CONVI TRAN

LA CIUDAD CON TRANVÍAS

Modelo de convivencia de movilidad segura

TRAM SYSTEMS IN SPAIN AND THEIR IMPACT ON ROAD SAFETY

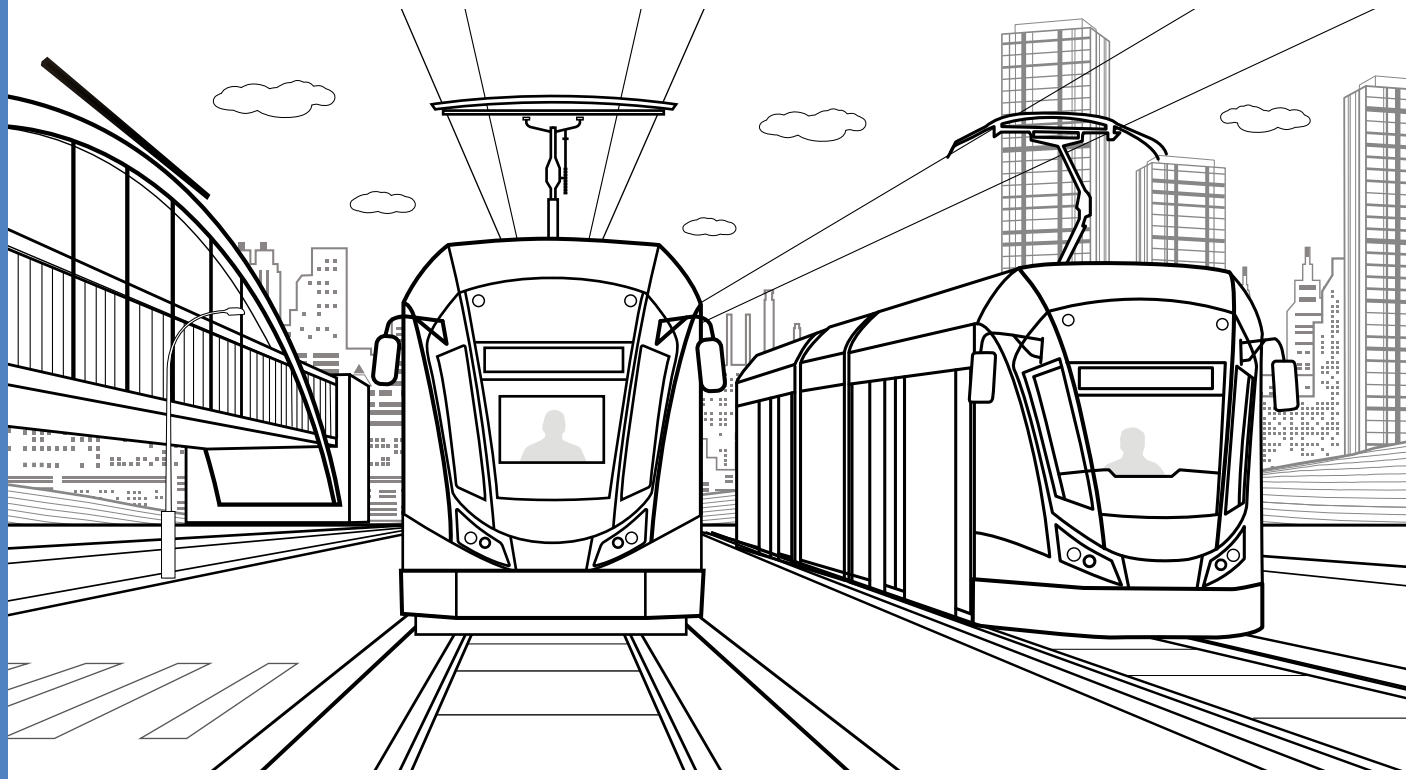
Short report

Fundación de los FERROCARRILES Españoles

In collaboration with:

INICIATIVAS SOCIALES OFESAUTO

www.ffe.es/convitran/



This report has been prepared by the Knowledge Management Department of the Spanish Railway Foundation (FFE). The project 'Model of coexistence for safe mobility: the city with trams. conviTRAN', is promoted by the Spanish Railway Foundation and financed by the Spanish Motor Insurers' Bureau (OFESAUTO), within the framework of the isOFESAUTO 2024 social initiatives.

Fundación de los
FERROCARRILES
Españoles

Fundación de los Ferrocarriles Españoles
Calle de santa Isabel, 44
C.P. 28012 – Madrid
www.ffe.es
www.ffe.es/convitran/

INDEX

INTRODUCTION

Mobility is a crucial factor in the planning of modern cities. Transportation systems significantly influence urban development and directly affect residents' quality of life.

In this context, trams have regained considerable significance worldwide, becoming a key component of mass public transportation services. In Spain, tram systems operate in cities that serve a combined population of over 8 million people.

However, the substantial increase in population and number of vehicles in urban areas presents a challenge: as city density rises, so does the likelihood of accidents or incidents involving trams. Although tram-related accidents tend to attract considerable public attention, data show that tram transport systems are relatively safe compared to other modes of transportation. It is important to note, however, that when accidents involving trams do ccur, injuries to pedestrians tend to be more severe than those involving other motor vehicles.

Therefore, ensuring safety and reducing the risk of such accidents is a critical concern that must be addressed in both the design and operation of tram systems.

To better understand safety trends and identify risk factors, the **A Model for Safe Mobility Coexistence: The City with Trams. conviTRAN** project focuses on analysing accidents and incidents involving trams in Spain. The goal is to enhance safety in urban and metropolitan environments where trams operate and interact with other participants in the urban mobility ecosystem, including drivers, cyclists, users of micro-mobility devices, pedestrians, and individuals with reduced mobility.

EVOLUTION OF THE TRAM MODE

The tram emerged as a mode of urban transport at the beginning of the 19th century, driven by the growth of cities during the Industrial Revolution, which created an urgent need for mass transit systems. In Spain, trams were implemented at the end of the 19th and early 20th centuries, slowly due to the country's slow industrialisation and predominantly rural population.

The first tram vehicles, known as "horse-drawn trams," relied on animal power and were pulled by horses. However, with the advent of electricity, these earlier traction systems—such as horses, steam, and cables—were gradually phased out. The history of Spanish trams began with animal traction in cities like Madrid (1871), Barcelona (1872), Valencia (1876), Bilbao (1882), and Zaragoza (1885). By 1900, twenty Spanish cities had adopted horse-drawn trams.

Steam traction was introduced on the Madrid-Leganés line in 1879, and in Barcelona towards Sant Andreu in 1877. Electrification came later: the first electrified tram line was introduced in Madrid in 1887. However, the first city to offer a fully electric tram service was Bilbao, with the Bilbao-Santurce line electrified in 1896. In Valencia, steam traction began in 1892, followed by initial electrification in 1900.

After the Spanish Civil War, most public transport networks were left in a fragile state due to a lack of maintenance during the conflict and a shortage of materials, which hindered their reconstruction.

In the early 20th century, the rise of internal combustion engine vehicles, such as cars and buses, negatively impacted the tram. These newer forms of transport were seen as more flexible and modern, leading to the replacement of tram lines with buses in many developed countries starting in the 1930s. In Spain, this dismantling process began in the early 1960s.

Several factors contributed to the decline of trams, including a shift back to road transport, the limited financial capacity of transport companies, and the government's unwillingness to modernise transit networks. As a result, tram facilities and rolling stock became outdated. Between 1960 and 1970, many cities dismantled their tram networks, claiming that they obstructed urban traffic. In some instances, trolleybuses, which used electric traction, were introduced as an intermediate step before fully transitioning to buses.

A common theme among countries that eliminated trams was a clear objective to promote the use of cars and buses while neglecting the modernisation and separation of public transport systems. This shift led to a decline in tram usage and an increase in their replacement.

The 1973 economic crisis further intensified the decline in public transport usage. In the years that followed, the rising rate of motorisation increased reliance on private cars for

urban transport, making it difficult for public transit to compete for mobility. This, in turn, deteriorated the quality of public surface transport due to congestion, negatively impacting the quality of urban life (noise, pollution, etc.).

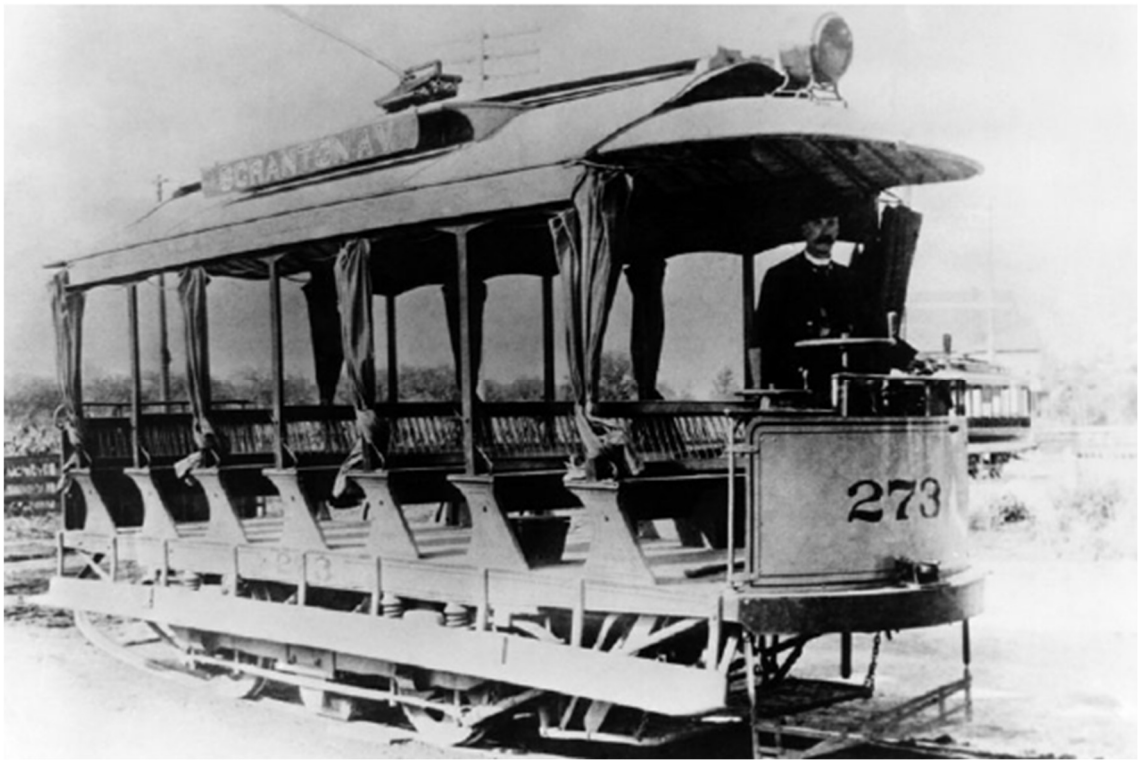
Faced with this situation, it became evident that buses were ineffective in meeting new mobility demands in intermediate ranges—specifically, corridors with between 2,500 and 20,000 passengers per hour in each direction. While buses were suitable for low demand (up to 2,500 passengers per hour), and metros/subways catered to high demand (over 20,000 passengers per hour), trams and streetcars were identified as the appropriate solution for intermediate volumes.

The last tram lines to close in Spain were in Granada (1974) and Zaragoza (1976).

In the 1990s, a shift occurred as cities faced traffic congestion and recognised the success of new tram systems in Europe. The earlier decision to eliminate tram services was acknowledged as a mistake, leading to the construction of new tram lines in Spain. From this point onwards, trams became a viable solution to urban congestion and pollution.

A significant turning point came in 1994 when Valencia became the first city to reintroduce trams (the Tram de València), marking a change in trends.

The widespread implementation of new tram systems continued well into the 21st century, with inaugurations in Parla, Tenerife, Seville, Vitoria, and various other cities.



TRAM SYSTEMS

The reintroduction of the modern tram was based on a paradigm shift: the city should no longer revolve around the car, but around collective and sustainable mobility.

The modern tram has strategically positioned itself at the urban mobility pyramid by attributes that make it especially suitable for medium-demand corridors.

MODE OF TRANSPORT	TRAM ADVANTAGES	TRAM DISADVANTAGES
COMPARED TO THE BUS	**Higher Capacity:** The tram can move more passengers per hour and direction (ideal for demands of 2,500–20,000 p/h/d). **Lower Pollution:** It is electric and generates no local emissions. **Comfort and Stability:** Trams offer a smoother and quieter ride. **Incentive for Use:** Increases the appeal of public transport and incentivises its use. **Lifespan and Maintenance:** Longer useful life of the rolling stock.	**Fixed and Rigid Infrastructure:** It requires a high initial investment, and routes cannot be easily modified. **Visual and Spatial Impact:** Requires a segregated platform taking up urban space. **Vulnerability by Interruptions:** Can be blocked if segregation is not strict.
COMPARED TO THE METRO / SUBWAY AND COMMUTER RAIL	**Lower Investment Cost:** The investment per kilometre is significantly lower than that of an underground metro. **Greater Accessibility:** Its integration at street level facilitates access for people with reduced mobility (Universal Accessibility). **Faster Construction:** Network construction is less disruptive and quicker than tunnel drilling.	**Lower Capacity:** Its capacity is inferior to that of a metro or a commuter train (more than 20,000 p/h/d). **Limited Speed:** Its commercial speed is lower due to interaction with the surface and traffic lights. **Dependence on Traffic:** Although segregated, it can still be affected by surface crossings and turns.

The key to the success of the modern tram lies not only in its characteristics but also in how it integrates with the rest of the urban transport network, seeking intermodality and synergy between modes:

- **Coordination with the Bus Network:**

Buses could be restructured to serve tram stops and stations, rather than competing with their routes.

Single fares and tickets should be established to allow for fluid transfer between the bus and the tram, optimising travel times.

- **Integration with the Metro/Subway and Commuter Rail:**

Tram stations must be strategically located as mass interchange points with the metro and commuter trains (for example, the tram network could be an extension of metro lines into peripheral neighbourhoods), facilitating transfers.

The infrastructure must be designed so that the tram acts as a capillary network that feeds the high-capacity systems.

- **Priority and Segregation:**

The physical segregation of the tram platform (often with grass tracks or curbs) is fundamental to guarantee its reliability and punctuality, making it independent of traffic congestion.

Traffic light priority systems should be implemented at crossings (giving the tram a green light) to ensure a high commercial speed and reduce unnecessary stops, a crucial aspect of its attractiveness.

- **Education and Coexistence:**

Because accidents generally are linked to human factors (such as distractions or improper turns), it is essential to promote continuous road safety campaigns ("Unplug, look, cross..."). One aspect to consider is that pedestrians and motor vehicle drivers should be informed about tram priority and the need for attention at intersections.

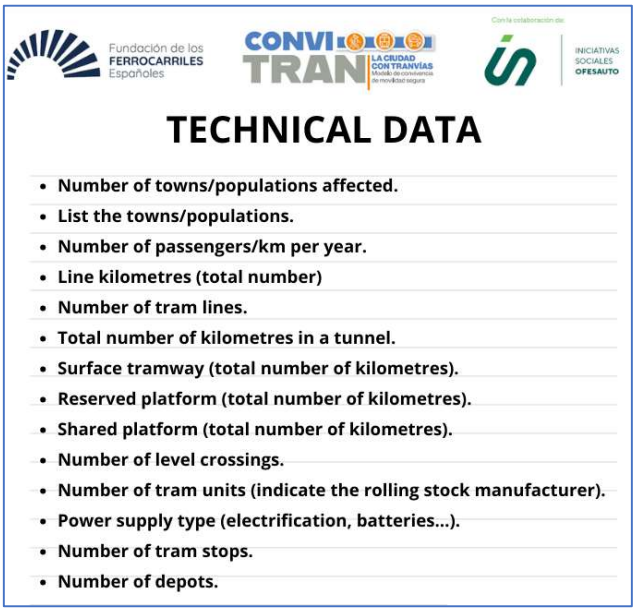
METHODOLOGY

The methodology presented in this report relies on a descriptive analysis of data provided by the following organisations operating tram services in Spain:

- Eukotren.
- Ferrocarrils de la Generalitat Valenciana.
- Metro de Málaga.
- Metro Ligero Oeste.
- Metro de Tenerife.
- Metropolitano de Granada.
- Metros Ligeros de Madrid.
- Tram.
- Tranvía de Murcia.
- Tranvía de Parla.
- Tranvía de Soller.
- Tranvía de Zaragoza.

The data covers measures implemented in 2022, 2023, and 2024, as reported by these organisations.

The data was compiled using a self-completion questionnaire that the entities themselves filled out and which focused on the following aspects:



The report presents technical and safety data provided by entities linked to the operation of the Spanish tram.

Using the compiled information, we have calculated an indicator to show the year-on-year percentage variation in accident rates, the types of accidents and the victims, as well as the vehicles and individuals involved in these incidents. This indicator enables us to analyse changes in accident rates over the reference years 2022, 2023, and 2024.

This report is a milestone because data on tram accidents and incidents in Spain and internationally are not readily available to the public. However, having reliable and comparable data is crucial for developing proactive safety measures and educational initiatives to raise awareness.

KEY FIGURES RELATING TO TRAM SYSTEMS IN SPAIN

Below are the key figures for the year 2024 provided by the tram entities participating in the **conviTRAN** project:

Fig. 1: Key figures for trams in Spain, 2024

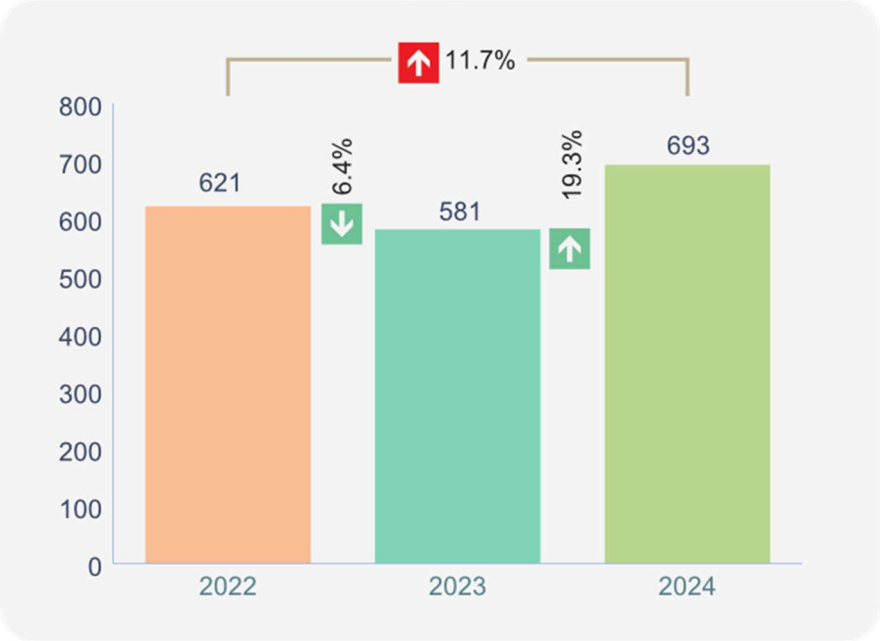
Source: Data provided by collaborating entities within the framework of conviTRAN.

TRAM ACCIDENTS IN SPAIN

Accident trends

Data reported by tram authorities indicate a general trend of increasing accident rates from 2022 to 2024. The graph below illustrates the total number of incidents for the reference years.

Fig. 2: Trend in tram accidents in Spain, 2022-2024



Source: Data provided by collaborating entities within the framework of conviTRAN.

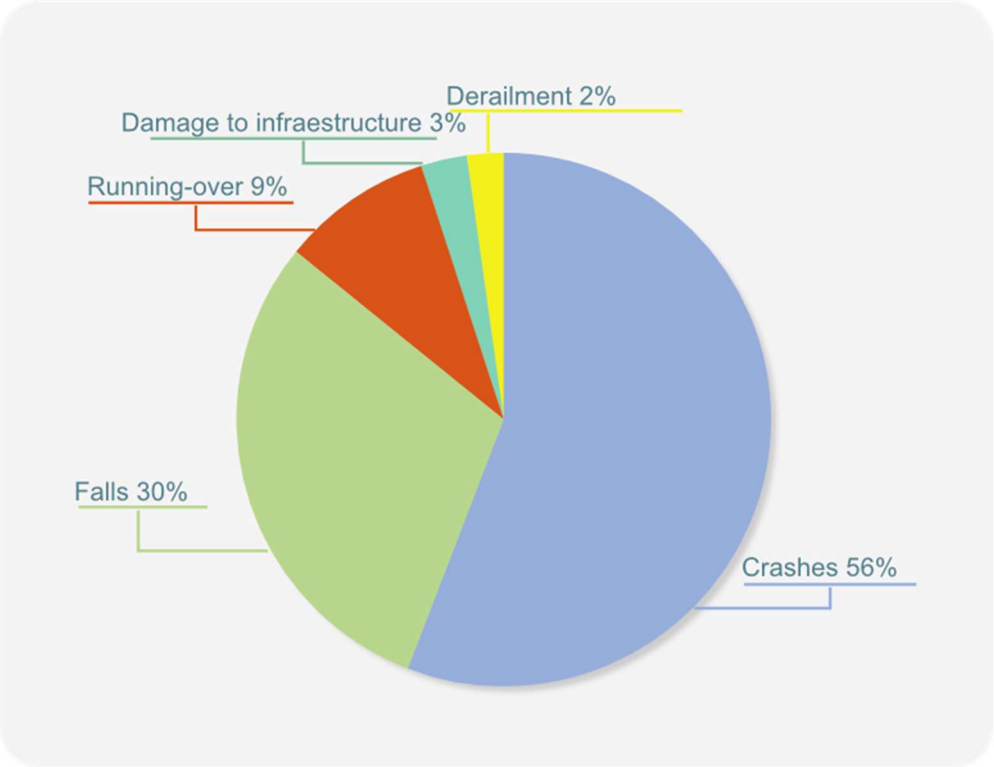
The percentage variation between 2022 and 2024 was 11.7%. Specifically, the percentage difference between 2022 and 2023 was -6.4%, and between 2023 and 2024 it was 19.3%.

Accident tipology

The information provided by the tram entities indicates that, in general, collisions and falls are the most frequent accidents in the 2022–2024 period. The following graphs present the data on the types of accidents reported by the entities in 2022, 2023, and 2024.

In the year 2022, the most frequent accidents were collisions (56%), falls (30%), and run-overs (9%).

Fig. 3: Types of accidents involving trams in Spain, 2022

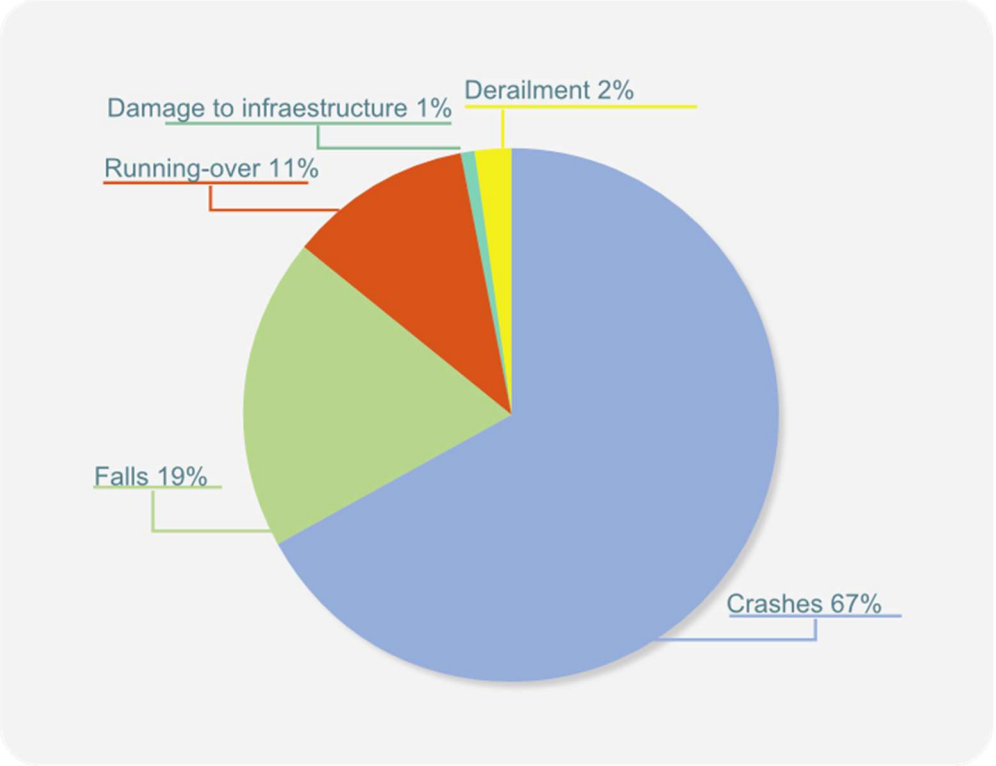


Source: Data provided by collaborating entities within the framework of conviTRAN.

In 2023, the distribution of accident types was the same as in the previous year. However, two relevant changes were observed. On the one hand, collisions increased significantly, rising from 56% in 2022 to 67% in 2023. On the other hand, the percentage weight of falls decreased significantly, dropping from 30% to 19%.

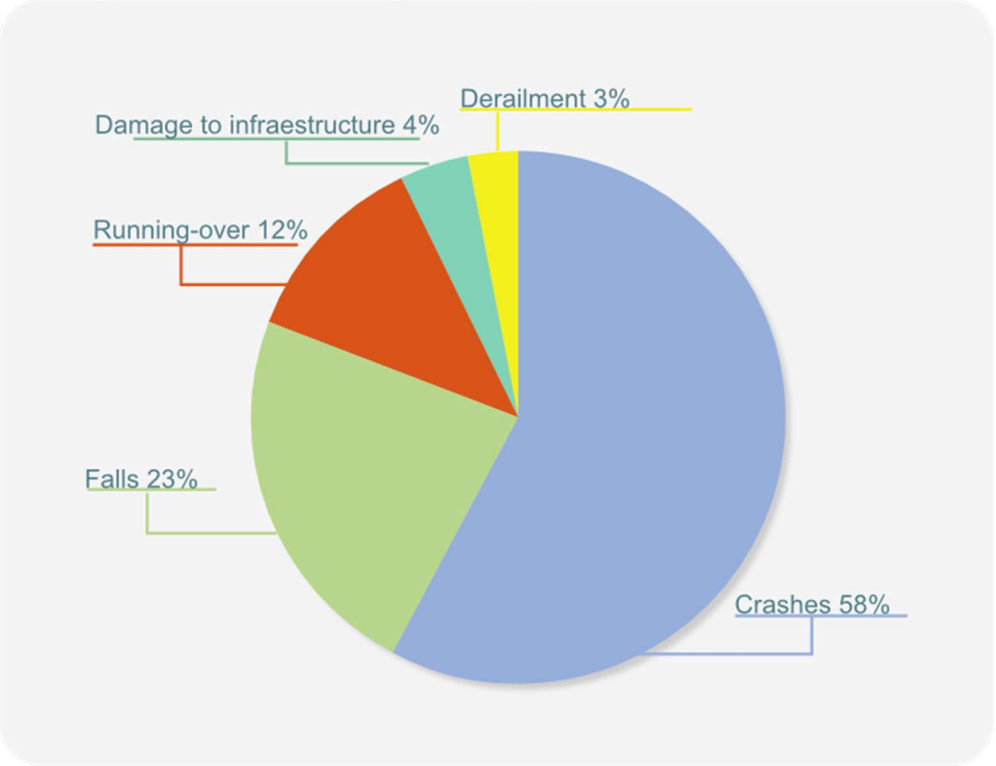
When comparing 2024 data with 2023, a decrease in collisions is noted, dropping from 67% to 58%. In contrast, the number of falls reported by tram companies has increased, rising from 19% to 23% over the same period.

Fig. 4: Types of accidents involving trams in Spain, 2023



Source: Data provided by collaborating entities within the framework of conviTRAN.

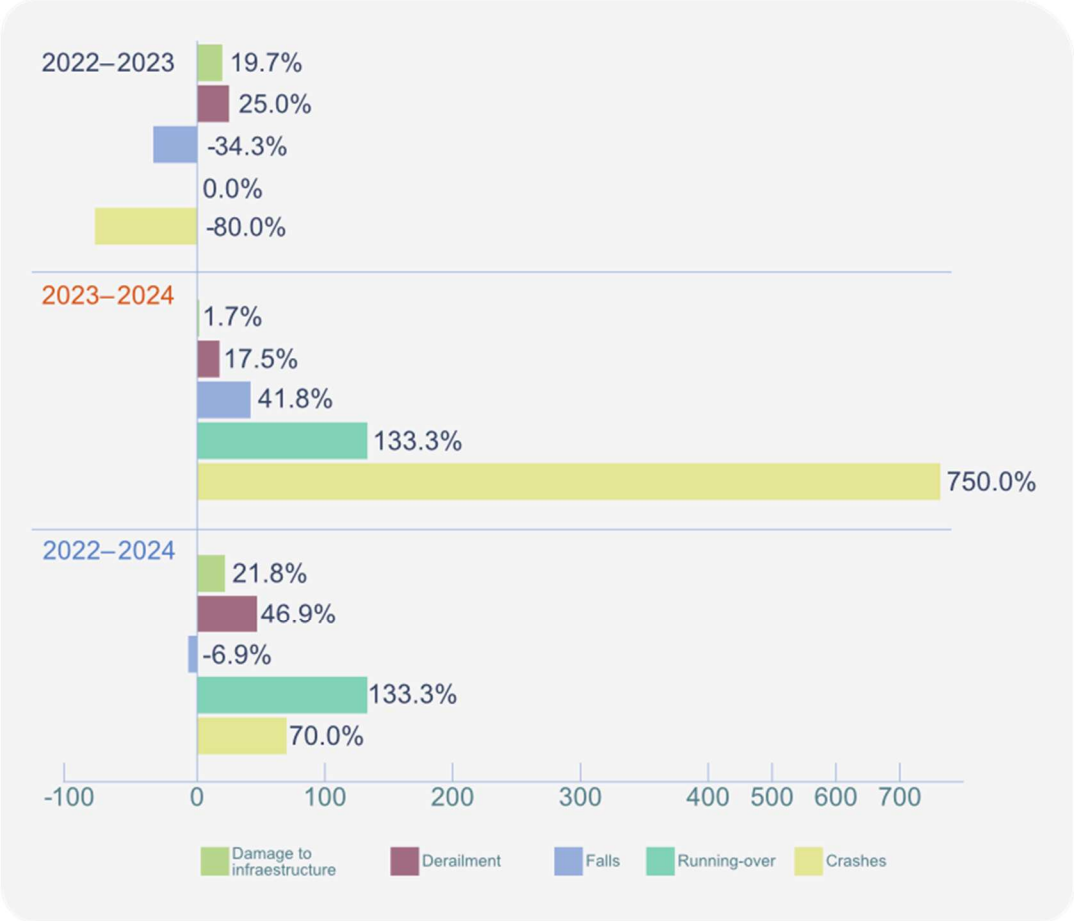
Fig. 5: Types of accidents involving trams in Spain, 2024



Source: Data provided by collaborating entities within the framework of conviTRAN.

In summary, the following figure presents the percentage change in tram accidents in Spain, by type. Between 2022 and 2024, the most significant percentage change was in derailments (which increased by 133.3%). Damage to infrastructure increased by 70%, collisions by 46.9%, and falls by 21.8%.

Fig. 6: Percentage variation in the distribution of types of accidents involving trams in Spain, 2022-2024

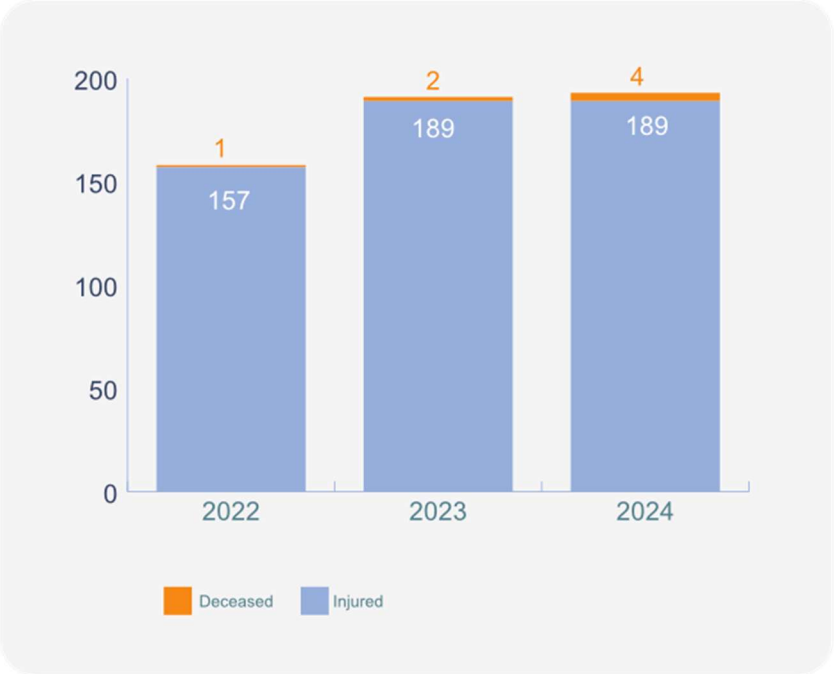


Source: Data provided by collaborating entities within the framework of conviTRAN.

Victims

The information provided by the Spanish tram entities shows that, overall, the number of victims has increased in the 2022–2024 period. By type of victim, data indicate that the most frequent victims are the injured. The following graph presents the data on the types of victims reported by the entities in 2022, 2023, and 2024.

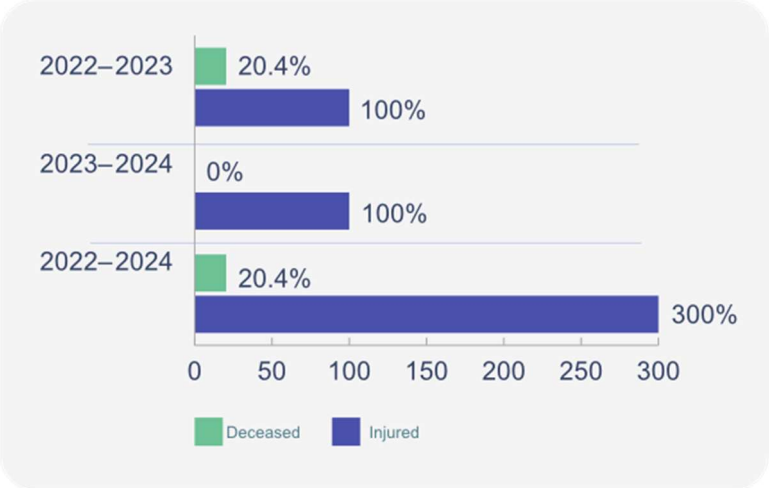
Fig. 7: Evolution of victims in accidents involving trams in Spain, 2022-2024



Source: Data provided by collaborating entities within the framework of conviTRAN.

In summary, the figure below illustrates the percentage variation of victims in tram-related accidents reported in Spain, categorised by type. From 2022 to 2024, the most notable change was a 300% increase in fatalities. Additionally, the number of injuries resulting from accidents in tram environments rose by 20.4% during this period.

Fig. 8: Percentage change in the distribution of types of victims in accidents involving trams in Spain, 2022-2024



Source: Data provided by collaborating entities within the framework of conviTRAN.

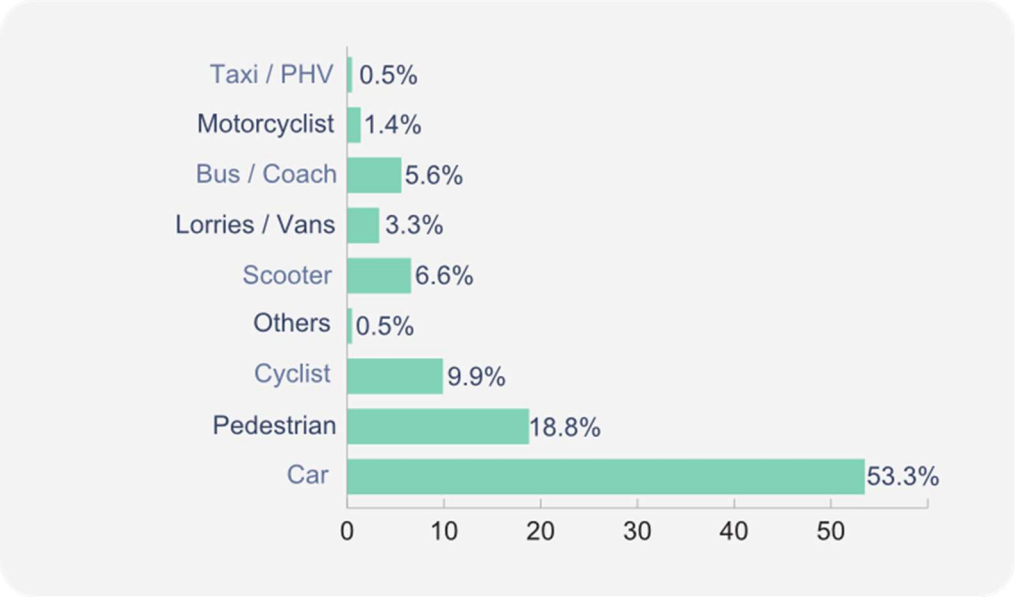
Vehicles and people involved in accidents

The information provided by the entities indicates that, in general, accidents between trams and automobiles are the most frequent in the 2022–2024 period. The following graphs present the types of vehicles and/or people involved in accidents with trams data in 2022, 2023, and 2024.

In 2022, accidents involving automobiles were the most frequent (53.5%), followed by those involving pedestrians (18.8%), cyclists (9.9%), scooters (6.6%), and buses and/or coaches (5.6%).

In 2023, the distribution of vehicle types and the people involved in tram accidents remained consistent with the previous year. However, two notable changes were observed. First, the number of automobile accidents increased, rising from 53.5% in 2022 to 58.6% in 2023, rising from 53.5% in 2022 to 58.6% in 2023. Similarly, pedestrian accidents also increased, from 18.8% in 2022 to 23.3% in 2023. Conversely, the proportion of cyclists involved in these accidents decreased, dropping from 9.9% in 2022 to 6.7% in 2023.

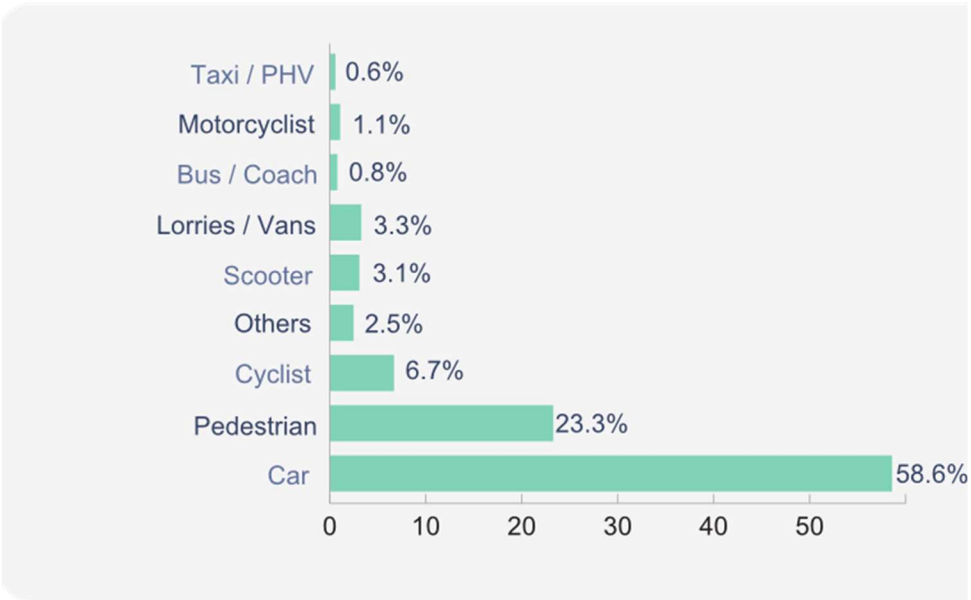
Fig. 9: Vehicles and persons involved in accidents with trams in Spain, 2022



Source: Data provided by collaborating entities within the framework of conviTRAN.

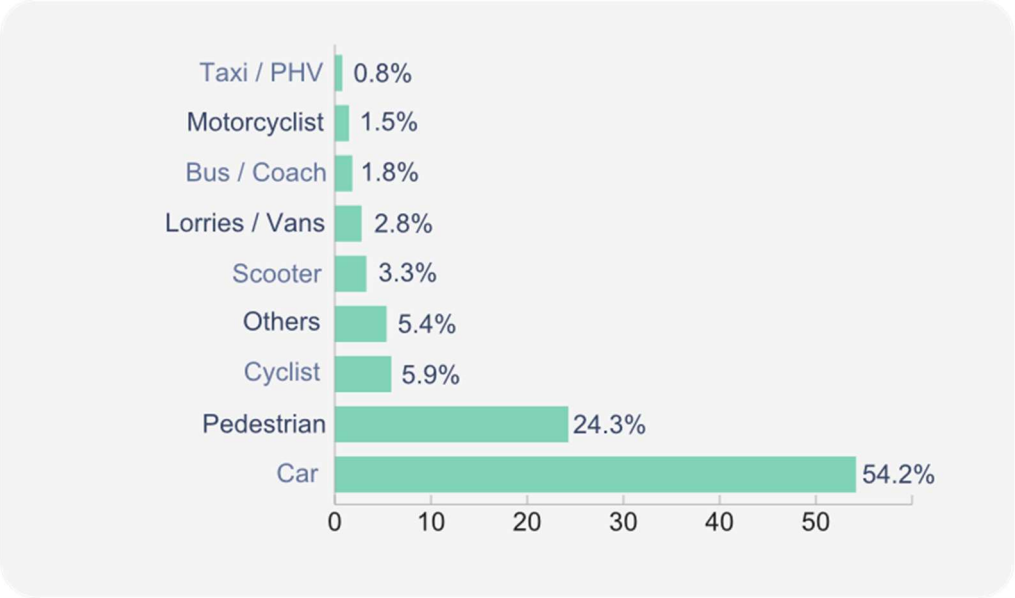
When comparing 2024 and 2023 figures, a slight decrease is observed in accidents involving automobiles, pedestrians, and cyclists. However, there is a notable increase in accidents involving other types of vehicles, such as those used by people with reduced mobility and city council vehicles. Specifically, accidents involving these vehicles rose from 2.5% in 2023 to 5.4% in 2024.

Fig. 10: Vehicles and persons involved in accidents with trams in Spain, 2023



Source: Data provided by collaborating entities within the framework of conviTRAN.

Fig. 11: Vehicles and persons involved in accidents with trams in Spain, 2024



Source: Data provided by collaborating entities within the framework of conviTRAN.

In conclusion, the following figure shows the percentage change in the distribution of vehicle types and people involved in tram accidents in Spain. The most notable change during this period is seen in accidents involving other vehicles, including those related to individuals with reduced mobility and city council vehicles. Specifically, accidents involving taxis increased by 63.4%, those involving pedestrians increased by 29.4%, and those involving motorcyclists by 9%. Conversely, the involvement of other vehicles in tram-related accidents decreased during this timeframe.

CONCLUSIONS

The results regarding accident rates gathered from tram companies for the 2022-2024 period reveal several key insights:

- There has been a general increase in accident rates within tram environments, with a significant rise observed between 2023 and 2024.
- While injuries are the most common outcome, the notable increase in fatalities is particularly concerning.
- Collisions are the most frequent type of accident, yet derailments are the fastest-growing category, followed closely by incidents of infrastructure damage.
- Accidents involving automobiles are the most prevalent, followed closely by those involving pedestrians. However, the higher percentage growth has been in accidents involving other types of vehicles, such as those used by individuals with reduced mobility or city council vehicles.

This overall increase in tram accident rates in Spain is related to a rise in tram circulation and interaction with other participants in the mobility ecosystem within metropolitan areas.

To prevent accidents in tram areas, it is essential to consider the human factor. This term encompasses the actions, omissions, skills, and psychological states of individuals—whether they are driving a motor vehicle, riding a bicycle, or walking—that contribute, directly or indirectly, to the occurrence of accidents or the worsening of their consequences. In tram environments, this includes distractions, failure to yield the right of way, violations of traffic signs, and platform invasion.

A key element highlighted by the results is that a significant portion of accidents involves more vulnerable road users, such as pedestrians, cyclists, passengers, and users of micro-mobility devices.

While the data shows a relatively low incidence of tram accidents, we should not underestimate road safety.

In the near future, we expect more people to utilize the tram transportation system, resulting in significant expansions of tram lines, which will increase the risk of accidents.

These findings lead to the formulation of recommendations aimed at improving safety in areas where trams operate.

Measures should focus on enhancing road safety by reducing or eliminating risks and incorporating educational initiatives.

Additionally, the results underscore the importance of ensuring that the **conviTRAN** project remains stable over time. Regular collection of statistical data will enable monitoring of trends in tram accidents and incidents across Spain.

CONVITRAN

LA CIUDAD CON TRANVÍAS

Modelo de convivencia de movilidad segura

In collaboration with:

euskotren · FGV · 1912 FERROCARRIL DE SÓLLER · metro Málaga · metroligero oeste · metrotenerife · Metropolitano de Granada · Junta de Andalucía · metros ligeros de madrid · tram · Tranvía de Murcia · TRANVIA PARLA · tranvía zaragoza

Fundación de los FERROCARRILES Españoles

In collaboration with:

INICIATIVAS SOCIALES OFESAUTO

www.ffe.es/convitran/