of the world.
- Location-based real-time data at a rate of updating 25 million times routinely.
- The infrastructure to operate the usage of 1 billion users actively on a monthly basis.
- Roads of up to 40 million miles to work with.

Three main features of Google Maps Platform in terms of traffic management are:

- **Directions** - The ability to get directions to the user based on the ongoing status of traffic and the predictions of travel times ahead of time with the support of analysis and real-time data.
- **Distance** - Provides the distances and travel time between many locations.
- **Roads** - Has the capability to find the perfect routes due to one's journey in the past by studying previous trips and calculating closer routes at every point of that journey.

Traffic APIs	Cost for every 1000 Request ($)
Directions	5
Directions Advanced	10
Distance Matrix	5
Distance Matrix Advanced	10
Roads - Route Traveled	10
Roads - Nearest Routes	10
Roads - Speed Limits	20

Tab.3. Routes- Pricing table.

We will use Distance Matrix Advanced because it offers real-time traffic and the $200 free every month, considered enough to meet our needs.

Price Examples

To get efficient information for a satisfactory price. It is preferable to request more information during the busiest times of the day and request less information during the quieter periods, taking into account the schedule of traffic jams that we have commented on previously and $200 free that google offers us free every month. The cost for every 1000 requests is $ 10 (Advanced Distance Matrix), and for $ 200, we have 20,000 requests. The public schedule is seen below.

Time	Total monthly (min)	Refresh every (min)	Refresh Total
00 : 00 - 07 : 30	**13500**	**8**	**1687,5**
07 : 30 - 09 : 30	**3600**	**0,75 (45 seconds)**	**4800**
09 : 30 - 14 : 00	**8100**	**4**	**2025**
14 : 00 - 15 : 00	**1800**	**1**	**1800**
15 : 00 - 18 : 00	**5400**	**4**	**1350**
18 : 00 - 21 : 00	**5400**	**0,75**	**7200**
21 : 00 - 00 : 00	**5400**	**8**	**675**
		Total =	**19537,5**

Tab.4. Public schedule.

Contact

You can contact Google Maps in two different ways, using its official page where there is all the information about API, prices, etc. The other way is to write a message to the sales department. They take a long time to respond, most of the time they send the same message.

- ➔ https://cloud.google.com/maps-platform/pricing/sheet
- ➔ https://cloud.google.com/contact-maps

6.2.2. Waze

Description and process

Founded in 2008, Waze was developed in Israel and was funded by early-stage American venture capital firm Bluerun Ventures, which was acquired by Google in 2013. Waze is a social application that allows its users GPS-assisted navigation and real-time traffic detection. Waze belongs to a new generation of applications called crowdsourced. These are interactive applications, which seek an active exchange of the user to capture information from other users in order to improve the application. In the case of Waze, the interaction is made through the establishment of notices by the user. During navigation to their destination, the user has a section of alerts for different causes; among them, we find:

- Traffic
- Police
- Crash
- Alerts

The community-driven map service is fast to navigate and very intuitive. Is a highly interactive system, which lets you warn other drivers of changes in traffic, speedcams, hazards and so on. It proved to be very popular and well-received by the public that Google bought the company in 2013. It's telling that Waze continues to exist as a separate entity from Google Maps six years on.

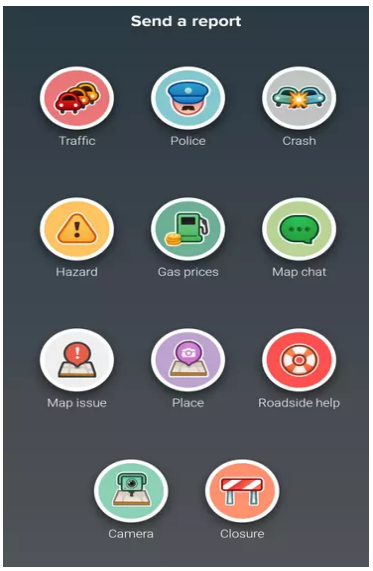


Fig.18. Waze interface.

The user will only have to press the corresponding alert, and a notification will be sent to the Waze servers. From that moment, and thanks to different algorithms that process the number of alerts of an event, the number of users in the place and other data, the servers can determine if there is any congestion on the road.

Once the scope of the event is determined, this alert can be sent to other Waze users. These different types of data may be taken into account when choosing the most optimal navigation route.

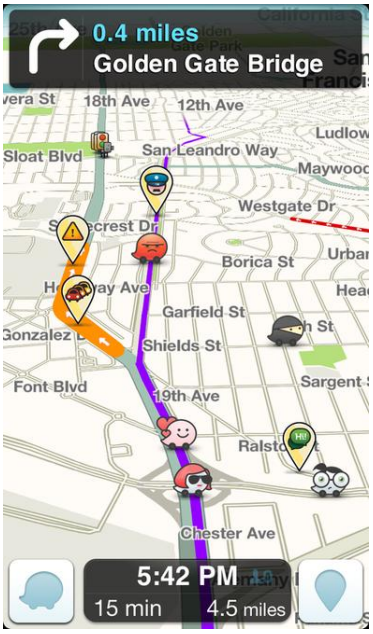


Fig.19. Waze - general view of the route.

Services

Waze uses the same services as Google Cloud to get their traffic information. “Real-Time Crisis Communication”

Costing

WAZE for cities is for improving traffic management around the world to better the environment. Many cities have formed working relationships with WAZE to acquire the high-quality data and intelligence the company can provide. The aim is to lessen the time cars spend on the road, thus cutting out the unnecessary, overused cars polluting the environment.

Waze for cities aims to work with partners with additional data sources, such as road closures, street cameras or road sensors, not found within the Waze app. We tried to contact them (see appendix) as a Fuzz Sensoring Team, but it was ineffective as they rejected us, saying we did not meet their criteria. If the Vilanova city council contacted them directly, they could offer their data for free, since instead, the city council would have to provide their available traffic data.

Contact

You can contact Waze for cities using their official website.

- ➔ https://www.waze.com/es/ccp/

6.2.3. TomTom

Description

TomTom, famous for its satellite navigation products, became one of the highest demanded companies for their development and sold millions of devices in record times. Nowadays, are leaders in the field of specialising in location technology. With years of experience and wealth of knowledge, and success in the past, this is a company to acknowledge.

Fig.20. Logo of TomTom.

TomTom's mission is to help customers arrive at their destinations faster, more safely and more reliably, regardless of their location. TomTom delivered the first live traffic product in 2007, and his experience has taught us how to continue delivering the best traffic products on the market. Our real-time traffic products are created by merging multiple data sources, including anonymized measurement data from over 550 million GPS-enabled devices. Using highly granular data, gathered on nearly every stretch of road, we can calculate travel times and speeds continuously. TomTom End-User Traffic delivers accurate, real-time traffic information straight to the OEM navigation system. By delivering a location-based feed to the in-dash navigation device, the content is highly car- and route-centric. At the same time, it aims to minimise OEM system requirements in terms of bandwidth consumption, processing power, and memory.

Process

TomTom End-User Traffic provides access to two real-time traffic products:

TomTom Traffic Incidents delivers information on the current observed congestion and incidents on roads in all countries where we offer this service. Traffic 'incidents' in this context include traffic jams, road closures, lane closures, construction zones, and accidents.

TomTom Traffic Flow delivers a detailed view of the current observed speed and travel times on the entire road network in all countries where TomTom Traffic is available. This product is designed for easy integration into routing engines to calculate precise travel times.

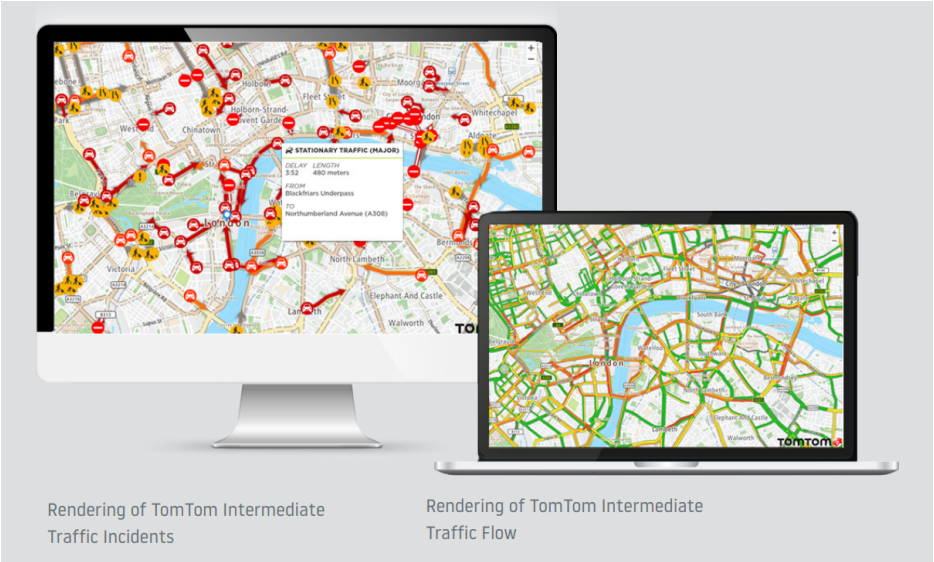


Fig.21. TomTom live traffic.

Service

- Measure the stability and reliability of travel times on a route
- Analyze speed on all road segments to determine congestion bottlenecks and their effects

• Measure the travel time before and after a change in the road network to assess the impact

• Detect impact of seasonality, events, and incidents on traffic congestion or density

• Identify and prioritize problematic congestion spots on a route

• Display typical speeds (V85, Average, Median) on a map

• Provide actual driven ground truth speeds and travel time data for use in transportation model

• Navigation, mobility and mobile applications: in real time traffic information enables efficient routing and redirection as well as precise estimated times of arrival. It reduces travel times, fuel usage and emissions, and improves safety.

• Fleet, logistics and on-demand services: routing controllers around traffic incidents improves customer service and performance on time.

• Traffic management: real-time traffic information allows authorities, highway agencies and traffic management centers to monitor traffic with an accurate and detailed view of average speeds and incidents on the entire road network.

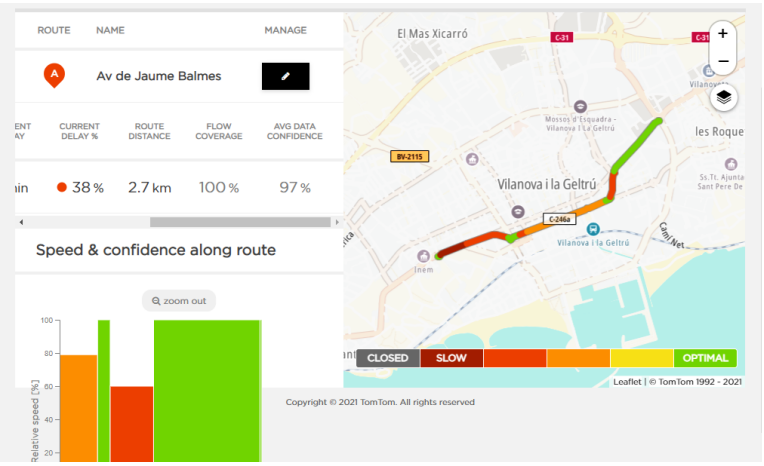


Fig.22. TomTom app- route through Vilanova i la Geltrú.

TomTom has in-depth information in Spain

Assurances of:

100% of roads that are mapped have traffic information coverage

A data source for millions of people giving real-time traffic information

Quality of data is state of the art, providing accurate location information with only a 10-metre margin for error.

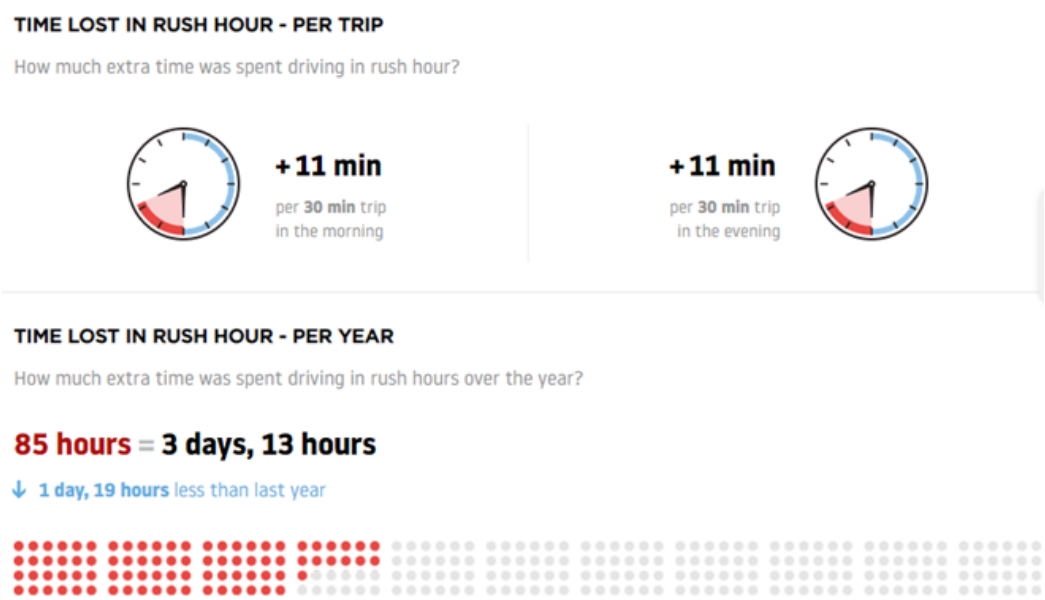


Fig.23. Tom Tom app - traffic statistics.

Contact

You can contact TomTom here;

➔ https://www.tomtom.com/es_es/drive/maps-services/shop/real-time-traffic/europe/

TomTom Developer Portal | Maps APIs and SDKs for Location Applications

6.2.4. Ontonomo

Otonomo is a platform that simplifies the process of accessing vehicle data. Suppose you need aggregated data or personal data. They have it all. They receive data from different providers worldwide. It undergoes a strategic process to clean it, normalize it, add metadata, and most importantly, enable you to retrieve high-quality data in a number of methods, all so you can effortlessly increase your data pool.

otonomo

Fig.24. Logo of otonomo

Service

- **Easy Access:** providing easy access to the data; via API, visual query builder, and geo-fencing UI.

- **Data Normalization:** making the data easily understood and in the same format across all manufacturers.
- **Data Cleansing and Sanity:** fixing and eliminating erroneous data to improve the quality of the data and query results.
- **Dynamic Filtering and Aggregation:** supporting aggregation and filtering capabilities so data consumers can find the data they want.
- **Scalability:** as more connected cars hit the road, data platforms need to be able to quickly scale to support the processing of billions of data points in real-time.

Contact

You can contact Otonomo for cities using their official website.

➔ Otonomo: The Global Platform for Connected Car Data

6.2.5. Servei Català de Trànsit

The Servei Català de Trànsit (SCT) is an agency under the Generalitat de Catalunya in charge of designing and implementing road safety policies in Catalonia. It was created in 1998 as a result of the transfer to the Generalitat of various executive powers in the field of traffic that until then had been held by the State. The Servei Català de Trànsit offers a continuous traffic-map based on Google Maps. The basic road network is reproduced on a Google Maps map focused in Catalonia, which allows different levels of zooming and searching by visualizing this information in map, satellite or relief format. On the represented network, different information can be seen like:

• Real-time traffic incidents
• Traffic density
• The images provided by the video cameras located on the tracks
• Information panel messages
• The name of the roads

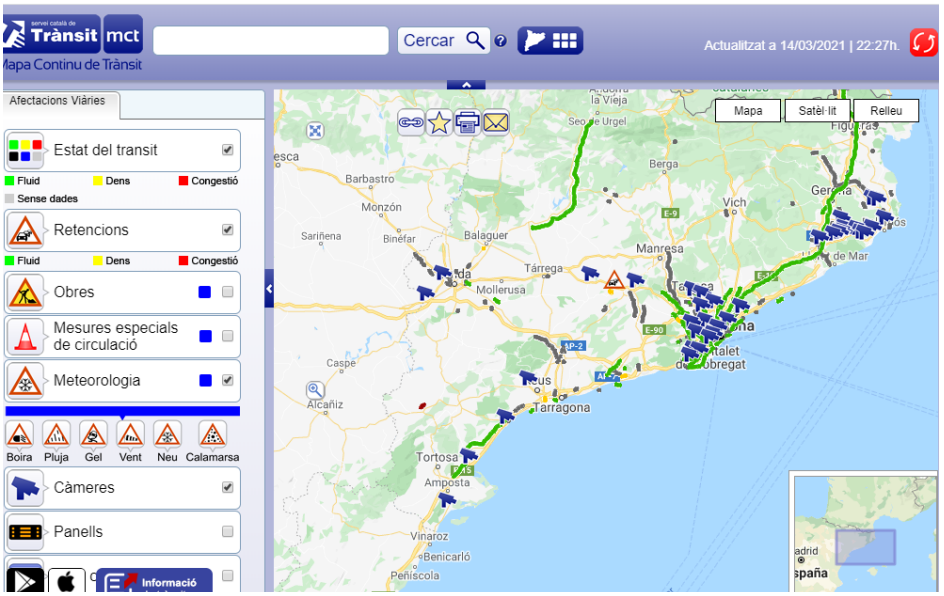


Fig.25. Map from Servei Català de Trànsit.

The Servei Català de Trànsit data are public and all available data can be found in open format on the *Dades Obertes de la Generalitat de Catalunya*. As we mentioned before, Vilanova i la Geltru does not have a very advanced traffic infrastructure, and due to this, the traffic situation cannot be seen in real-time. The only street that shows traffic in real-time is the one that goes from Cubelles to Sitges (C246-a) and passes through the city, using the main street Rambla de Josep Antoni Vidal.

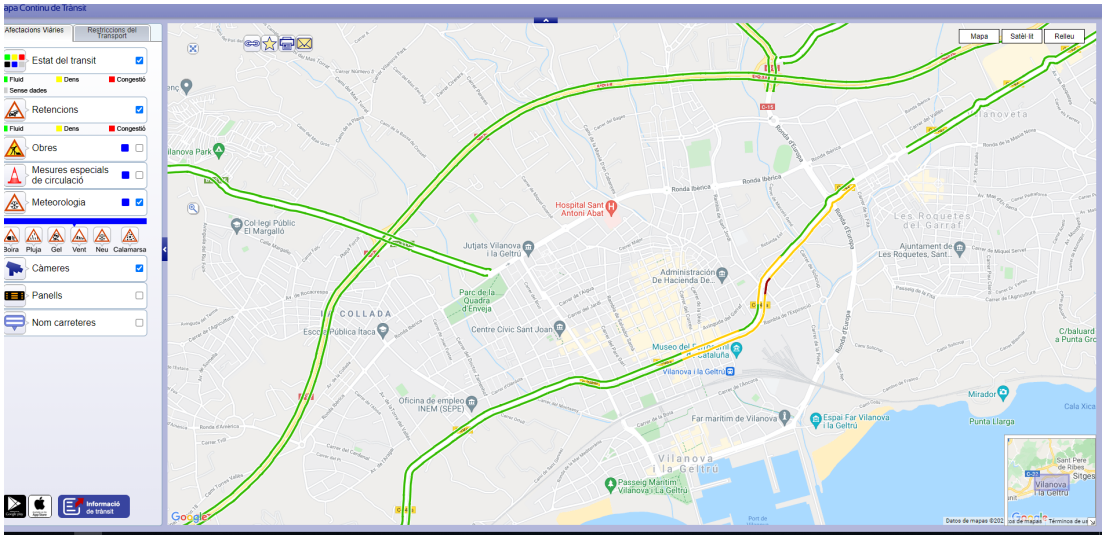


Fig.26. Traffic map of Vilanova in real-time.

Contact

You can contact Servei Català de Trànsit using next link.

➔ http://transit.gencat.cat/ca/canales_cabecera/contacte/

7. Sensors

The sensor is an electronic device that measures physical attributes such as temperature, pressure, distance, speed, torque, acceleration, etc., from equipment, appliances, machines and any other systems. The sensor produces an electrical signal/optical signal using multiple technologies proportional to the inputs. These signals are either interpreted into a readable format or passed on to the next stage for further processing. Sensors are broadly grouped into analog and digital sensors. Analog sensors measure the exact value of physical variables, whereas digital sensors measure the status. Applications classify sensors, Property sensed, Technology used and Systems where they are deployed. Let's analyze the applications of sensors in detail.

The biggest problems of modern cities are the ones related to transport, such as safety, pollution and traffic congestion; using sensors to achieve an intelligent and smooth transportation system is the best solution. Modern cities are facing a significant increase of traffic volume. This results in traffic jams, an increase in CO2 emission, accidents, oil prices and emergencies. According to Texas Transportation Institute research, citizens waste 11.5 billion litres of fuel every year and spend 42 hours in traffic per year.

Traffic data collection is critical to signal timing and is often performed manually. Intelligent transport systems, on the other hand, continuously optimize signal timing and require high-quality real-time traffic data. A variety of sensors can be used for real-time data collection, the most common of which is the inductive loop detector. Those detectors consist of one or more loops of wire embedded in the pavement and connected to a control box, activated by a signal ranging in frequency from 10 KHz to 200 KHz. When a vehicle passes over or rests on the loop, inductance is reduced, thus indicating the presence of a vehicle. They work in most weather conditions but can be unreliable and expensive. Ultrasonic sensors, microwave sensors, and infrared sensors are also used to monitor traffic, though these have limitations as well. Ultrasound sensors are vulnerable to pedestrian and vehicular impact and have a limited range (12m); infrared sensors perform poorly in noisy environments; microwave sensors are unable to detect slow or stationary vehicles. Consequently, loop detectors remain the most popular technology in-vehicle data monitoring.

Other new techniques for measuring traffic data include radar; cellular phones that record motorists' positions at checkpoints; Global Positioning Systems; and RFID (radio-frequency identification) receivers which can be installed at strategic locations and are already used for toll collection. There is also a concern that some of these technologies violate personal privacy and

allow government agencies to monitor the behaviour of private citizens. The use of video surveillance is considered particularly pernicious by privacy advocates. Nevertheless, vision-based systems are flexible and versatile in traffic monitoring applications; improvements in technology will most likely continue to make these increasingly reliable and robust. Laser sensors used in autonomous vehicles are very effective for detecting vehicles, but their cost is still too high to be installed massively.

A robust tracking algorithm for crowded intersections has been developed by a company named Kamijo. Based on the Spatio-Temporal Markov Random Field model, this algorithm is robust against occlusion and clutter issues and can be modified to deal with illumination variation. This system is capable of generating traffic event statistics such as vehicle count, travel direction, velocity, and frequency paths.

With the advent of vehicular sensors, there is an excellent potential for improving traffic efficiency. Sensor data can enable real-time control of traffic and improve the performance of existing adaptive systems by allowing a more precise adjustment of signal timing sequences.

7.1. Different type of traffic sensors

There are two types of sensors for the detection and monitoring of vehicles:

- Intrusive technologies, which are installed in or along the pavement.
- Non-intrusive technologies that are located above or to the side of the road causing a minimal effect on the flow of traffic.

7.1.1. Intrusive sensors

Within the intrusive sensors, there are many types that will be detailed below: the inductive loop detector, the pneumatic tube and the piezoelectric sensors. Their mechanism is similar; they detect the passage of a vehicle when it passes over the sensors; the first two technologies are the most used on the roads.

Intrusive sensors are, in general, cheaper in terms of installation. However, they have several drawbacks:

- Traffic disruption during installation and repair.

- Errors can appear if the road conditions are not suitable or if the installation has been flawed.
- Resurfacing highways may require the reinstallation of sensors.

These kinds of sensors can provide information on the volume of traffic, detection and classification of vehicles, and even information on speed.

➢ **Inductive Loop Detector (ILD)**

This sensor is the most commonly used in traffic management. Inductive Loop Detector is used to gather data about: traffic flow, length, speed and occupancy of the vehicle. Long wire coiled to loop form is mounted under or into the road surface. The message is sent to the processing unit while the vehicle is passing on thanks to an electrical signal. An important point of this method is that while the inductive loop detectors only give direct information on the passage of vehicles and presence, other traffic flow parameters such as density and velocity are inferred from the algorithms that interpret or analyze measured data.

Advantages :

- ❑ Last long in time
- ❑ low power consumption
- ❑ High accuracy

Disadvantages :

- ❑ poor detection of small vehicles,
- ❑ damaged by road deterioration or heavy vehicles,
- ❑ major disruption to traffic during installation,
- ❑ sensitivity to temperature fluctuations,
- ❑ affected by metallic road construction materials and high risk of the loop and feeder cable theft.

Price : 250€ - 700€ per sensor

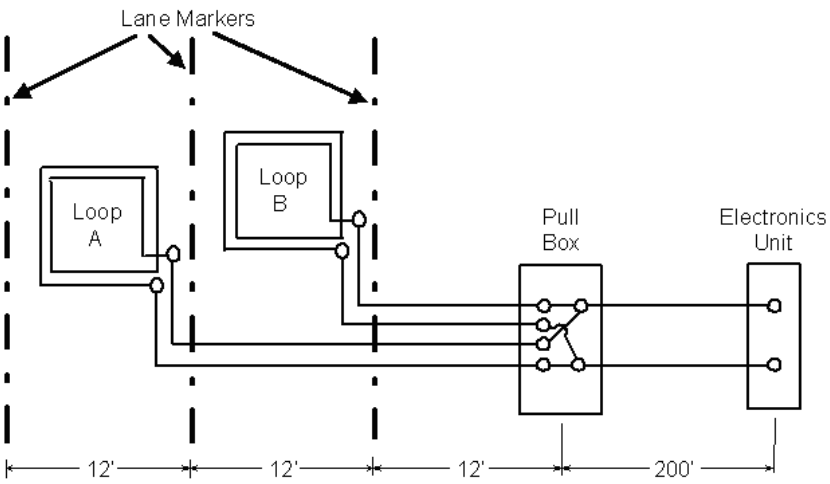


Fig.27. Installation diagram of loops for two rails.

➢ **Pneumatic road tube sensors**

The pneumatic tubes are rubber tubes (see figure 1) that are placed along the pavement on the road and that are capable of detecting the passage of the vehicle by the change in pressure that it exerts on the air contained in the tube when passing over the same. Then this burst of air pressure creates an electrical signal which is sent to the processing unit.

The pneumatic tubes are placed perpendicular to the direction of circulation (see figure 2). These kinds of sensors can provide information on the volume of traffic, detection and classification of vehicles, and even information on speed.

Fig.28. Pneumatic road tube.

The placement of two tubes at a short distance allows one to calculate the speed of the vehicle (double pneumatic tube).

Fig.29. Example of laying on a road.

With this technology, it is possible to obtain different variables such as the volume of traffic, the speed (using the double tube referred to) and the classification (based on the number and space between axles) of the vehicle.

Advantages :

- ❑ High accuracy
- ❑ Quick to install
- ❑ Low power consumption

Disadvantages :

- ❑ Maintenance costs
- ❑ Affected by temperature variations
- ❑ Easily vandalised or broken by heavy vehicles

Price : around 5800€ per sensor (including installation cost)

http://www.mikeontraffic.com/pneumatic-tube-counters/ - how to install them

➢ **Piezoelectric sensors**

The detection is made based on the pressure generated by the vehicle when passing over them. They detect the passage of the vehicle based on the electrical charge that is generated in the piezoelectric material when it is stepped on by a wheel and it deforms.

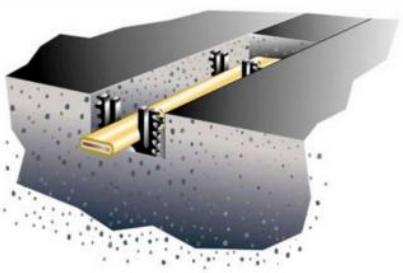


Fig.30. Piezoelectric sensor.

They offer advantages over rubber tubes, which are more resistant and, being thinner, affect driving less.

Its functionality is similar to that of rubber tubes, allowing it to measure variables such as the volume of traffic, the weight of the vehicle and its type (based on the number and space between axles.)

Advantages :

- low power consumption
- high accuracy
- Affordable

Disadvantages :

- detection can be affected by temperature changes,
- damaged by road deterioration
- major disruption to traffic during installation.
- temperature sensitivity

Price : 400€ – 1300€ per sensor

7.1.2. Non-intrusive sensors

These sensors can be installed at many various places on the roads but not over the road. They can detect vehicle transit and speed as well as lane coverage. The biggest disadvantages of non-intrusive sensors are their high price and sensibility to environmental conditions. They provide data on a selected area, such as traffic light, traffic and weather conditions of the road and pavement.

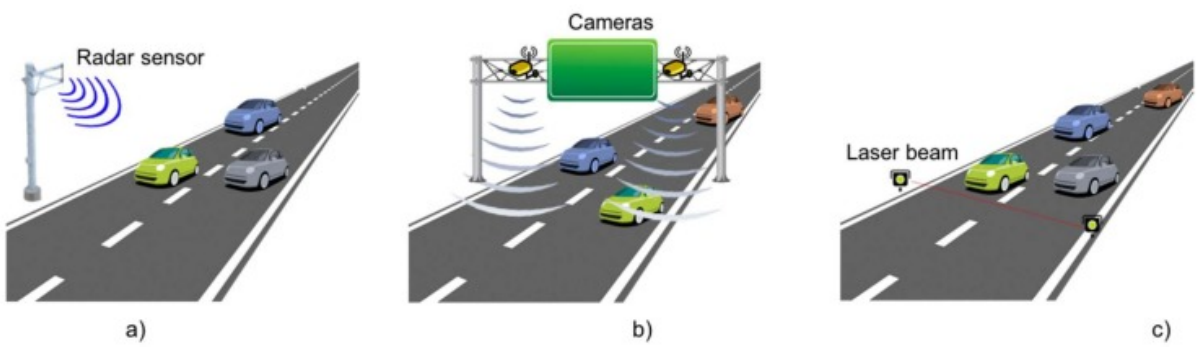


Fig.31. Non-intrusive sensors.

a) roadside mast-mounted

b) bridge mounted

c) across roadside

An important fact is that non-intrusive sensors can as well provide functions of intrusive ones, but not as easily. Indeed they can be affected by weather conditions (snow, rain, fog, etc.). Consequently, these sensors are more likely to be spotted by drivers. It can induce faster reactions, for example: using a proper drive lane or slowing down. The biggest challenges are driver's reaction time, installing sensors and providing a more precise view of the real situation.

- **Infrared sensors**

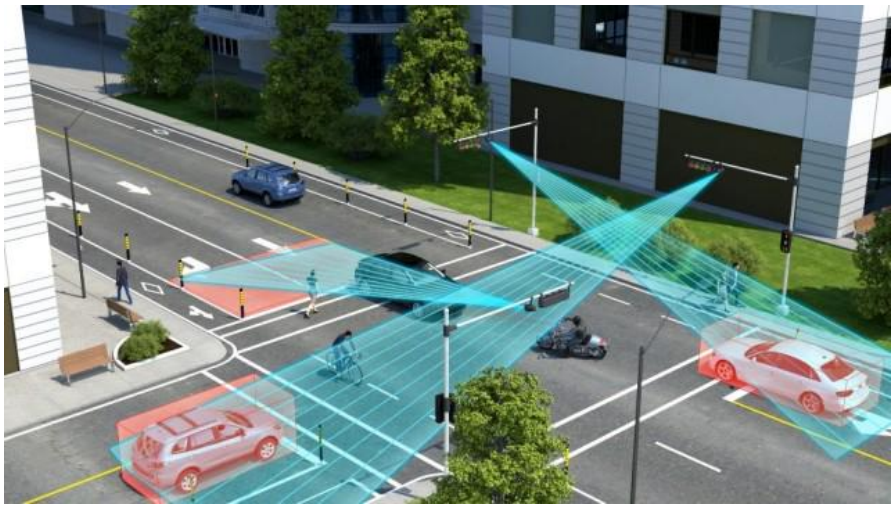


Fig.32. Infrared sensors.

These sensors can react to vehicle generated energy, objects and road surfaces. Infrared sensors are transforming reflected energy into electrical signals then transferred to the processing unit. We can list two categories:

- Active InfraRed (AIR)
- Passive Infrared (PIR)

Active InfraRed ones use laser diodes or LED for reflection time, measuring and collecting data about speed, traffic density, classification, flow volume or vehicle presence.

Passive Infrared sensors are detecting vehicles on the road because of infrared radiation reflection or emission. These types of sensors can gather information about vehicle presence, occupancy and flow volume.

Advantages :

- provides good stability over time
- No corrosion or oxidation can affect the accuracy of infrared sensor
- delivers high repeatability

Disadvantages :

- supports lower data rate transmission compare to wired transmission
- affected by hard objects, smoke, dust, fog, sunlight
- Expensive

Price : 3000€ - 3600€ per sensor

➢ **Video Image Processor (VIP)**

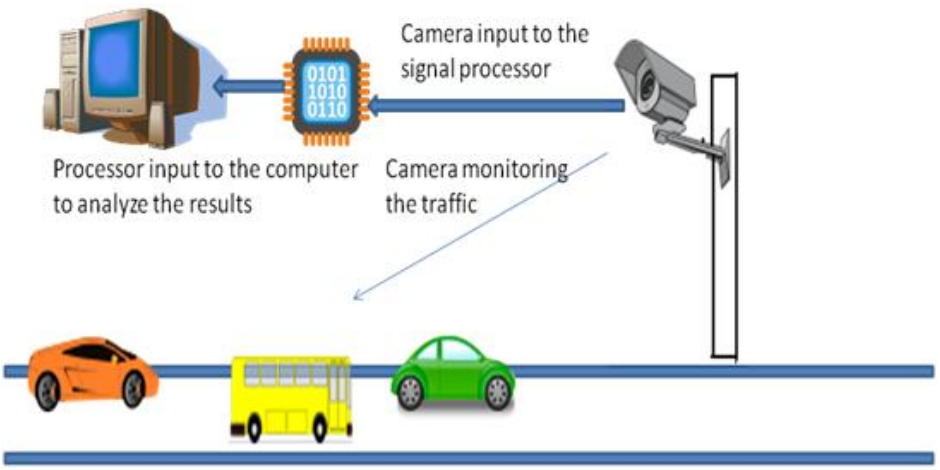


Fig.35. Video Image Processor.

This system is made of a computer for image processing, video cameras and algorithm-based software used for analyzing and translating images into traffic data. Cameras are installed at the roadside. They can be extended to real-time live video feeds.

Advantages :

- Tracking and counting of moving vehicle
- Collect and interpret images to determine changes using flow, occupancy and volume parameters
- Detection, extraction and also recognition - a vehicle can be classified (up to 90% accuracy)
- far more efficient method of traffic control compared to traditional techniques
- 90% accuracy

Disadvantages :

- susceptible to bad weather conditions
- Can violate privacy and citizen's right
- High price

Price : 700€ - 900€ per sensor

➢ **Ultrasonic sensors**

These sensors are measuring the distance between two objects. It is based on an elapsed time between a sound wave sent at 25 kHz – 50 kHz frequencies and reflected an ultrasonic sensor by this object. Received energy is transformed into electrical energy and then transferred to a processing unit. These sensors can gather information about speed and vehicle flow. The downside of ultrasonic sensors is their high susceptibility to environmental conditions.

Advantages :

- quick to install,
- very reliable,
- optional uni-directional operation,
- no disruption to traffic during installation.

Fig.34. Ultrasonic sensor.

Disadvantages :

- high initial cost,
- detection accuracy affected by occlusion, temperature fluctuations and wind noise.

Price : 350€ - 450€ per sensor

➢ **Acoustic array senso**

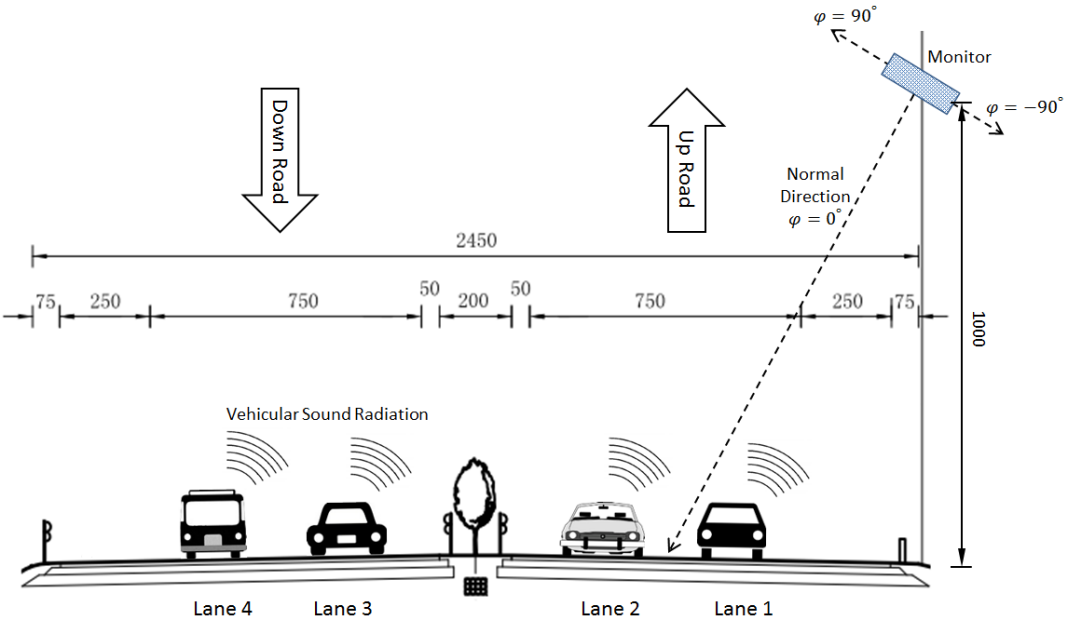


Fig.35. Acoustic array sensors.

It consists of microphones used to identify increased sound energy that was produced by passing vehicles. These sensors can replace magnetic induction loops in order to determine occupancy, average speed or traffic volume.

Advantages :

- ❑ passive monitoring technique, which means that no harmful signals will be transmitted to the human body.
- ❑ hardware cost can be reduced since no signal transmitting device is needed.
- ❑ inexpensive compared with other types of sensors,
- ❑ very robust against light and weather variations.

Disadvantages :

- ❑ Cannot perform accurate lane-wise vehicle counting and speed estimation
- ❑ Operation time of wireless microphone is limited due to battery life

Price : 400€ - 500€ per sensor

➢ **Magnetic sensors**

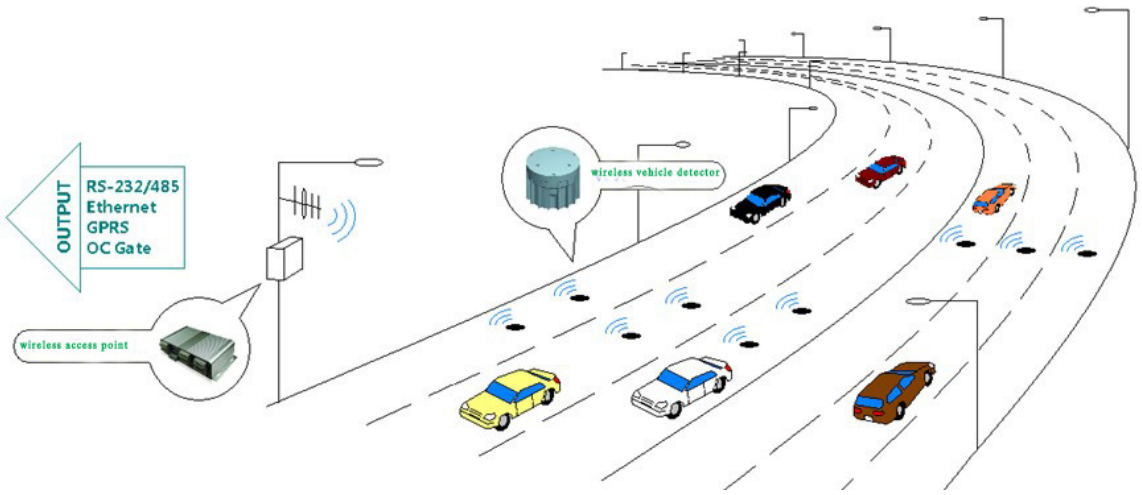


Fig.37. Magnetic sensors.

These sensors are used to collect speed, occupancy, flow and length of vehicles. Magnetic sensors can be mounted on bridges and at signalised intersections. They can detect metallic vehicles when changes occur in the sensor's magnetic field.

Advantages:

- high accuracy,
- quick to install,
- low power consumption,
- long service life,
- wireless technology
- low operating cost.

Disadvantages:

- high initial cost,
- minor disruption to traffic during installation.

Price : 100€ - 150€ per sensor

➢ **Radar sensors**

These sensors are sending low-energy microwave radiation reflected by detection zone objects. Their placement depends on the desired purpose. It can be placed on the road, in the center of a lane, to measure the specific lane, or it can be placed on one side of the road to measure traffic parameters through all lanes. The basis of its operation can be seen in the next figure.

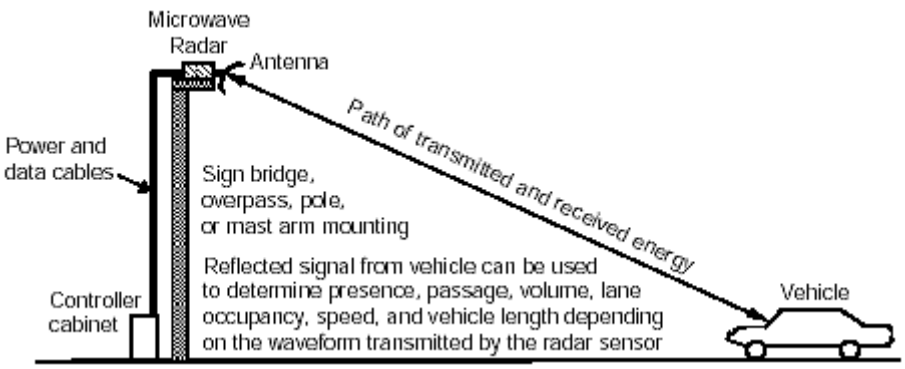


Fig.37. Microwave radar operation.

A part of its location it is possible to differentiate two types of microwave radars:

- CW radars (Continuous wave using doppler system): used for very accurate speed measuring and tracking the number of vehicles.
- FMCW radars (Frequency modulated continuous wave): used for speed, flow volume and presence measuring.

Radar sensors are characterized by a very high accuracy and an easy installation. Radar sensors can function on multiple detection areas during both day and night. Unfortunately they are very susceptible to electromagnetic interference.

Advantages :

- ❑ very high accuracy
- ❑ cheap
- ❑ easy installation
- ❑ performs well in all weather conditions,
- ❑ flexible setup,
- ❑ no traffic disruption during installation.

Disadvantages :

- detection accuracy affected by occlusion,
- decreased counting accuracy with slow moving traffic
- some radar units can only detect moving vehicles
- Very susceptible to electromagnetic interferences

Price : 50€ - 200€ per sensor

➢ **Road condition sensors**

Road condition sensors are used to assess pavement surface conditions and schedule winter maintenance operations. They are found across the roadside and are commonly used to monitor roads, highways, bridges, parking areas, and sidewalks. Airports also make use of road condition sensors to monitor aircraft runways and taxiways. They may also detect chemicals that affect the freezing point or friction coefficient. The ability to assess pavement surface conditions in real-time increases the efficiency of maintenance operations while improving traffic safety. Infrared and laser technologies are used to determine the road conditions.

Fig.38. Road condition sensor.

Advantages :

- Preventing risks for road users,
- Improve traffic safety

Disadvantages :

- need for periodic maintenance,
- Expensive

Price : around 4000€ per sensor

➢ **Radio-Frequency Identification (RFID) sensors**

RFID is a subcategory of the Automatic Identification and Data Collection (AIDC) technologies. An RFID Sensor (Radio Frequency Identification Reader) is a device used to gather information from an RFID tag, which is used to track individual objects. It is a wireless identification technology that uses

radio waves to transfer data from the card tag to an RFID reader and identify the object's presence. Just like the bar code technology, RFID is used to identify objects, persons, by reading the card tag. This is better than the bar code because the bar code can sometimes be damaged or unreadable.

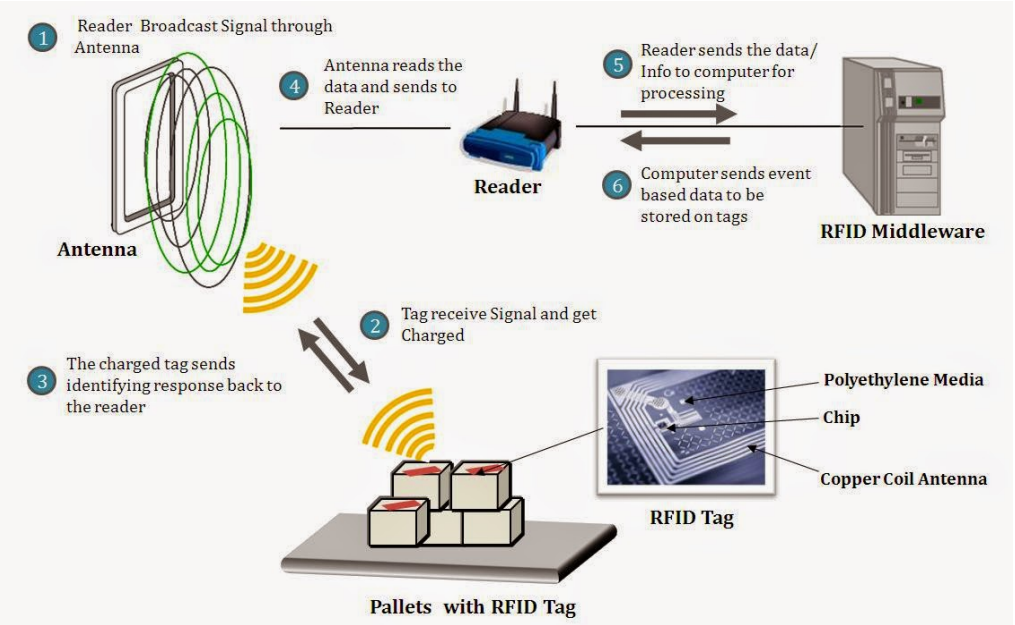


Fig.39. RFID sensor.

The information is stored in a memory that can be accessed using a simple radio frequency link. This memory is in the form of an electronic tag, which contains an antenna and an integrated circuit. The tag contains the information associated with the object to which it is fixed. When a tag enters the field generated by the reader/smart antenna, it detects the signal and exchanges the data (read or write) between its memory and the reader/ smart antenna.

This type of sensors can be used for:

- Smart parking
- Identifying passing vehicles
- Collecting vehicles information
- Detecting vehicles to assign parking space

Advantages :

- ❑ extremely convenient.
- ❑ incredibly small
- ❑ rugged technology
- ❑ easy inventory management solutions

- ❏ allows for a database to become portable
- ❏ Everything happens in real time

Disadvantages :

- ❏ easy to intercept the data on the RFID chip
- ❏ range of scanning can be quite small
- ❏ cost of its development can be rather high

Price : 60€ - 120€ per sensor

7.2. Proposition for sensor locations

Now the traffic signals are usually on the both ends of a span of a road. Thus, at any given time, the density of vehicles in between any two nodes in such a city graph represents the amount of traffic on that span of a road. Based on this principle, we will have to maintain a data-structure that can hold both the information about the specific road-spans which will allow the identification of each individual road and also the corresponding information through which traffic density will be determined.

Despite many technological advances in APIs, momentum sensors are still among the best options to know the traffic in real-time. To locate these sensors in Vilanova i la Geltrú, the following factors must be taken into account.

- **Acoustic map**

  The acoustic map is one of the main factors to consider when placing the sensors, as it helps us know which streets have a higher acoustic level than allowed, and with this information, we can know which streets have more traffic.
- **Google Maps**

  Google Maps does not give us complete city traffic because we only can know the real-time traffic in some streets and main avenues. We could conclude that these streets are the busiest, as Google Maps needs active users to show the traffic. In addition, we can also counteract the information that Google provides us with the sensors since the sensors give us information in real-time. That is, with this data, we can assess Google if they give us 100% precise information or not.

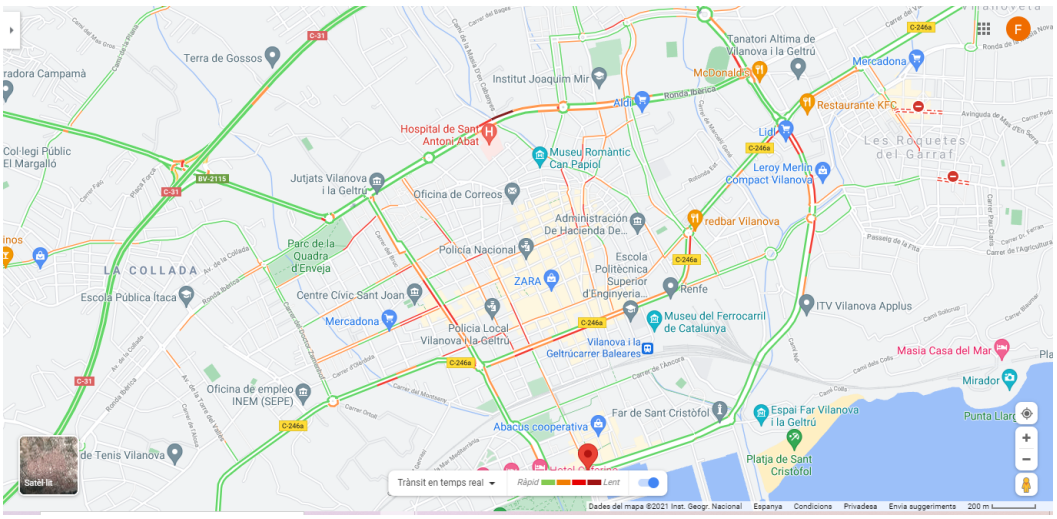


Fig.40. Vilanova map with real-time traffic on Google Maps.

- **Pacification plan for the centre**

  The objective of this plan is to reduce the traffic in the city centre. Therefore, taking this into account, we will not put many sensors within this area because they are not necessary.

- **Main roads**

  As we mentioned earlier, four main roundabouts go into Vilanova i la Geltrú. Then these four rounds end in the main avenues, such as: Ronda Ibèrica, Carrer de Josep Coroleu, Av de Jaume Balmes and Rambla de Josep Antoni Vidal.

- **Personal experience**

  A colleague of ours works in emergency medical services of Catalonia and he has given us names of some streets where there are traffic accidents. For example, Carrer del Cardenal, Av. de l'Aragai, Carrer del Pare Garí, BV-2115, Plaça dels Ocells, Carrer de Josep Coroleu, Ronda iberica 141 and etc.

Taking into account all the factors mentioned above, the sensors will be placed on the following streets:

- Avenida de Cubelles, 86,
- Carretera de Vilanova a l'Arboç,
- Ronda de Ibèrica, 153, 08800 Vilanova i la Geltrù
- Rambla dels Països Catalans, 15
- Ronda d'Europa, 81
- C-246a

- Ronda d'Europa, 37
- Ronda d'Europa
- Paseo del Carme, 14
- Paseo Marítim, 92,
- Ronda de la Mar Mediterrània, 46A
- Calle de Ramón Muntaner, 18
- Avenida de Jaume Balmes, 36
- Plaça de l'Associació d'Alumnes Obrers
- Calle del Forn del Vidre, 20
- Calle del Cardenal, 17
- Avenida de l'Aragai, 34
- Ronda Ibérica, 226A,
- Rambla de Arnau de Vilanova, 108,
- Rambla de Salvador Samà, 70
- Calle del Jardí, 87
- Avenida de Francesc Macià, 125
- Rambla de Josep Tomàs Ventosa, 21B
- Calle del Pare Garí, 30
- Calle de los Estudis, 4
- Calle de la Unión, 1
- Calle del Agua, 208
- Avenida de Rocacrespa, 33
- Calle de la Agricultura, 19
- Calle del Fes, 25
- Calle de Sant Gervasi, 35

As we mentioned earlier, there are four main roundabouts to enter the city. Below we can see the location of those four roundabouts with the sensors, plus ten other roundabouts connected to them. There are four sensors near the Hospital Sant Antoni de Abat because, on many occasions, the ambulance takes a long time to get there. After all, there is usually a traffic jam around the hospital, and because the Ronda Iberica is only a single lane, the ambulance cannot overtake the cars. The hospital is also close to the Joaquim Mir Institute, where children enter or leave the institute to cause many traffic jams. If the ambulance knows the situation of the Ronda Iberica in real-time, it can decide which route will be faster to get there.

When the Ronda Iberica has collapsed, drivers who don't want to enter the city also begin to join because they see less traffic inside the city, increasing pollution.

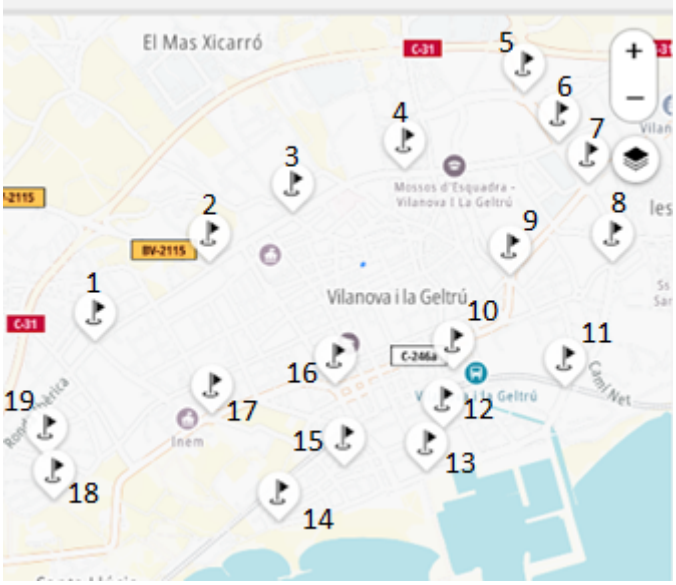


Fig.41. Sensor locations on main avenues.

Inside the city, there will only be sensors on the main streets near schools and institutions. There is also a sensor near the university and the train station because all students who come by car always try to park near the university, but there is not much space to park and they cause traffic jams. Also, there is a lot of traffic from taxis and buses, which largely concentrate at Vilanova's train station in this area and a taxi rank.

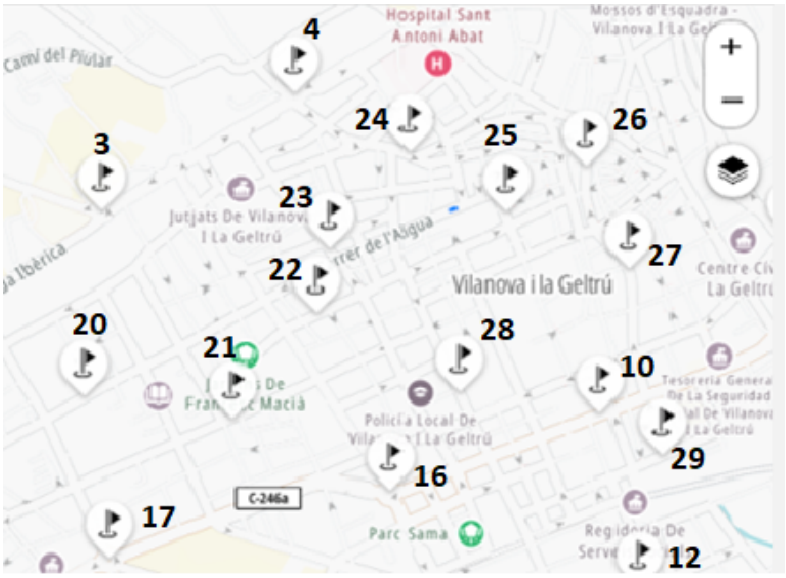


Fig.42. Sensor locations in the city center.

As we can see on the beachside, we have also placed several sensors even though it does not fit into any of the factors mentioned above. However, this is due to the fact there is a lot of traffic in this area in the summer. Most of the traffic is not because many cars are stopped, or there are accidents, but instead, people are looking for parking near the beach.

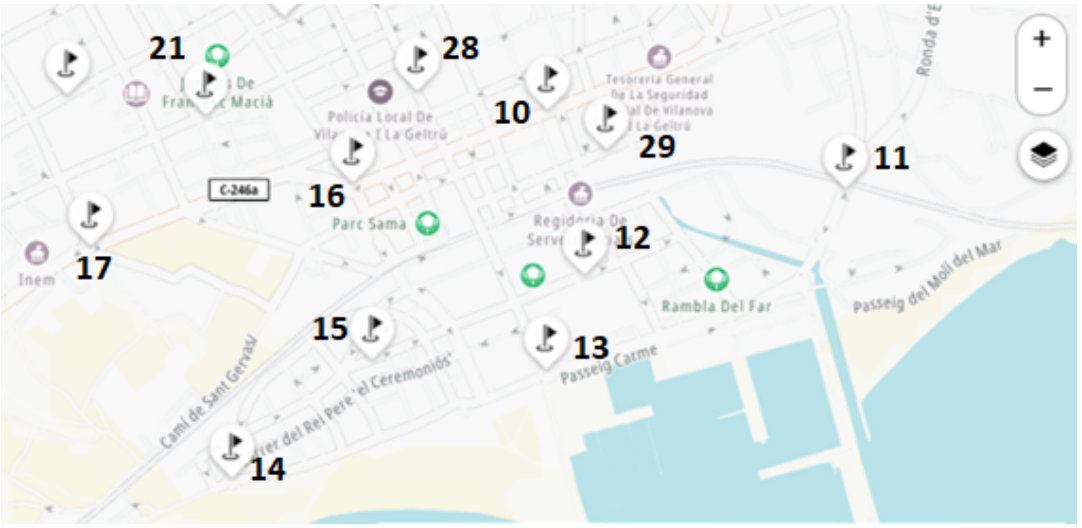


Fig.43. Sensor locations on the beachside.

If we have the sensors placed, people will be able to see the real-time traffic status of the area (if there is a lot of traffic, it means there is no parking because many are looking for it and if there is no traffic is that means you can park easily) and can decide whether to park in the beach area or you can use free bus service (fig. 46). We ensure that people do not waste a lot of time trying to park and reduce traffic in the area.

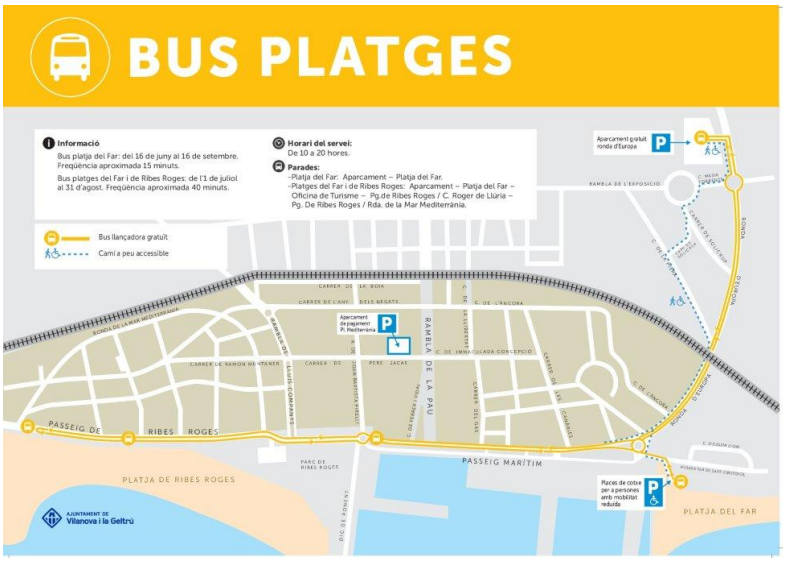


Fig.44. Shuttle bus route.

Shuttle bus slogan “If you want to enjoy the beach, don't waste time parking. You have a free and guarded car park on the Ronda de Europa, a shuttle bus to the lighthouse beach and another bus that also takes you to the other beaches. They are free. Hours: 10 a.m. to 8 p.m.”

In the following image, we can observe the positions of the sensors with a global view.

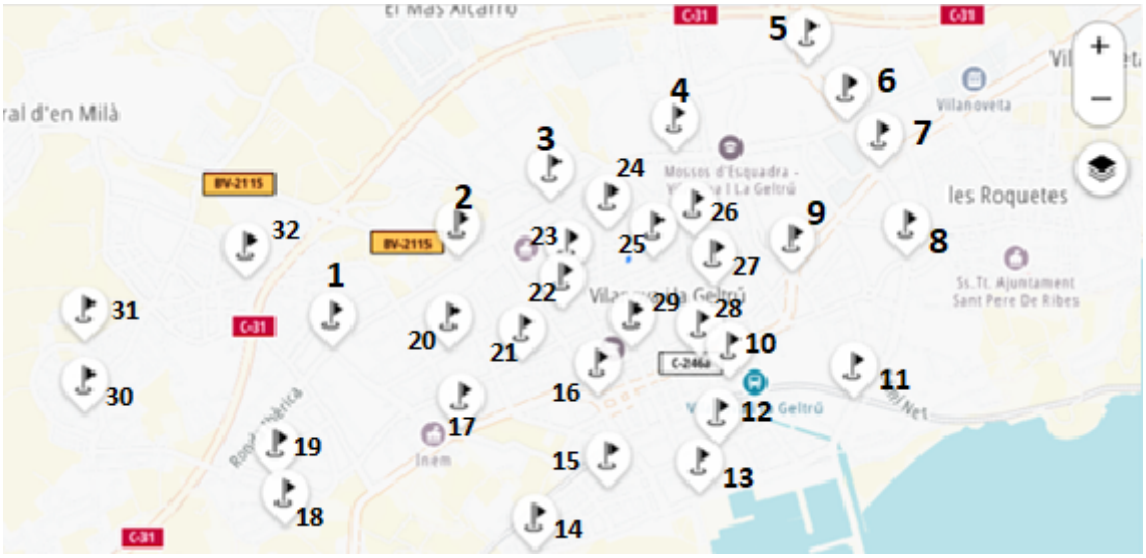


Fig.45. Sensors locations with a global view.

7.3. Sensors price analysis

In order to have a pretty reliable idea of which sensors would be the most suitable to implement in the city of Vilanova i la Geltrú, we based our budget estimation on a life cycle cost analysis (LCCA) of vehicle detection technologies and their impact on adaptive signal control strategies. Therefore, the price list below (Tab.5) serves as a reference for the cost of the most commonly used sensors on the market. This information can provide recommendations toward installing adaptive/responsive signal control and vehicle detection. This LCCA is focused on four adaptive signal control technologies and seven types of vehicle detection technologies.

In this context, and according to the Federal Highway Administration (FHWA), the selection process that is suggested when determining if an Adaptive Signal Control Technology (ASCT) is appropriate and which system should be chosen, requires first and obviously, an examination of the initial purchase and deployment costs as well as the usual maintenance, replacement and operational costs throughout the life cycle of single control and vehicle detection technologies. This study also shows the cost difference when a single adaptive system is subjected to multiple detection layouts.

The cost analysis has been developed for the following sensors :

- Inductive Loop Stopbar
- Inductive Loop Advanced
- Sensys Magnetometers
- Wavetronix SmartSensor Matrix (radar)
- Wavetronix SmartSensor Advanced (radar)
- Iteris VersiCam (video)
- Iteris Vantage Vector (hybrid radar and video)
- Traficon FLIR (thermal)

This analysis assumes that the costs for all components outside of major hardware, software, and maintenance costs are equivalent among detection technologies (i.e. wiring and man-hours for installation). Cost information and detection configurations came in the form of completed surveys, bid sheets, traffic engineer cost estimates, and personal emails.

Vehicle Detection – 1 Intersection | 10 years

This scenario compares the life cycle costs of each type of vehicle detection for one intersection over a ten-year analysis period. This analysis captures the per intersection costs including total initial cost, total present annual cost, and total present replacement cost for each type of vehicle detection. This analysis is instrumental as typical vehicle detection technologies are replaced with newer emerging technologies after a 10-year life span. Shown in Figure 48 and Tab.5, inductive loop detection has the lowest life cycle cost for a ten year analysis period at $19,500 for a single intersection. The alternative with the highest life cycle cost is Wavetronix Radar at $85,469 which consists of $46,520 in initial costs and $38,949 in annual costs for maintenance and troubleshooting.

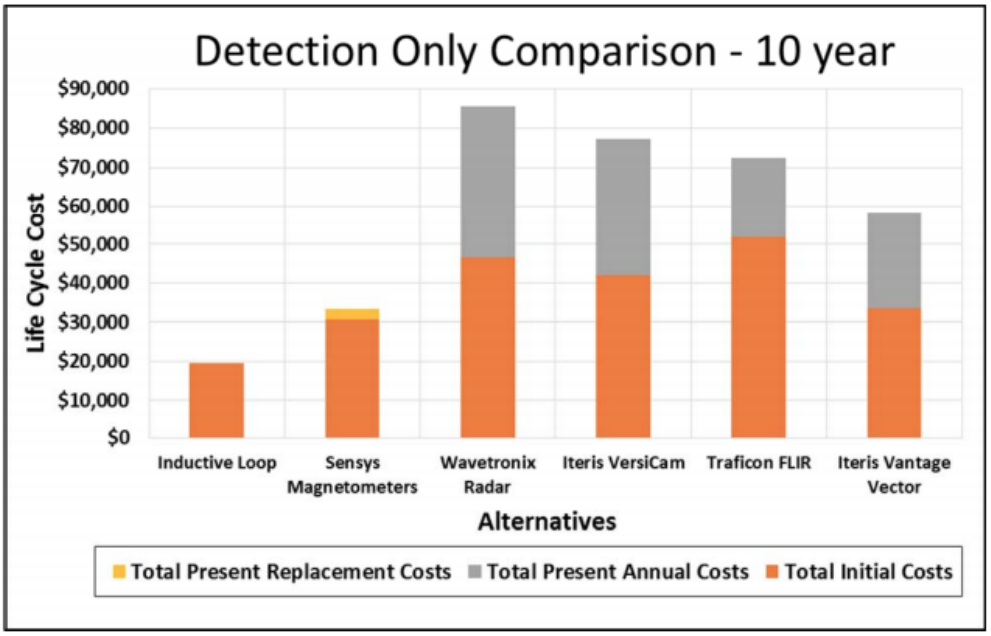


Fig.46. Detection only comparison for 1 intersection over 10 years.

To sum up, the results reveal that inductive loops not only have the overall lowest life cycle cost but also the lowest initial cost. On the other hand, radar and video sensors are significantly more expensive due to their range of measurements, their efficiency and reliability. Eventually, when considering which detection to use for a long term deployment, other factors must be considered including annual maintenance costs, the accompanying traffic control.

8. Finding a way to get data where we still can't find any.

8.1. Public transport

Transport data is probably the type of open data most requested by entrepreneurs, activists and citizens. In the last decade, real-time public transport data has become an essential part of urban life. From screens with information about the arrival of trains or buses to applications for smartphones that help citizens to plan routes and improve urban mobility.

One of the best-studied cases is that of London, which began publishing data in real-time more than ten years ago, being one of the pioneering cities in the world. According to a study carried out by Deloitte for the Transport Authority of London (TfL) in 2017, the publication of open data for free and in real-time on public transport contributes to the city's economy of around 130 million pounds a year. The estimated cost of the publication is 1 million pounds a year.

The observed benefits, which may apply to other cities, include creating jobs, saving time for citizens, checking the arrival of the next train/bus or optimizing routes and greater use of public transport.

Vilanova has two main urban bus lines, which run through the main or more passable streets, called Línia 1 Tacó-Càmping and Line 2 Càmping-Tacó, they also offer you in real-time the arrival of each bus at all its stops.

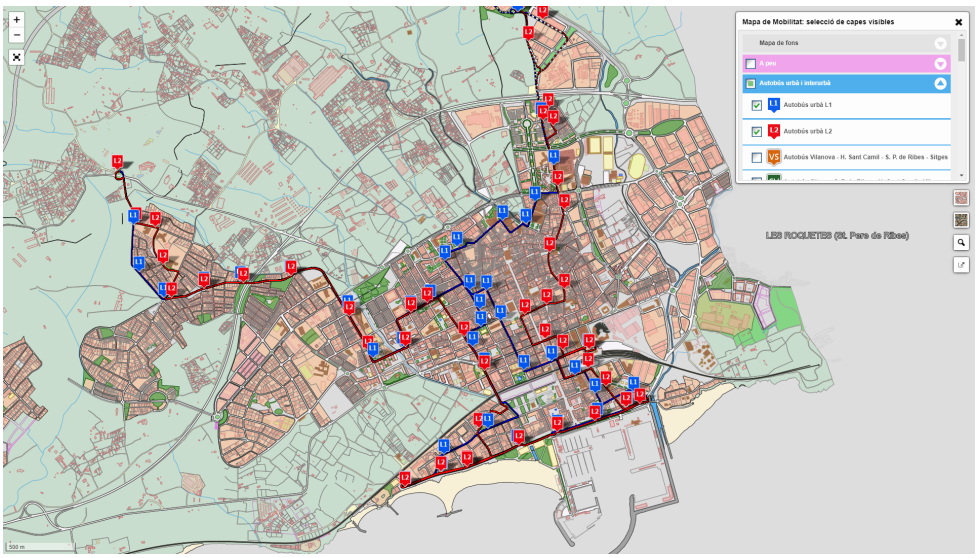


Fig.47. Route of L1 and L2.

Moventis (manages public transport in Vilanova) offers you that from your mobile phone or online and in real-time, you know how many minutes until the next bus arrives at your stop. If we know the distance between two stops and the time it takes to get there, we can calculate the flow of traffic on that section of the street.

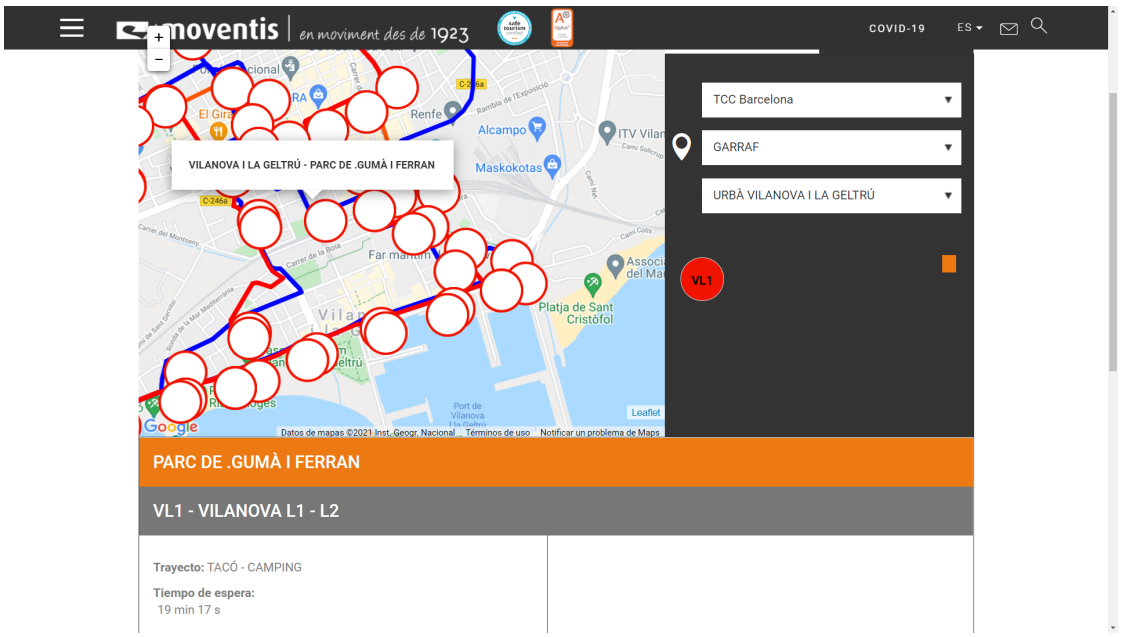


Fig.48. moventis page for real-time traffic.

In the following image, we can see all the bus lines that pass through Vilanova; these lines include city buses such as L1 and L2. In addition to these two, all other lines go from Vilanova to Barcelona, Sitges, Cubelles, Vilafranca, Tarragona and vice versa.

As we have mentioned before, each bus has a location system and if we know the distance between each stop and the time it should take from one bus stop to the next. Only with this information could we know the traffic between these two stops. If the bus takes longer than it should, we can say that there is traffic and if it arrives on time, the traffic flows smoothly.

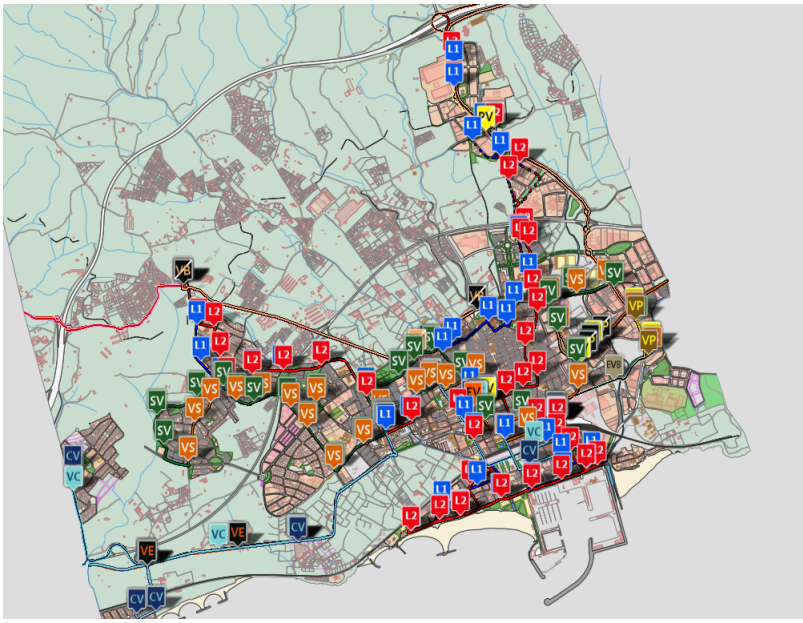


Fig.49. All bus lines in Vilanova i la Geltrú.

8.2. Historical record

Historical data for traffic management can predict where the traffic could go and take measures to prevent potential congestion. We can use historical records; the plan would be to place pneumatic sensors for road tubes. This sensor will not be permanent, but we will only use it for a few days to calculate the traffic that circulates on the street. This same sensor could then be reused in other streets for the same function since it is a sensor that can be easily placed. That is, it does not require much time to use.

Fig.50. Pneumatic sensors for road tubes.

9. Final Proposition

Taking into account different factors that we have previously commented on API and sensors, we will propose which are better or which are more adapted to our needs.

9.1. API

Below we can see a general comparison of all the applications that we have mentioned entirely. The best option is to use the local service SCT, but at the moment they do not have much real-time data from Vilanova. If in the future they had it, it would be the best option for Vilanova. We propose Waze as the Traffic API to seek. Mainly due to their specific niche to improve traffic in cities all over the world. This application can provide us a lot of information and the important thing is that we can use it for free, unlike the others. We have to bear in mind that Waze for Cities only provides their information to the authorities and not to ordinary people, therefore a person from the city council would have to contact them.

Tab.5. Comparison table of different API

API	It is free?	Are they available in Vilanova?	Do they have real-time data for Vilanova?	Can we use their real-time data?
Google Maps	200$ free	Yes	Yes	Yes
Waze	Yes	Yes	Yes	Yes
Tomtom	No	Yes	Yes	No *
Ontonomo	No	Yes	Yes	Yes
SCT	Yes	Yes	No	---

* TomTom were contacted and they said they couldn't provide us data

We can also use the Google platform because it gives us $200 for free, something more than enough for our needs and we discuss in section 3.2 how we would use this money.

We also propose, if needed, a programmable data system that is able request the data from the traffic APIs and display it in visual representations to convey useful traffic information such as using graphs and a live map view of Vilanova. The system must be able request this information at the times most ideal in a constant loop to be able to get consistent reliable data over time.

For example; to get the 'duration_in_traffic' you must request data from google's Distance Matrix API, you use the following example of an URL.

https://maps.googleapis.com/maps/api/distancematrix/json?origins=Boston,MA|Charlestown,MA&destinations=Lexington,MA|Concord,MA&departure_time=now&key=YOUR_API_KEY

You simply put in the API key, registered to your account, in the section 'YOUR_API_KEY' and you retrieve the information. Hence if a programme was built to request all the different types of useful traffic data on a loop you will see all the data at once on a loop. Therefore you can achieve real time

traffic data for the system. Below is the information provided, the example is based on the journey between Boston, MA or Charlestown, MA, and Lexington, MA and Concord, MA.


```
{
   "destination_addresses" : [ "Lexington, MA, USA", "Concord, MA, USA" ],
   "origin_addresses" : [ "Boston, MA, USA", "Charlestown, Boston, MA, USA" ],
   "rows" : [
      {
         "elements" : [
            {
               "distance" : {
                  "text" : "22.5 km",
                  "value" : 22476
               },
               "duration" : {
                  "text" : "28 mins",
                  "value" : 1668
               },
               "duration_in_traffic" : {
                  "text" : "29 mins",
                  "value" : 1743
               },
               "status" : "OK"
            },
            {
               "distance" : {
                  "text" : "41.3 km",
                  "value" : 41283
               },
               "duration" : {
                  "text" : "34 mins",
                  "value" : 2041
               },
               "duration_in_traffic" : {
                  "text" : "34 mins",
                  "value" : 2063
               },
               "status" : "OK"
            }
         ]
      },
```

```
      {
         "elements" : [
            {
               "distance" : {
                  "text" : "20.5 km",
                  "value" : 20452
               },
               "duration" : {
                  "text" : "27 mins",
                  "value" : 1619
               },
               "duration_in_traffic" : {
                  "text" : "28 mins",
                  "value" : 1663
               },
               "status" : "OK"
            },
            {
               "distance" : {
                  "text" : "29.6 km",
                  "value" : 29584
               },
               "duration" : {
                  "text" : "32 mins",
                  "value" : 1898
               },
               "duration_in_traffic" : {
                  "text" : "37 mins",
                  "value" : 2222
               },
               "status" : "OK"
            }
         ]
      }
   ],
   "status" : "OK"
```

9.2. Sensors

Keeping in mind that we would certainly be limited in terms of budget and also regarding the town/government on traffic sensor policy, it is of course, without doubt, unrealistic to implement all these sensors. At the moment, we will only recommend covering the four main roundabouts of Vilanova since an estimate of around 95% of city traffic passes through there. If we know how many cars enter and leave these roundabouts, we can determine how much traffic there will be in the city.

- The best option is to set up video sensors as long as it delivers us the traffic situation in real-time thanks to live video of the road. Immediate visual confirmation through a monitor is invaluable for operators or traffic managers, as it allows them to know exactly what is happening and what measures to take. This video sensor would cost 1,290€ (FLIR TrafiCam x-stream 2), knowing that we would set up a total of 8 sensors: the overall budget required would amount to 10,320€ (without installation).

We can also use other types of sensors, the good thing about these sensors that we are going to explain next is that we can use them within the city because that way we would avoid legal problems about video recording with sensors.

- Implementing some inductive loop sensors on the most critical roundabouts of the city of Vilanova i la G. As soon as a typical loop system – based on 40cm ducts, 3 chambers, traffic management, permits, loop cutting and cable would cost around 6500€ per approach, knowing that we would set up a total of 8 IDL sensors: the overall budget required would approach €52,000.
- Implementing some pneumatic road sensors on the most critical roundabouts of the city of Vilanova i la G. As seen previously, the overall cost of a pneumatic road sensor, including the installation and the maintenance, would reach 5,800€ so for a total of 8 sensors: around 47000€.

Below are visuals of each 4 major roundabouts of Vilanova to place sensors. It includes sketches to indicate the positionings of each sensor. The positions of these sensors are optimised to get the most accurate reliable data.

Orange Mark - Camera position

Pink lines - Pneumatic and inductive loop sensor positioning.

Green arrow - Entering Vilanova

Red arrow - Exiting Vilanova

Fig.51. Sensor Positioning - Ronda Ibérica (BV-2115)

Fig.52. Sensor Positioning - Ronda d'Europa(C-15)

Fig.53. Sensor Positioning - Avinguda d'Eduard Toldrà (intersection with Ronda Europa)

Fig.54. Sensor Positioning - Avinguda de cubelles (intersection with Carrer del Doctor Zembenhof and Carrer Ortoll)

Due to having traffic sensors in these positions, you will be able to identify how many vehicles (cars/motorbikes/trucks/lorries) are in Vilanova i la Geltrú. Thus you can determine how busy it is and what the likely state of traffic is all over the city. This can be helpful in predicting data where data is not found from sensors and GPS locationing directly. For example in theory, if there were 250 vehicles flowing through the city, then quite suddenly it rises to 500 cars. It would be a good indicator to suggest there is a higher probability of traffic to be found where data is not achieved.

With the combination of API and our proposal of traffic sensors this will as a result make an effective/useful inference to analyse the traffic of Vilanova i la Geltrú.

10. Unlocking the secrets of Vilanova.

In this section, you will find the insight on how the city of Vilanova i la Geltrú could manage, improve and even reduce their traffic. First, from an IoT perspective and then for further general recommendations.

Traffic data and analytics company INRIX estimates that traffic congestion cost U.S. commuters $305 billion in 2017 due to wasted fuel, lost time and the increased cost of transporting goods through congested areas. Given the physical and financial limitations around building additional roads, cities must use new strategies and technologies to improve traffic conditions.

This is why advanced traffic management technologies such as adaptive traffic control and traffic analytics can improve safety and significantly decrease traffic congestion levels and greenhouse gas (GHG) emissions.

Global spending on smart cities initiatives is projected to hit a staggering $189.5 billion in 2023. One of the most important factors in developing a smart city is making sure Internet of Things (IoT) systems are implemented in an integrated fashion. Every piece of technology must work and communicate together in order for city leaders to use IoT data effectively to improve the lives of citizens.

The range of smart city applications is highly diverse. What they have in common is the approach to implementation. Whether municipalities plan to automate waste collection or improve street lighting, they should start with the foundation – a basic smart city platform. If a municipality prefers to expand the range of smart city services in future, it will be possible to upgrade the existing architecture with new tools and technologies without having to rebuild it.

Here is a six-step implementation model to follow for creating an efficient and scalable IoT architecture for a smart city.

Stage 1: basic IoT-based smart city platform

To be able to scale, smart city implementation should start with designing a basic architecture – it will serve as a springboard for future enhancements and allow adding new services without losing functional performance. A basic IoT solution for smart cities includes four components:

The network of smart things

A smart city – as any IoT system – uses smart things equipped with sensors and actuators. The immediate goal of sensors is to collect data and pass it to a central cloud management platform.

Actuators allow devices to act - alter the lights, restrict the flow of water to the pipe with leakage, etc.

Gateway

Any IoT system comprises two parts – a "tangible" part of IoT devices and network nodes and a cloud part. The data cannot simply pass from one part to the other. There must be doors – field gateways. Field gateways facilitate data gathering and compression by preprocessing and filtering data before moving it to the cloud. The cloud gateway ensures secure data transmission between field gateways and the cloud part of a smart city solution.

Data lake

The main purpose of a data lake is to store data. Data lakes preserve data in its raw state. When the data is needed for meaningful insights, it's extracted and passed over to the big data warehouse.

Big data warehouse

A big data warehouse is a single data repository. Unlike data lakes, it contains only structured data. Once the value of data has been defined, it's extracted, transformed and loaded into the big data warehouse. Moreover, it stores contextual information about connected things, e.g., when sensors were installed, as well as the commands sent to devices' actuators by control applications.

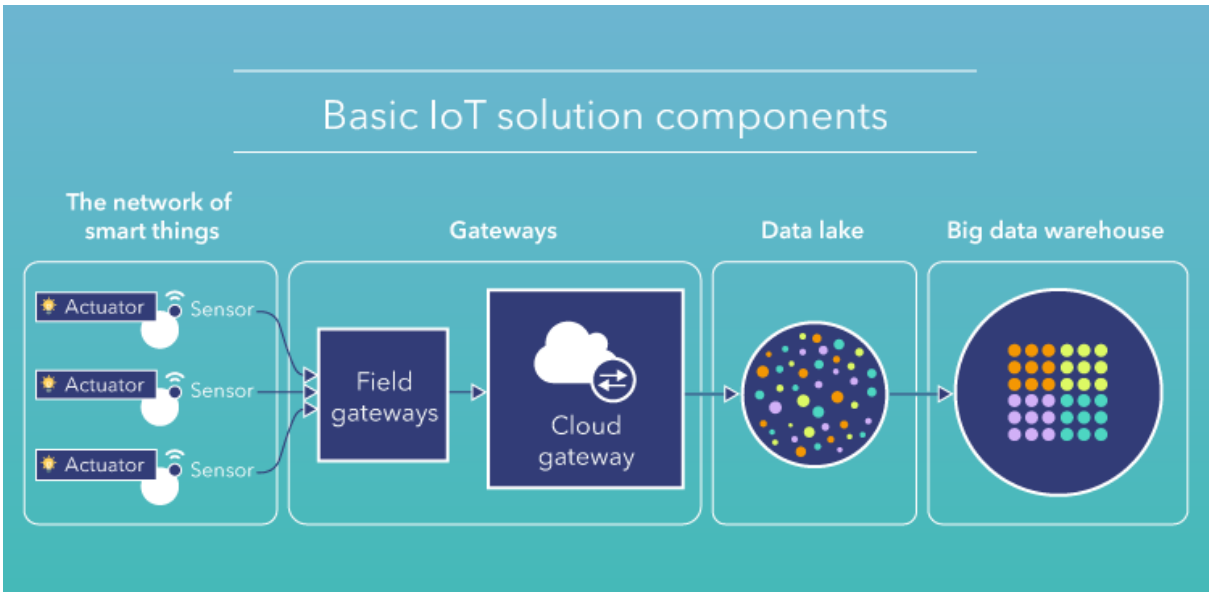


Fig.55. Basic IoT solution components.

Stage 2: Monitoring and basic analytics

With data analytics, it is possible to monitor devices' environments and set rules for control applications (we cover them at stage 4) to carry out a particular task.

For example, analyzing the data from soil moisture sensors deployed across a smart park, cities can set rules for the electronic valves to close or open based on the identified moisture level. The data collected with sensors can be visualized on a single platform dashboard, allowing users to know the current state of each park zone.

Stage 3: Deep analytics

Processing IoT-generated data, city administrations can go beyond monitoring & basic analytics and identify patterns and hidden correlations in sensor data. Data analytics uses advanced techniques like machine learning (ML) and statistical analysis. ML algorithms analyze historical sensor data stored in the big data warehouse to identify trends and create predictive models based on them. The models are used by control applications that send commands to IoT devices' actuators. Here is how it applies in practice.

Unlike a traditional traffic light that is programmed to display a particular signal for a definite period, a smart traffic light can adapt signal timings to the traffic scenario. Machine Learning (ML) algorithms are applied to historical sensor data to reveal traffic patterns and adjust signal timings, helping to improve average vehicle speed and avoid congestion.

Stage 4: Smart control

Control applications ensure better automation of smart city objects by sending commands to their actuators. Basically, they "tell" actuators what to do to solve a particular task. There are rule-based and ML-based control applications. Rules for rule-based control applications are defined manually, while ML-based control applications use models created by ML algorithms. These models are identified based on data analysis; they are tested, approved and regularly updated.

Stage 5: Instant interacting with citizens via user applications

Along with the possibility of automated control, there should always be an option for users to influence the behavior of smart city applications (for example, in case of emergency). This task is carried out by user applications.

User applications allow citizens to connect to the central smart city management platform to monitor and control IoT devices, as well as receive notifications and alerts. For example, using GPS data from drivers' smartphones, a smart traffic management solution identifies a traffic jam. To prevent even bigger congestion, the solution automatically sends a notification to the drivers in the area, encouraging them to take a different route.

At the same time, employees at a traffic control center who use a desktop user app receive a 'congestion alert.' To relieve the congestion and re-route part of the traffic, they send a command to the traffic lights' actuators to alter the signals.

Stage 6: Integrating several solutions

Achieving "smartness" is not a one-time action – it is a continuous process. Implementing IoT-based smart city solutions today, municipalities should think of services they might like to implement tomorrow. It implies not only increasing the number of sensors but, more importantly, the number of functions. Let's illustrate this functional scalability with the example of a smart city solution for traffic monitoring.

A city deploys a traffic management solution to detect traffic jams in real time and manage traffic lights to reduce traffic in the areas with intensive traffic. After some time, the city decides to ensure city traffic doesn't harm the environment and integrates the traffic management solution with a smart air quality monitoring solution. Cross-solution integration allows controlling both traffic and air quality in the city dynamically.

Adapting IoT implementation strategy to the city size

On the way to smartness, mid-sized and small cities face many barriers, including budgetary and procurement shortages, limited resources for public services, under-resourced IT infrastructure, etc. However, it doesn't mean a smaller city cannot be a smart city.

Starting a smart initiative in a city of medium or small size, it makes sense to begin with the projects that do not require huge investments and deliver tangible return on investments, such as smart parking or waste management, and use the established infrastructure to implement new services.

To determine which applications would be the most suitable for small cities, we've analyzed them by the volume of investments, required infrastructure, pay-off period, the visibility of benefits for citizens and came up with the following table :

Tab.6. The relevance of IoT applications for smaller smart cities.

THE RELEVANCE OF IOT APPLICATIONS FOR SMALLER SMART CITIES

	Highly relevant	Can be implemented with certain restrictions	The value is questionable
Traffic management			✓
Parking	✓		
Public transport		✓	
Utilities			✓
Street lightning	✓		
Waste management	✓		
Environment		✓	
Public safety		✓	

Another non-trivial way to enhance the affordability and accessibility of smart applications is sharing a common platform with a larger city. The cloud nature of IoT-enabled smart city solutions is suitable for that. This way, smart city solutions of both large and smaller smart cities are connected to and managed via a single cloud platform. By sharing the platform based on open data, several smart cities form a common urban ecosystem. One of the examples of such sharing is the Iberian Smart Cities Network, which currently includes 111 cities in Portugal and Spain. The network comprises cities of different sizes, which cooperate in multiple areas including smart energy, mobility, environment, and transport.

To sum this up, we can definitely say that IoT helps cities connect and manage multiple infrastructure and public services. From smart lighting and road traffic to connected public transport – the range of use cases is highly diverse. What they have in common is the outcomes.

Applying IoT solutions leads to reduced costs for energy, optimized use of natural resources, safer cities, and a healthier environment.

However, to enjoy these benefits, municipalities like Vilanova y la Geltrú should take a consistent approach to design a functional and scalable smart city architecture. Well-designed, it will allow to reduce investments in IoT development and hasten the implementation of smart city solutions, still leaving space for expansion.

Therefore, these previous guidelines would enable the city of Vilanova i la G. to manage their traffic using IoT technologies But this is not the only way of dealing with issues related to traffic. Indeed, instead of managing the traffic, why not try to reduce it?

Actually, cities could endlessly optimise their road network by :

- widening streets,
- adding on/off ramps,
- squeezing in roundabouts,
- designing new interchanges,
- flat out burying your problems with tunnels.

But often, a savvier and elegant solution is to reduce the amount of traffic that takes to the roads in the first place. Bearing this in mind, there would be lots of ways to reduce demand so that people and things move efficiently around the city.

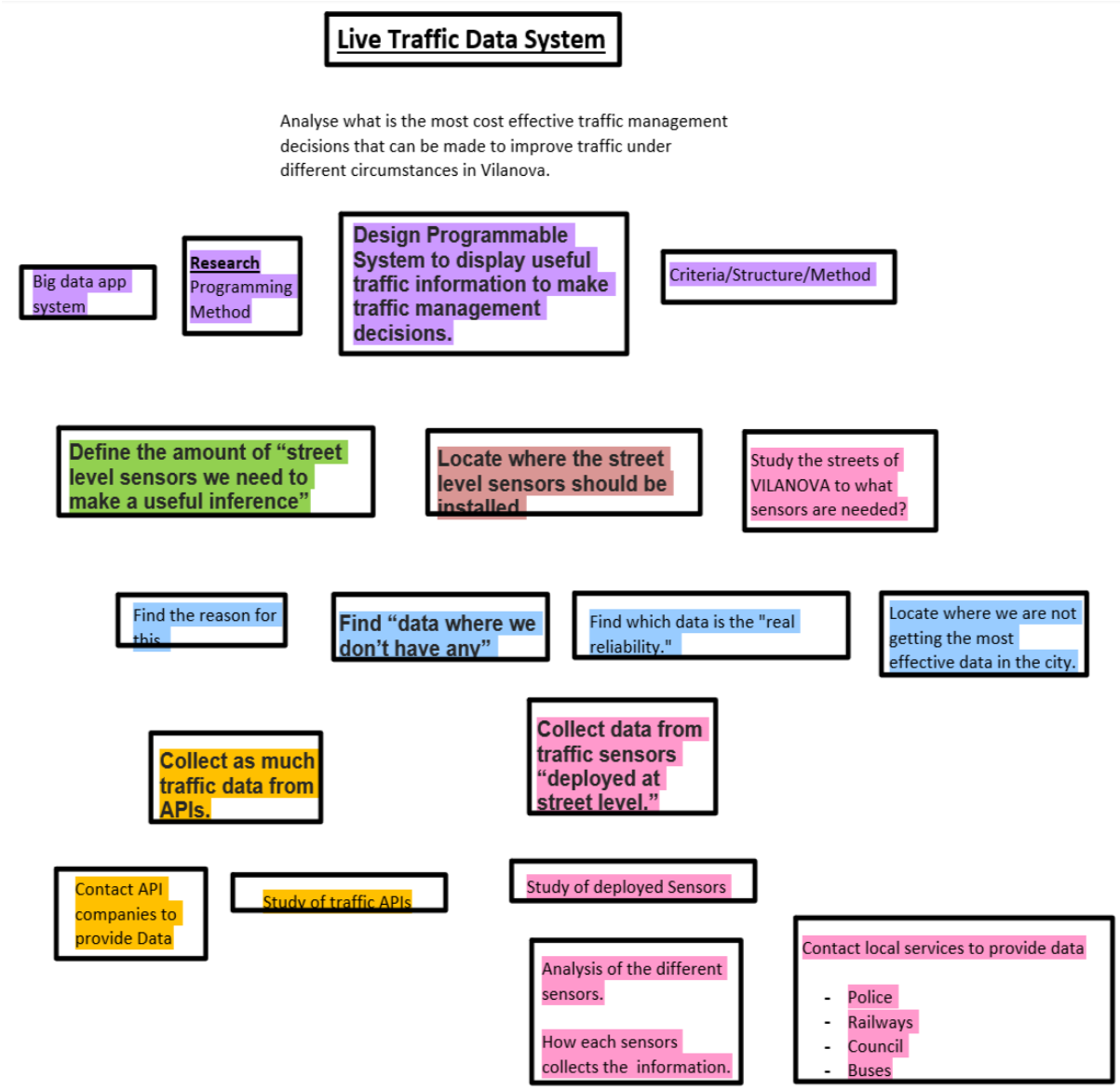
Here is the list of further recommendations we would provide to the city of Vilanova i la G. :

- **Free Public Transport** policy will tend to make people leave their car at home. Pull up the budget panel and look at your total public transport income. Compare that with your budget surplus and see if you can cope with it. Road traffic could benefit from decreased congestion and faster average road speeds, fewer traffic accidents, easier parking, savings from reduced wear and tear on roads.
- **Encouraging Biking** is a fantastic policy which is starting to become popular in many cities around the world. Communicate on it, allow biking self services paired with an attractive price and people will favour riding over driving.

- **Heavy Traffic Ban** is another big hit. It stops trucks carrying cargo through a designated district while making sure they stick to the main road and to the junctions designed to handle high volume.
- **The Old Town** is another cornerstone policy for reducing traffic. It can have a huge effect in the right place. An obvious use is to stop tourists from pulling out their 'pocket car' and driving straight into the city centre after their arrival. Instead, they would rather walk to the nearest transit connection. You can use this policy to stop people from using a district as a shortcut to their destination. It's a bit similar to the Heavy Traffic Ban but for cars.

11. Future Prospect

As you can see the final steps are yet to be achieved. Thus below we created



What is the future of this project?

1. Build a relationship with the Traffic Api company.
    - Prioritise Waze then respectively if needed proceed to seek and build a relationship with the following, Google Traffic, TomTom, Servei Català de Trànsit & Ontonomo.

2. Build and Design a Programmable System to display useful traffic information to make traffic management decisions with the support of Waze and Fuzzy Traffic Sensors.

3. After testing the system on Vilanova, analyse and discover what are the most cost effective traffic management decisions that can be made to improve traffic under different circumstances, scenarios and events in Vilanova.

12. Discussion and conclusions

The aim of the project was to perform deep research about traffic management systems and gather all necessary information related to the topic, in order to create the guideline for Vilanova i la Geltrú.

Firstly, it was necessary to study the current situation of the city, to know where and what kind of improvements should be implemented. One part of the studies was focused on sensors, what kind of the sensors are used for monitoring the traffic and where they are situated. What is more, it was essential to check the location of the main roads and mostly frequently used ones.

Another factor considered is local public transportation, bus lines and trains. Based on the council information from city sensors, historical record data and thanks to the map of acoustic, the proposition of location of the new sensors was made. For that reason the budget plan had to be taken into consideration.

Collecting and displaying real time data of traffic and related factors which can influence it, is essential for improvement of traffic management systems. Hence, further researchers included contacting with API' companies, whose services allow the users to display real time data of traffic congestion in the area of interest, in order to understand the traffic management system, know the price of data and establish cooperation in future perspective.

Moreover, to propose the final plan of improvement in Vilanova i la Geltrú, traffic management systems in different countries and cities were analysed and compared. Depending on the size of the population and the stage of the development different systems are applied. Although, in each case, style of management is aimed to make the city smarter, safer and more eco friendly.

Finally, based on all gathered information and research, the guidelines for Vilanova i la Geltrú were created. They would enable the city to manage their traffic using IoT technologies and could help in reducing traffic by implementation of described solutions. The plan consists of 6 stages: basic IoT-based smart city platform, monitoring and basic analytics, deep analytics, smart control, instant interaction with citizens via user applications and Integrating several solutions.

The first stage is focused on designing the basic architecture for future enhancements of the smart city. It involves four components like: the network of smart things, gateway, data lake and big data warehouse. Simply it is focused on collecting, storing and extracting data in order to manage traffic. The second and third stage is to monitor and analyze the data from sensors. Whereas the fourth one is about controlling what ensures better automation of smart cities. Next stage allows citizens to connect to the central management platform to monitor and control IoT devices, as well as receive notifications and alerts. The last step is integration of the solutions.

What is more, it consists of further recommendations for Vilanova i la Geltrú considering: free public transport, encouraging biking, heavy traffic ban and the old town policy. For reducing the traffic, optimisation of the road network is recommended. Solutions consist of: widening streets, adding on/off ramps, squeezing in roundabouts and designing new interchanges.

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14. Appendix

Waze e-mails:

Your application to the Waze for Cities Inbox ×

Waze for Cities <ccp-noreply@google.com> Mon, 3 May, 14:32
to me

Hello Neapolis,

Thank you for applying to the Waze for Cities Program. As much as we appreciate your interest, at this time, you haven't met our criteria for being a partner.

Waze works with Partners that meet the following criteria:

- Are a government agency
- Are a private road operator
- Organization is not from an embargoed country
- Are not a military organization

If you feel that you do meet the criteria for membership, please write back to this email and let us know.

Have questions? Check out our help center or fill out this form.

Thank you again for taking the time to apply.

Sincerely,
The Waze Team

Google LLC. 1600 Amphitheatre Parkway, Mountain View, CA 94043
This email was sent to sean.johnston@estudiantat.upc.edu to update you on the current status of your account with the Waze for Cities Program.

Hello Waze Team,

We believe we do in fact fit the criteria.

Neàpolis is an "innovation public agency" from a non embargoed country (Spain.) It is also not a Military Organisation.

It is an innovation, entrepreneurship and creativity centre of Vilanova i la Geltrú.
Technological, creative and business projects are the prime focuses here at Neàpolis, the agency also leads courses for companies and professionals. It
is part of the Vilanova i la Geltrú City Council.

Please check out our website (Qui som - Neapolis.)

To clarify, who we are and what we are doing.

We are a team of 5 students carrying out a project for Neapolis in a joint programme with the Universitat Politècnica de Catalunya EPSEVG for the European Project Semester (EPS). Where international engineering students participate as part of their studies.

Our Project mission is to achieve a high standard of real time traffic data in Vilanova i la Geltrú.

We aim to collect the real time traffic data in Vilanova i la Geltrú using the phone's gps system and real data found from sensors deployed at street level. This will be used in order to understand and manage the traffic better. Our task after this is to establish where data is not achieved and find a way of getting traffic information in those areas.

It is worth noting that our backgrounds are in Engineering. Therefore we lack in-depth knowledge in the IT & Data industry. Thus we would love to hear from your expertise and learn from you.

Neàpolis is driven to solve this problem at the highest level to improve Vilanova i la Geltrú. As far as the company is concerned, Neapolis is a place that connects business, technology, coworking, design and research.

If possible we would like to have a meeting at your earliest convenience.

We look forward to hearing from you.

Best Regards
The Fuzz Team

Tomtom emails:

Kamil Nowacki (TomTom)
May 4, 2021, 14:56 GMT+2

Hello Paul,

Unfortunately, data cannot be archived outside of the functionalities offered by the product.

For more information, I recommend reviewing our Terms And Conditions located here: https://move.tomtom.com/assets/TomTom%20Online%20Evaluation%20Agreement.pdf

Best regards,
Move Support

Kamil Nowacki / Senior Quality Specialist – TTI Customer Support / Traffic and Travel Information / kamil.nowacki@tomtom.com / www.tomtom.com

Paul VILAIN
May 3, 2021, 14:27 GMT+2

Hi,

We are a team of 5 students carrying out a project for Neapolis in a joint programme with the Universitat Politècnica de Catalunya EPSEVG for the European Project Semester (EPS).

Our main question regarding Route Monitoring is the following : would it be possible to extract the data from the chosen roads so that we can use them for our project and create some kind of operable Data Base.

We hope to hear from you.

Kind Regards,

Paul Vilain

TomTom API Query Extern Safata d'entrada ×

Abhishek Nair <Abhishek.Nair@tomtom.com>
per a mi

anglès > espanyol Tradueix el missatge

Hello Youssra,

I am one of the channel managers for the developer portal. I would love to help answer your questions. Please reach out if I can help.

Thank You,
Abhishek Nair
Channel Manager, Developer Portal

Google emails:

Google Maps Inquiry Safata d'entrada ×

Orlando Neftali Garcia <orlandon@google.com> dj., 25 de març 15:35
per a mi

anglès > espanyol Tradueix el missatge Desactiva per a: anglès ×

Thank you for your interest in Google Maps Platform

I'm reaching out to you in response to the web inquiry that you've submitted requesting to speak with the Google Maps Platform sales team.I would like to schedule a 10 minute call to understand your mapping requirements. When might be a good time to connect?

Thanks,
The Google Maps Platform team

Youssra Benaddi <youssra.benaddi@upc.edu> dt., 30 de març 9:27

Orlando Neftali Garcia <orlandon@google.com>
per a mi

anglès > espanyol Tradueix el missatge

Google Maps Platform

Thank you for your interest in Google Maps Platform APIs

Unfortunately, I haven't been able to reach you regarding your online inquiry about Google Maps Platform APIs.

If at any point you'd like to get in touch, feel free to fill out this "Get In Touch" form.

In the meantime, check out our white paper, "More than Pins on a Map: How Google Maps Can Add Value to Your Bottom Line" to learn about the innovative ways businesses have employed Google Maps Platform APIs.

Thanks,

The Google Maps Platform team

Orlando Neftali Garcia <orlandon@google.com>
per a mi

anglès > espanyol Tradueix el missatge

Thank you for your interest in the Google Maps Platform.

I'm reaching out to you in response to the web inquiry that you've submitted requesting to speak with the Google Maps Platform sales team.

To better assist you and understand your potential use case for Google Maps Platform, can you please answer the following questions:

1) Which of the Google Maps Platform APIs do you plan on using?

2) How does mapping fit into your solution?

3) Does your use case involve the inclusion of the APIs in a product or service that you will sell?

4) What is the website and/or mobile application that will be using the APIs?

5) Where are you currently in terms of development?

6) Where is your company HQ? Total number of Employees? What is your title at the company?

7) What is your expected call volume per day?

Thanks,

Youssra Benaddi <youssra.benaddi@upc.edu>

Ontonomo emails:

Youssra Benaddi <youssra.benaddi@estudiantat.upc.edu>
per a mi

anglès > espanyol Tradueix el missatge

---------- Missatge reenviat ----------
De: **Liat from Otonomo** <liata@otonomo.io>
Data: diumenge, 7 de març de 2021
Assumpte: Youssra, did you find everything you were looking for from Otonomo?
A: youssra.benaddi@estudiantat.upc.edu

Hi Youssra,

Thank you for your recent interest in Otonomo's car data services platform.

I'm writing to make sure that you found all you need for Polytechnic University of Catalonia.

If you would like to speak to one of our data specialists, we've made it easy to book a meeting. Click here to select a time that is convenient for you.

As a reminder, Otonomo's platform reshapes and enriches car data from over 18 million vehicles, offering:

- Global coverage with connected vehicle data from multiple OEMs (BMW, Daimler, FCA etc.) and fleets
- Enriched datasets including vehicle status polling, periodic historical reports, accumulated trip analytics and more
- Separate streams for real-time and historical data
- An easy-to-use RESTful API

One of our data specialists would be happy to answer any questions you may have, and share some relevant use cases with you over the phone.

Best Regards,

Liat Amosy

Account Executive

LiatA@otonomo.io

Hi Youssra,

You recently downloaded our Datasheet: Traffic Data and I'd like to help you learn more about using the Otonomo data platform to Get consent for fleet use.

Would you be open to for a quick call? You can check for a convenient time here.

As a reminder, the Otonomo Vehicle Data Platform - provides actionable data from >22 million vehicles, offering:

- Global coverage directly from the OEMs Back-end (BMW, Daimler, Mitsubishi, FCA, etc.) and fleets
- Enriched datasets including Vehicle Status Polling, Vehicle Trip Data, Vehicle data location, Road Sign Data, etc.
- Real-time / Historical data / Personal Data / Aggregate Data
- An easy-to-use RESTful API

Looking forward to your reply,

Best regards,

Liat Amosy | SDR

otonomo

M: +972 (52) 854 52 88
E: LiatA@otonomo.io

W: www.otonomo.io

Meeting with Youssra Benaddi Safata d'entrada ×

Liat Amosy <Liata@otonomo.io>
per a mi

anglès > espanyol Tradueix el missatge

Meeting with Youssra Benaddi
Mostra a Google Calendar

Hora	dt. 16 març 2021 1pm – 1:30pm (CET)
Ubicació	https://us02web.zoom.us/j/83623960541
Participants	Liat Amosy*

Sí Potser No Més opcions

Liat Amosy is inviting you to a scheduled Zoom meeting.

Topic: Meeting with Youssra Benaddi
Time: Mar 16, 2021 02:00 PM Jerusalem

Join Zoom Meeting
https://us02web.zoom.us/j/83623960541

Meeting ID: 836 2396 0541
One tap mobile
+13017158592,,83623960541# US (Washington DC)
+13126266799,,83623960541# US (Chicago)

Dial by your location

From: Liat Amosy
Sent: Thursday, 18 March 2021 23:10
To: youssra.benaddi@estudiantat.upc.edu
Subject: Otonomo MNDA

Hello Youssra,

It was a pleasure speaking to you and your colleagues today.

Following our conversation please find a link to our open platform http://bit.ly/3cxzzhZ

Also attached please find our MNDA for your review and signature,

Kind Regards,

Liat Amosy| **SDR Manager**

otonomo

M: +972 (52) 854 52 88
E: LiatA@otonomo.io
W: www.otonomo.io
If you do not wish to receive further emails, kindly reply with "Leave Out" or "Unsubscribe"

Liat Amosy
per a mi

anglès > espanyol Tradueix el missatge

Hello Youssra,

I would be happy to set up a call with our solution architect. Can you please fill out the MNDA so we can proceed to further discussions?

Kind Regards,

Liat Amosy| **SDR Manager**

otonomo

M: +972 (52) 854 52 88
E: LiatA@otonomo.io
W: www.otonomo.io
If you do not wish to receive further emails, kindly reply with "Leave Out" or "Unsubscribe"

otonomo

MUTUAL NON-DISCLOSURE AGREEMENT

This **MUTUAL NON-DISCLOSURE AGREEMENT** ("**NDA**") governs the disclosure of information by and between **otonomo GmbH.**, a German corporation, together with its parent, subsidiaries and affiliates (collectively, "**otonomo**"), and _____, a company registered under the laws of _____ ("**Company**") and is effective on _____ (the "**Effective Date**").

1. This NDA is entered into so that the parties may engage in discussions on potential business relations.

2. In connection with discussions related to the opportunity described above, the parties may disclose Confidential Information to each other. As a condition to such information being disclosed, each party agrees to treat all Confidential Information in accordance with the provisions of this NDA. For purposes of this NDA, "Confidential Information" means nonpublic, confidential and/or proprietary information (whether prepared by the Discloser, its representatives or otherwise, and irrespective of the form or method of communication), which is furnished hereunder to a party (the "**Recipient**") now or in the future, by or on behalf of the other party (the "**Discloser**"), including but not limited to any trade secret or other confidential technical, business, financial or other proprietary information including but not limited to processes, procedures, hardware, software, code, inventions, ideas, designs, research, know-how, business methods, production plans, data samples, marketing and branding plans, and information relating to organizational structure, management, products and services, customer service, processes and technology, customer and supplier lists.

3. Confidential Information will include all information that should reasonably be understood by the Recipient, because of legends or other markings, the circumstances of disclosure, or the nature of the information itself, to be proprietary and confidential to the Discloser, regardless of whether such information is marked "Confidential" or "Proprietary."

4. Data Sample: Any limited access to data sample ("**Data Sample**") provided by Otonomo shall be used only for the opportunity described above. Prior to any Data Sample being shared with Company, Company shall sign a data sample annex which shall detail the specific purpose for which the Data Sample can be used, Data Sample duration and Data Sample usage duration. Company shall not (i) resell, distribute, rent, lease, transfer, lend, display or assign the Data Sample; (ii) attempt to gain unauthorized access to the Data Sample or the Otonomo platform or their related systems or networks; (iii) use or allow others to use the Data Sample for any activity that constitutes or encourages conduct that would constitute a criminal offense, give rise to civil liability or otherwise violate applicable laws, rules and regulations. (iv) derive, or attempt to derive, either directly or indirectly, the identity of an individual from any data-set included in the Data Sample.

5. Recipient will hold Discloser's Confidential Information in strict confidence and will not disclose or otherwise make it available to any third party, except with the Discloser's prior written approval, and will use the Confidential Information for no purpose other than the purpose set forth in Section 1. Under no circumstances will the Recipient use such information to its own advantage or to the advantage of any third party without the Discloser's prior written consent. Without limiting the foregoing, neither party will decompile, disassemble or reverse engineer any portion of the other party's Confidential Information. Each party will limit access to the other party's Confidential Information to those of its employees or authorized representatives having a need to know such information and who expressly agree to be bound by the terms of this NDA or who have executed confidentiality undertakings sufficient to comply with this NDA. Recipient

HERE emails:

Fwd: HERE Technologies - Su solicitud de contacto Safata d'entrada ×

Youssra Benaddi <youssra.benaddi@estudiantat.upc.edu> dc., 10 de març 12:19
per a mi

anglès > espanyol Tradueix el missatge Desactiva pe

---------- Forwarded message ---------
De: **Tamagnini, Carlos** <carlos.tamagnini@here.com>
Date: mié., 10 mar. 2021 11:20
Subject: HERE Technologies - Su solicitud de contacto
To: youssra.benaddi@estudiantat.upc.edu <youssra.benaddi@estudiantat.upc.edu>

Buenos dias, Youssra,

Me llamo Carlos y le escribo desde HERE Technologies. Gracias por su solicitud de contacto que nos mandó a través de nuestro sitio internet. He tratado de llamarla hoy día, lamentablemente sin éxito.

¿Podría hacerme saber cuándo podemos organizar una llamada telefónica entre nosotros? Hágame saber una fecha y un horario para que podamos discutir su solicitud de contacto. Gracias de antemano por su gentil respuesta.

Cordialmente,

Carlos Tamagnini
Market Development Specialist
T: +49 4022863981

HERE Technologies
52° 31' 52" N 13° 23' 5" E

Buenas tardes, Youssra y Fraz,

Tuve el placer de hablar con Fraz hoy día sobre vuestra solicitud de contacto. He hablado también con mis colegas del nuestro equipo técnico y estas son las informaciones que me han proporcionado para vuestro proyecto:

Podemos ofrecerles dos servicios completamente gratuitamente para vuestro proyecto.

1. Le aconsejamos de crear una cuenta en nuestro portal de desarrolladores usando el siguiente enlace.

   Por favor tengan cuenta que lamentablemente, el recopilar datos de nuestras API no es permitido. Pueden ver nuestros términos y condiciones, específicamente a partir de la octava cláusula donde encontraran el siguiente parágrafo que indica que la recopilación de datos es permitido solo si se usan por 30 dias:

   "Caching or storing any location data for the purpose of building a repository of location assets or scaling one request to serve multiple end users is prohibited. Customer may not use any HERE Services in a manner that pre-fetches, caches, or stores data or results, **except**:
   - As explicitly allowed by the caching headers (HTTP/1.1 standard) returned by HERE Services; or
   - **To the extent Customer is storing or caching for no more than thirty (30) days only to the extent necessary for enabling or improving an end user's use of the HERE Services**."

2. Le aconsejamos de también usar nuestro portal de datos para estudiantes, que podrán acceder una vez que hayan creado una cuenta en nuestro portal de desarrolladores.

Espero que estas informaciones le sean útiles. Les pido disculpa que no les podemos ser de más ayuda, pero espero que las informaciones que me proporcionaron mis colegas del equipo técnico sean suficientes. Si tienen cualquier otra pregunta o necesidad, por favor háganmelo saber. Les deseo a todos ustedes muchísima suerte con vuestro proyecto, y espero que les vaya bien.

Le pido disculpa que no le puedo ser de mas ayuda, pero espero los datos y las informaciones disponibles en nuestro portal Freemium le sean útiles. Encontrarán en nuestro portal varias APIs que les podrán ser útil, por ejemplo, nuestra API de tráfico en tiempo real and nuestra API para los puntos de interés (POI). Si tiene otra pregunta o duda, por favor no dude en contactarme. Muchísimas gracias por su interés en HERE Technologies.

Cordialmente,

Carlos Tamagnini
Market Development Specialist
T: +49 4022863981

HERE Technologies
52° 31' 52" N 13° 23' 5" E

Su cuenta Freemium Extern Safata d'entrada ×

Tamagnini, Carlos <carlos.tamagnini@here.com> dc., 21 d'abr. 15:49
per a mi

anglès > espanyol Tradueix el missatge Desactiva per a: anglès ×

Buenas tardes, Youssra,

Soy Carlos, desde HERE Technologies. Hemos comunicado a través de algunos correos hace unas semanas. Me alegra ver que ha creado una cuenta en nuestro portal de desarrolladores. Quedo a disposición si necesita cualquier tipo de información sobre nuestro portal Freemium. Gracias nuevamente por su interés en HERE Technologies.

Cordialmente,

Carlos Tamagnini
Market Development Specialist
T: +49 4022863981

HERE Technologies
52° 31' 52" N 13° 23' 5" E

Tamagnini, Carlos
per a mi

dj., 13 de maig 14:44

anglès > espanyol Tradueix el missatge

Desactiva per a: anglès

Buenas tardes, Youssra,

Gracias por su correo y disculpe el retraso en responderle. Tuve algunos problemas con mi ordenadora a principios de mes y luego estuve ausente durante una semana debido a mi permiso laboral. Quisiera aprovechar y mandarle estos enlaces introductorios para nuestro portal. Espero que les sean útiles para familiarizarse con nuestro portal:

Documentación

Tutorials

FAQ

Twitch channel

Nuestro blog.

Este video le mostrará los principales recursos a su disposición.

Espero que estas informaciones le sean útil. Gracias nuevamente por su interés en HERE Technologies.

Cordialmente,

Carlos Tamagnini
Market Development Specialist
T: +49 4022863981

HERE Technologies
52° 31' 52" N 13° 23' 5" E