REPORT

December 201

SERVICE TECHNIQUE DES REMONTÉES MÉCANIQUES ET DES TRANSPORTS GUIDÉS

# Annual report on the fleet, traffic and tramway operating events

## – Year 2016
## – evolution 2007 – 2016

Technical department for ropeways and guided transport systems (STRMTG)
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## History of document versions

| Version | Date | Comments |
|---|---|---|
| **1.0** | 22/12/2017 | Version 1 |
| | | |
| | | |
| | | |

## Case followed by


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## Intranet reference(s)

*http://www.strmtg.developpement-durable.gouv.fr/rapports-d-accidents-tramway-r137.html*

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# INTRODUCTION

The purpose of this report is to present the results from the use of the national database of tram events for 2016, as well as the developments in accidentology over the last ten years. This database is populated by declarations of accidents provided by operators.

The “tram” term covers systems on rails and rail-guided systems on tyres (mechanical guidance).

The statistical analysis is not intended to make a comparison between networks or present a classification based on safety levels. The different configurations, in terms of number and traffic of road crossings , as well as in terms ofthe urban structure would make such a comparison meaningless.

On the other hand, a comparative analysis of the accidentology of the various predefined and codified urban layouts, and its evolution over the period 2007-2016 is one of the main subjects of the report.

The basic developments that occurred in 2016 have allowed to validate the data of the previous years, mainly for the following data :

- signalling and layouts of gyratories and roundabouts with traffic lights (in collaboration with CEREMA)
- signalling and layouts of road junctions with turning movements.

We can thus present detailed analyses of these configurations in this report.

Similarly,any discrepancies in this report with the graphs in previous reports will be explained in this report, if need be; most of these result from verifications carried out by the operators and the STRMTG continuously on the data with a view to constantly enhance reliability.

# 1 - Reminder on the database construction

## 1.1 - Data concerning events

The database of tram events contains the following main information for the events:

- Network identification (city + line)
- Type of event, based on a predefined list of undesirable events
- Details of the event, mainly for the passenger events and collisions between trams and details of the third party if need be
- Temporal position (date and time)
- Geographical situation (laneV1/V2, location of event via the section number)
- Configuration of the site of the event, using a predefined coding system
- Environment of the event (adherence, degraded operation, visibility, etc.)
- Bodily (victims) and material consequences, duration of disruption of operation
- Record of system parameters (according to driver’s statement or data from tachymetric system, tram number)
- Police report and intervention of emergency services(yes/no)
- Circumstances of the event (summary of event, behaviour of the third party, aggravating factors, etc.)
- Follow-up on actions undertaken (investigation in progress, planned modification, action plan,etc.)

## 1.2 - Description of the networks via the codification of tram lines

The tram event database contains information on description of tram networks by means of codification data.

The codification aims to characterise the various configurations of tram lines in order to have a common descriptive reference system for all lines. It thus makes it possible to analyse events on all networks according to the characteristics of the sites where they occur, the comparison ofthe configurations between them and the identification  ofthe most accident-prone configurations.

The latter thus allows characterising the following configuration categories:

- Station

On-street/off-street section

- Pedestrian/cycle crossing

- Crossroads intersection :

  - ➢ Simple crossing
  - ➢ Turn left/right
  - ➢ Gyratory or roundabout with traffic lights
  - ➢ Resident's access
  - ➢ Mixed-zone entry/exit
  - ➢ Complex junction

For the Intersections, detailed traffic signals are available for eachconfiguration: static signals, light signals on close position of the tracks or before the conflict zone, etc. The possible presence of visual masks and ease of identification of the tram track are also new codified information.

Detailed principles of the new codification can be found in the guide “Codification des lignes de tram, nouvelle édition 2010” available on the STRMTG website.

*It is to be noted that in order to clarify the coding methodology of sections and to update or simplify the layout details, a working group was formed in late 2016, which shall contribute to the development of the tram lines codification guide in early 2018.*

## 1.3 - The adopted principles and definitions

### 1.3.1 - Operators' declarations.

In 2017, we specified the criteria for reporting passenger events and taking into account associated victims, in order to standardise the practices.

It was agreed that any event reported in the record book with the passenger involved, is entered in the database.

The operators continue to enter the information in the database and increase its reliability and manage the codification of their lines and extensions.

In this report we present the operating events for the last 10 years; the configuration-wise event analyses can be analysed for a different time period.

***/!*** *It should be noted that unlike in previous years, since 2014, a network has integrated this passenger event data. As a consequence, the graphs using the data related to passenger events are affected.*

### 1.3.2 - Definitions of victims

It is important to define the concept of victim used by the operators for the declaration of events and given in this report.

A victim (person involved in the event and who is not unharmed) is accounted for if there is an intervention or request for intervention of the emergency services or if there is proof of medical care (if known).The victim is classified under the categories of slightly injured, severely injured or fatal, if the information is available.

Definitions of severely injured and fatal (accepted and used within the European Union)

- Severely injured = hospitalisedfor over 24 hours.
- Fatal = death within 30 days following the event.

These statistical elements about the nature of the victims obviously remains dependent on the information available and “being brought to the knowledge” of the tram operator.

### 1.3.3 - Definition of the network panel

In this report, we distinguish the “pure STPG” networks from mixed networks, particularly for the graphs showing the number of events and collisions per 10,000 km.

This is a linguistic device to allow easy identification of tram networks built and commissioned fully in accordance with the STPG Decree of 2003.

**The “pure STPG” networks are the lines for which commercial operation was launched from 2006 (included) and which have possibly had line extensions.**

In addition, the “mixed” networks are those put in commercial operation before 2006 and may have had extensions authorised in accordance with the STPG Decree or previously.

The part of “pure STPG” networks represents the following production elements:

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Km | 9.48% | 15.31% | 15.07% | 15.19% | 19.01% | 21.02% | 23.90% | 26.05% | 26.10% | 25.60% |
| Journeys | 7.61% | 13.96% | 14.54% | 14.42% | 16.26% | 18.73% | 20.14% | 21.43% | 21.55% | 21.10% |

Table 07b

### 1.3.4 - Definition of serious events, victims of serious events and severe victims

By convention and in accordance with the profession, serious events correspond to one of following criteria:

- serious physical consequences: fatality or serious injury or more than 5 victims,
- significant material damage (including for the third party) or derailment of the tram,
- derailment during commercial operation in a zone shared with third-parties.

Severe victims represent the sum of the injured persons and fatalities.

# 2 - Systems and traffic of the tramnetworks

## 2.1 - Analysed systems and 2016 production data

For accidentology analysis, we have taken into account the network lines appearing in the table below.

| Urban area | Type | No. of lines | Mkm | Mjourneys | Opening | Remarks |
|---|---|---|---|---|---|---|
| Angers | Tram on rails | 1 | 0.9 | 8.98 | 25/06/2011 | |
| Aubagne | Tram on rails | 1 | 0.14 | 2.11 | 01/07/2014 | |
| Besançon | Tram on rails | 2 | 1.06 | 10.85 | 01/09/2014 | |
| Bordeaux | Tram on rails | 3 | 6.44 | 86.32 | 20/12/2003 | |
| Brest | Tram on rails | 1 | 1.07 | 9.42 | 23/06/2012 | |
| Caen | Tram on tyres | 2 | 1.29 | 9.22 | 18/11/2002 | |
| Clermont-Ferrand | Tram on tyres | 1 | 1.08 | 14.97 | 13/11/2006 | |
| Dijon | Tram on rails | 2 | 2.11 | 23.47 | 02/09/2012 | |
| Grenoble | Tram on rails | 5 | 5.26 | 56.77 | 05/09/1987 | |
| Le Havre | Tram on rails | 2 | 1.13 | 13.41 | 12/12/2012 | |
| Le Mans | Tram on rails | 2 | 1.87 | 18.01 | 14/11/2007 | |
| Lille | Tram on rails | 2 | 1.52 | 11.21 | 04/12/1909 | |
| Lyon | Tram on rails | 6 | 6.62 | 92.42 | 18/12/2000 | Line T3 (extension): January 2016 |
| Marseille | Tram on rails | 3 | 1.59 | 23.26 | 01/06/2007 | |
| Montpellier | Tram on rails | 4 | 5.48 | 67.04 | 01/07/2000 | |
| Mulhouse | Tram on rails | 4 | 1.27 | 15 | 12/05/2006 | Including a “Tram-train” line |
| Nancy | Tram on tyres | 1 | 1 | 9.65 | 28/01/2001 | |
| Nantes | Tram on rails | 3 | 5.21 | 71.51 | 07/01/1985 | |
| Nice | Tram on rails | 1 | 1.28 | 29.74 | 26/11/2007 | |
| Orléans | Tram on rails | 2 | 2.41 | 20.92 | 24/11/2000 | |
| Paris/IdF | Tram on rails<br>Tram on tyres | 6<br>2 | 11.49 | 276.32 | 06/07/1992 | Line T6 (extension): June 2016 |
| Reims | Tram on rails | 2 | 0.99 | 13.14 | 16/04/2011 | |
| Rouen | Tram on rails | 2 | 1.46 | 17.31 | 16/12/1994 | |
| Saint-Etienne | Tram on rails | 3 | 1.71 | 22.1 | 01/01/1881 | |
| Strasbourg | Tram on rails | 6 | 5.67 | 68.2 | 26/11/1994 | Extended in 2016 |
| Toulouse | Tram on rails | 2 | 1.63 | 12.24 | 11/12/2010 | |
| Tours | Tram on rails | 1 | 1.26 | 15.74 | 01/09/2013 | |
| Valenciennes | Tram on rails | 2 | 1.77 | 6.35 | 03/07/2006 | |
| **28 urban areas** | | 74 | 74.7 | 1025.68 | | |

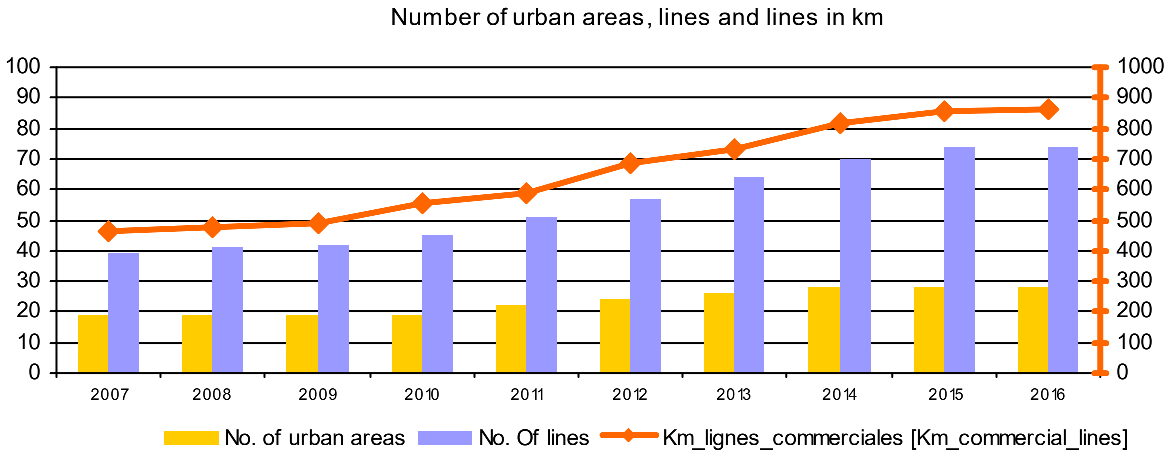
Table 01g

network, new line or extension line opened in 2016 and included in the results

## 2.2 - 2007-2016 evolution

### 2.2.1 - Systems in operation

The evolution of the systems in operation is represented by the diagram below.



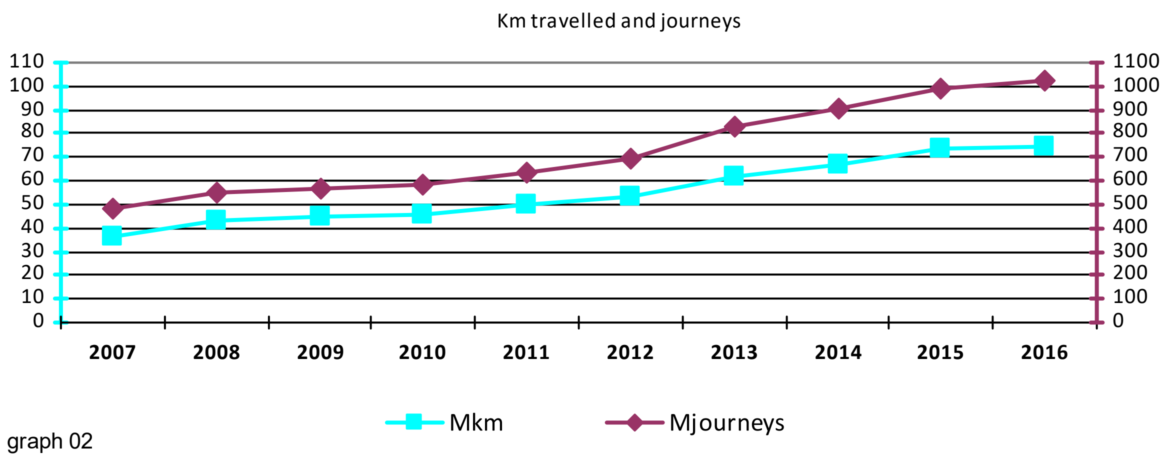

graph 01b

The trams in operation in 2016 are present in 28 urban areas and represent 74 commercial lines including 68 tram on railsand 6 tram on tyres linesIt should be noted that since 2007 the number of commercial lines has almost doubled and that the length of these lines in km has increased by 80%.

The fleet has stabilised somewhat over the last 2 years, even though a few extensions have been put into operation.

### 2.2.2 - Production data

The evolution of production data is represented by the diagram below.




graph 02

The number of journeys and the distance travelled in km has more than doubled since 2007.

The production data also somewhat stabilised over the last 2 years. It should be noted that this year, the number of passengers were more than one billion.

# 3 - Events

## 3.1 - Overall data for 2016

The number of events declared by the operators in the database is 2562 for the year 2016; the table below gives the breakdown of the number of events and victims per category of event, according to the list of undesirable events.

| Events | | |
|---|---|---|
| Type | No. | Victims |
| Fire Explosion | 11 | 0 |
| Panic | 0 | 0 |
| Electrocution | 0 | 0 |
| Derailment | 8 | 0 |
| Passenger event | 1025 | 891 |
| Collision between trams | 3 | 0 |
| Collision with obstacle on track | 29 | 0 |
| Collision with a third party | 1439 | 441 |
| End of track | 5 | 0 |
| Other events | 42 | 13 |
| **Total** | **2562** | **1345** |

Table 03b

It should be noted that 11 Fire Explosion type events (5 in 2015, none in 2014) and 8 Derailment type events (5 in 2015, 8 in 2014) were declared in 2016.

The circumstances of these events are explained in detail in the following paragraph.

## 3.2 - Remarks concerning the events

#### *3.2.1.a - Fire Explosion*

11 fire explosion events were declared in 2016 (5 in 2015) but did not result in any victims:

- eight events related to APS batteries (ground-level power supply)
- six events related to brakes applied with emission of smoke
- an event concerned the ignition (lighting failure) in the rolling stock
- an event concerning the OCL (overhead contact line) power supply cables

#### *3.2.1.b - Derailment*

8 derailment events were reported in 2016 (11 in 2015) but did not result in any victims:

- three derailments (1 on the post-arrival management line, 1 on the line during a reversal operation, 1 on the line following a tram detection failure)
- three tram derailments (1 due to the presence of object in the groove of the rail, 2 with unidentified causes)
- A derailment on line following the presence of objects in the groove of the rail
- A derailment on line following the crossing of closed signal

#### *3.2.1.c - Passenger event*

This event category is the subject of a detailed analysis of victims later in the report, chapter Erreur : source de la référence non trouvéeErreur : source de la référence non trouvée.

No fatal events were reported in 2016.

#### *3.2.1.d - Collision between trams*

3 events (5 in 2015) of this type with no victims involved:

- 2 cases of trams colliding with another tram on the line
- 1 case of tram colliding with another tram stopped at a station.

#### *3.2.1.e - Collision with obstacle on the track*

29 collisions (35 in 2015) with obstacles on the track of different types: trolleys, garbage cans, barrier (construction site or not), site pipes, metal or concrete studs, cobblestones, wooden pieces, iron bars, etc.No victims was involved.

#### *3.2.1.f - Collision with third parties*

A detailed analysis of this category can be found in chapter 5 Collision with third parties of the report.

Here, we explain the circumstances of seven fatal events (4 in 2015), which resulted in the death of 5 pedestrians, 1 cyclist and a motorist.

7 fatal collisions with third-parties:

- 5 collisions with a pedestrian: crossing in front of the trams (4 at the running section, 1 at the road junction), the pedestrian did not see (or did not correctly see) the arrival of the tram.
- 1 case of collision with cycle where the cyclist did not see (or did not correctly see) the arrival of the tram.
- 1 case of collision with a car performing a U-turn and did not see (or did not correctly see) the arrival of the tram.

#### *3.2.1.g - Other events*

42 other events (51 in 2015), causing 4 seriously injured persons:

- 1 person fell from the end of the platform at the station.

- one person was hanging from the tram on the line

Most of the events are of the following nature: vandalism, catenary hanging, breaking of stay ropes, collisions of third party with tram system infrastructure, etc.

The “tram surfing” phenomenon was observed again (2 events, 1 of which involved serious injuries as mentioned previously).

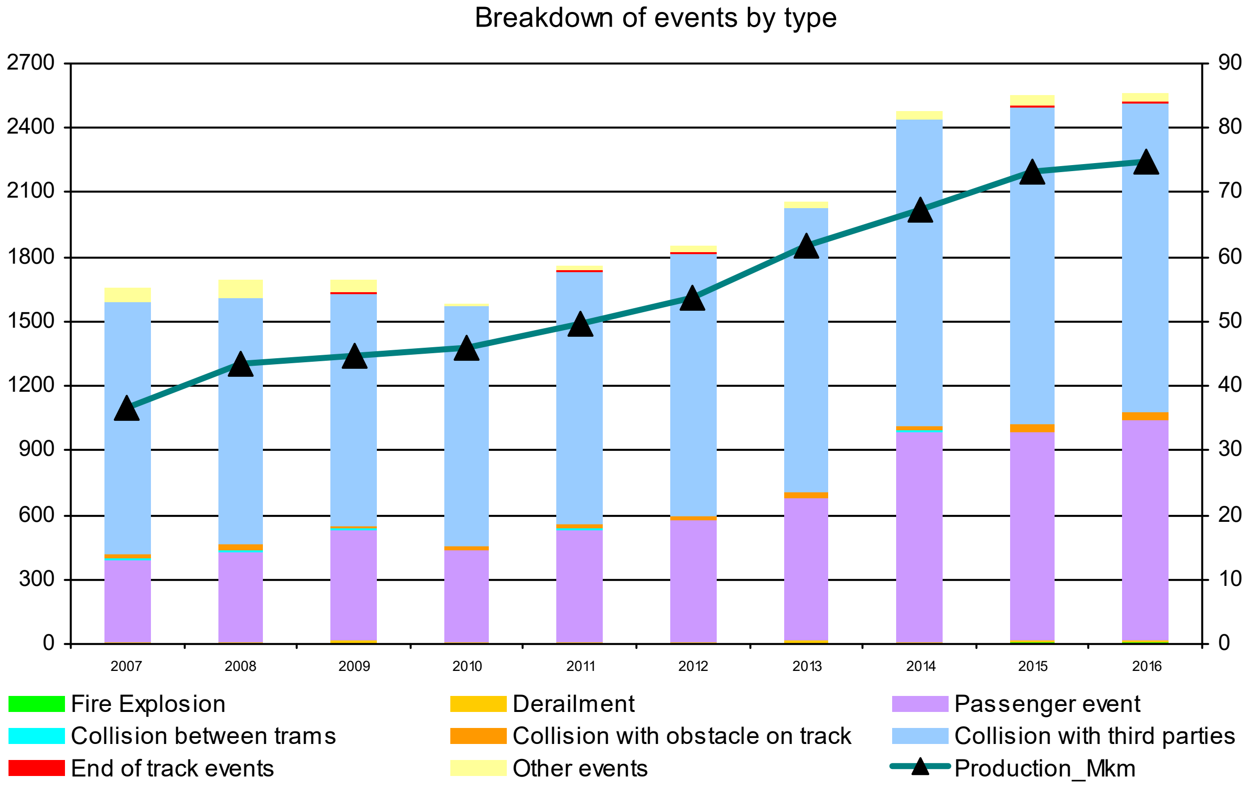
#### *3.2.1.h - End of track*

Five cases of end stops overrun (6 in 2015) were observed, which did not involve any victims (1 can be attributed to the reduced attention of the tram driver).

## 3.3 - 2007-2016 evolution

### 3.3.1 - Breakdown by type of event and evolution of travelled km

The graph below shows the evolution of the number of events over the 2007-2016 period, with breakdown per category, and shows the evolution in the number of travelled km at the same time.



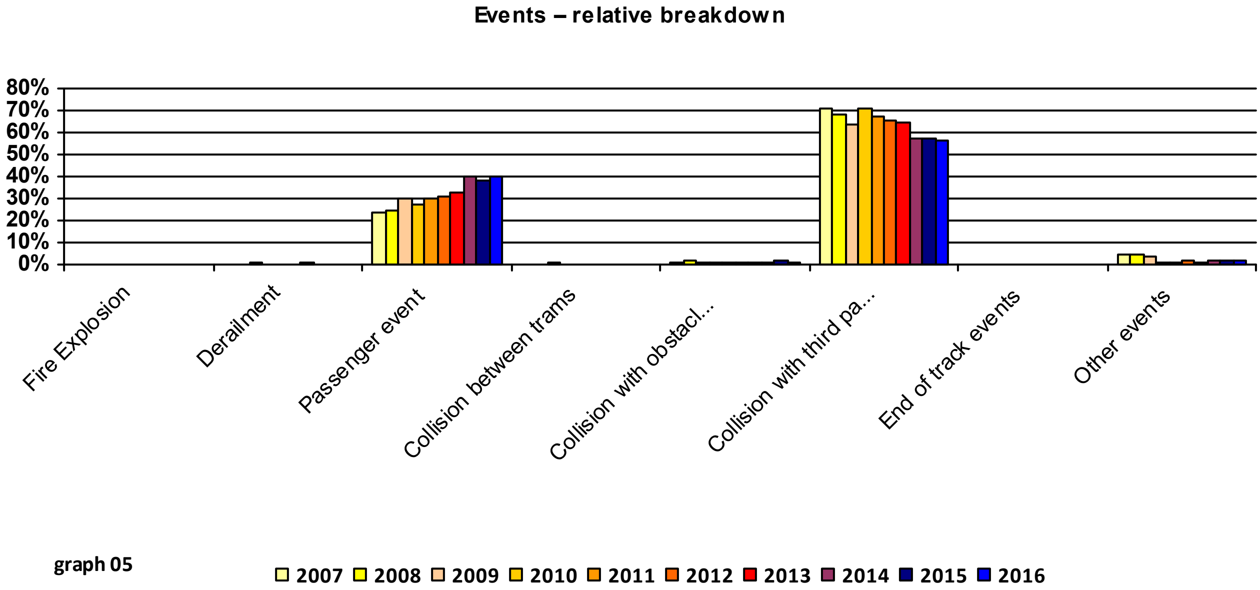

graph 04

Collisions with third parties always show the highest share of events.

***/!\ ****The "rise" that was observed concerning the passenger events since 2014, results from the integration of the passenger events for one network (See 1.3 - The adopted principles and definitions).*

### 3.3.2 - Evolution of the share of events by event type

The graph below shows the evolution of the relative proportion of each event type over the 2007-2016 period, with breakdown per type.




graph 05

Overall, we still observe an upward trend in the proportion of passenger events and a slight reduction in the proportion of collision with third parties.

The proportion of the other types of events remains very low.

There are several explanations put forward by the operators concerning the evolution of the proportion of passenger events:

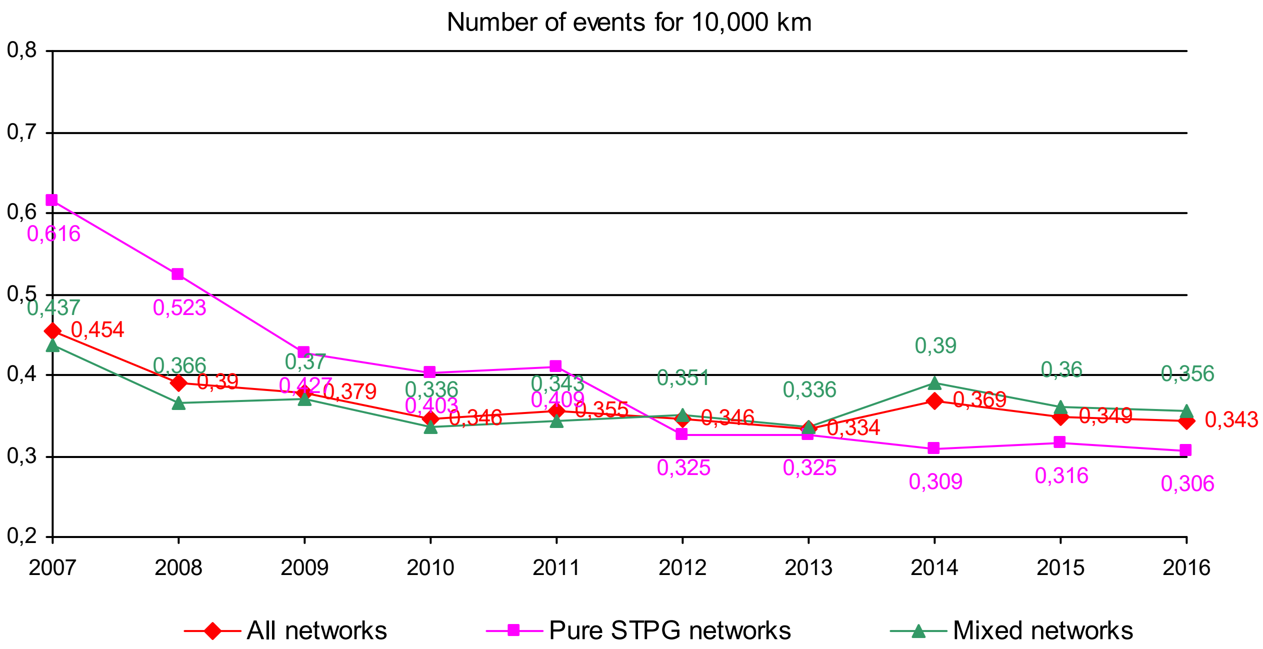
- Observation of a trend of the passengers holding on less frequently to the gripping devices present in the trams in view of a smoother ride in the trams, unlike buses.
- Tendency to claim for compensation
- Observation of an increasingly ageing clientele (considering the accessibility of trams).
- Augmentation des déplacements des modes actifs (piétons / cycles) induisant des freinages d'urgence pour éviter les collisions et ayant pour conséquence des chutes voyageurs. Increase in travel by soft modes (walking/ cycling) leading to emergency braking to avoid collisions and resulting in passengers falling.

This being the case, the majority of severe victims are from collisions with third parties (See 4.2.3.bEvolution of the proportion of severe victims according to the events).

## 3.4 - Monitoring of events indicators

### 3.4.1 - Events per 10,000 km travelled

The number of events per 10,000 km is a common indicator of accident used by tram and bus networks operators . The evolution of the indicator of the number of events per 10,000 km travelled is represented in the graph below.




graph 07b

With respect to the previous analysis report of events declared covering the 2006-2015 period, we have used the comparison between the mixed networks, opened before the STPG Decree of 2003, and the “pure STPG” networks opened fully in accordance with the STPG Decree *(refer to 1.3 - The adopted principles and definitions).*

**/!** As the panel of networks constitutes a modification since the previous report, the indicated ratios are not comparable with the “STPG lines” and “conventional lines” ratios *used in the reports prepared prior to the period 2006-2015.*

We observe that the ratio of events with 10,000 km for the “pure STPG” networks tends to stabilise and remains clearly below that of the mixed networks since 2014.

In addition, given the inclusion of the passenger events of a "mixed" network, , the upward trend in the indicator must be tempered for all networks and for mixed networks between 2013 and 2014.

### 3.4.2 - Comparison with buses

As a guideline, we were able to get the bus accident rate data for 5 typical tram networks. The events taken into account for buses are almost the same as those for trams, mostly collisions with third parties and passenger events.

We get the following table for the 5 networks being considered (events per 10,000 km) :

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| Bus | 0,80 | 0,80 | 0,79 | 0,73 | 0,67 | 0,67 | 0,72 |
| Tram | 0,39 | 0,39 | 0,34 | 0,34 | 0,42 | 0,38 | 0,39 |

Table 06e

he tramway maintains a ratio to its advantage, in comparison with the bus.

# 4 - Victims

## 4.1 - 2016 data

### 4.1.1 - All events victims

The table below provides details for the events of 2016, the breakdown of the number of victims per category according to the event type. A total of 1345 victims has been recorded.

| Event | Total victims | Victims % | Slightly inj. third-parties | Severely inj. third-parties | Third-party fatalities | Slightly inj. passengers | Severely injured passengers | Passenger fatalities |
|---|---|---|---|---|---|---|---|---|
| Fire Explosion | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 |
| Panic | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 |
| Electrocution | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 |
| Derailment | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 |
| Passenger event | 891 | 66,2% | 0 | 0 | 0 | 879 | 11 | 0 |
| Collision between trams | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 |
| Collision with fixed obstacle | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 |
| Collision with a third party | 441 | 32,8% | 279 | 44 | 7 | 111 | 0 | 0 |
| End of track event | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 |
| Other event | 13 | 1,0% | 6 | 3 | 0 | 4 | 0 | 0 |
| **Total** | **1345** | | **285** | **47** | **7** | **994** | **11** | **0** |

Table 03a

Please note the proportion of passenger victims in the victims of collision with third parties: they constitute 25 % of the victims of collision. This figure is higher with respect to previous year (23% in 2015).

**The collisions with third-parties are more severe than the passenger events as the former reports 51 severely injured victims (including 7 fatalities).**

### 4.1.2 - Breakdown of the victims of passenger events by type

| Details of passenger event | Victims of passenger events | No. of passenger events |
|---|---|---|
| Falls in the tram | 627 | 683 |
| Falls from the tram during travel | 2 | 2 |
| Falls from the tram at the station | 56 | 69 |
| Falls from the platform | 38 | 47 |
| Trapping in the tram | 99 | 144 |
| Dragged by the tram | 10 | 10 |
| Not defined | 58 | 69 |
| **Total** | **890** | **1024** |

Table 10e

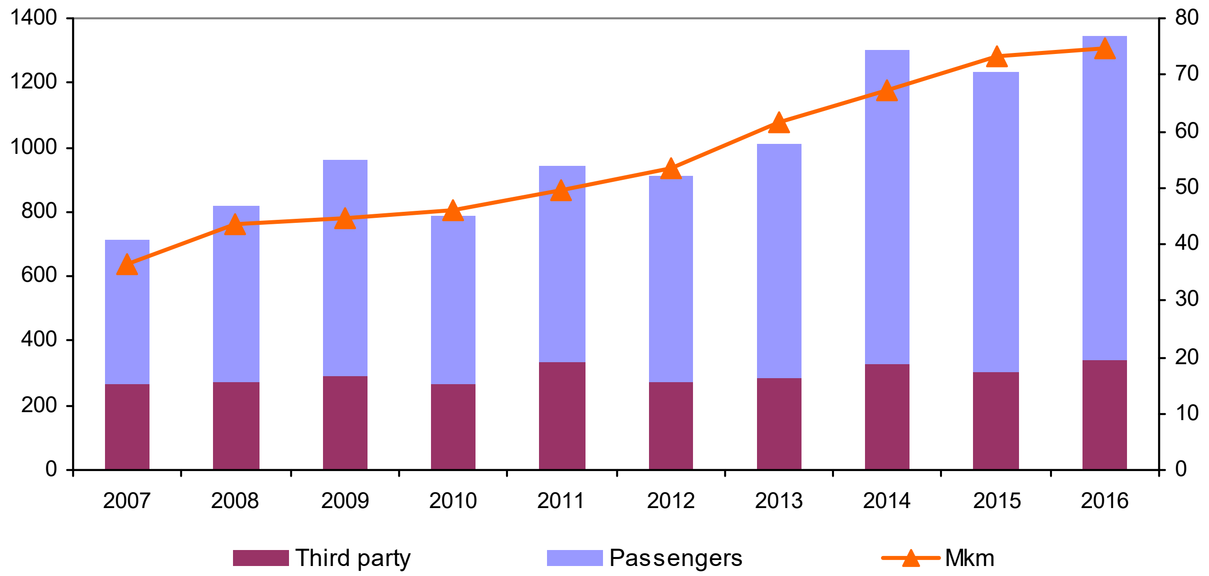
Passenger victims in passenger events are essentially concerned by falls in the train.

## 4.2 - 2007-2016 evolution

### 4.2.1 - Passenger and third party victims

The graph below shows the evolution of the number of third party and passenger victims over the 2007-2016 period, and shows the evolution in the number of travelled km at the same time.

Km travelled and proportion of the third party and passenger victims




graph 22

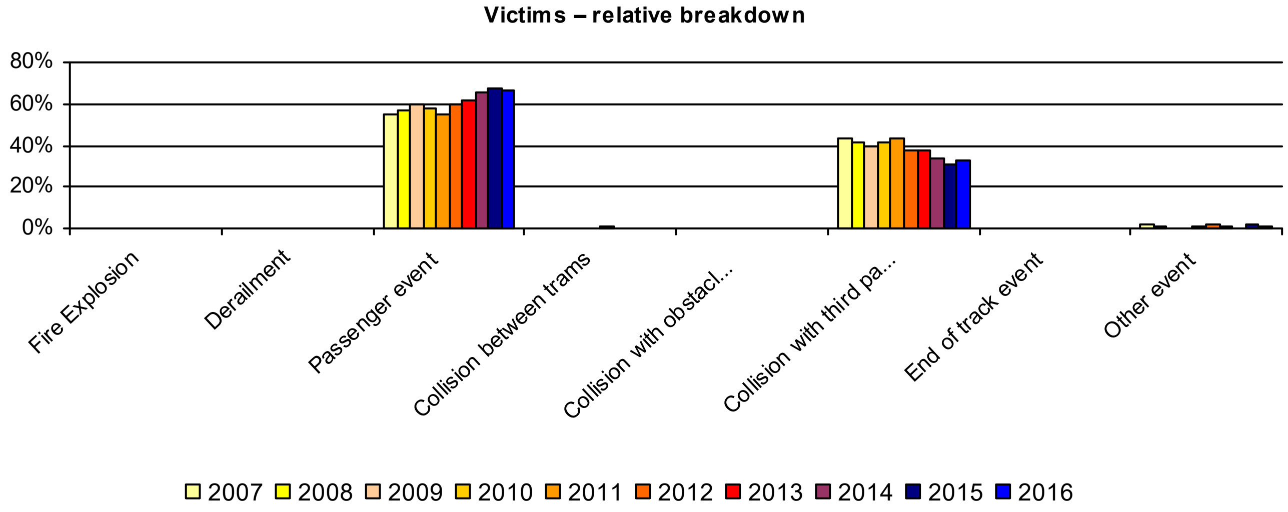
We observe that the passenger victims represent the greatest proportionof victims, with a proportional overall upward trend (see explanations put forward in 3.3.2.).Please also note the presence of passenger victims for collisions with third parties.

This also comes from procedures of reporting passenger events that are generally related to the existence of a victim, contrary to collisions with third party that can end in material consequences alone.

We would like to emphasise that the significant increase in distance (km) travelled over the past 10 years has not resulted in an increase in the number of collisions with third parties.

### 4.2.2 - Evolution in the proportion of victims according to the type of event

The graph below shows the change in the relative proportion of victims during the period 2007-2016, with a breakdown according to the event type.




graph 23

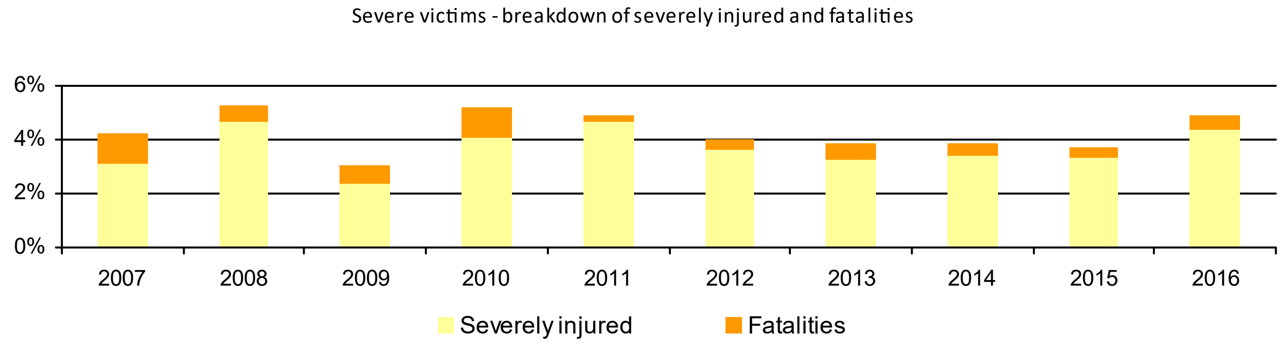
Over the last five years, we have observed an overall increase in victims of passenger events and a slight decrease in the proportion of victims of collisions with third parties.

This trend should be correlated with the change in the number of passenger events and the number of collisions with third parties reported in 3.3.1 and with the reporting of passenger events of the network that were not reported earlier.

## 4.2.3 - Severe victims

It is to be recalled that the severe victims comprise severely injured individuals and fatalities *(refer to 1.3The adopted principles and definitions).*

### *4.2.3.a - Increase in the proportion of severe victims*

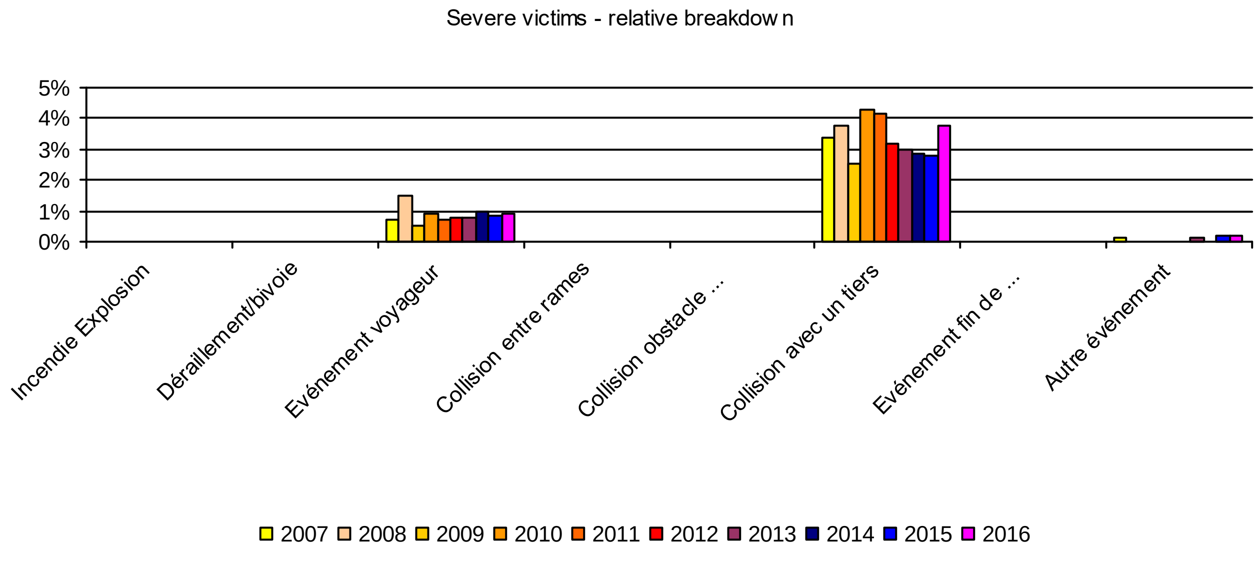



graph 25

Despite a low proportion of severe victims (less than 5% of all victims in 2016), a noticeable increase can be observed with respect to the previous year.

***It should be remembered that the statistical elements about the nature of the victims remain dependent on the information available and brought to the knowledge of the tram operator.***

### *4.2.3.b - Evolution of the proportion of severe victims according to the events*



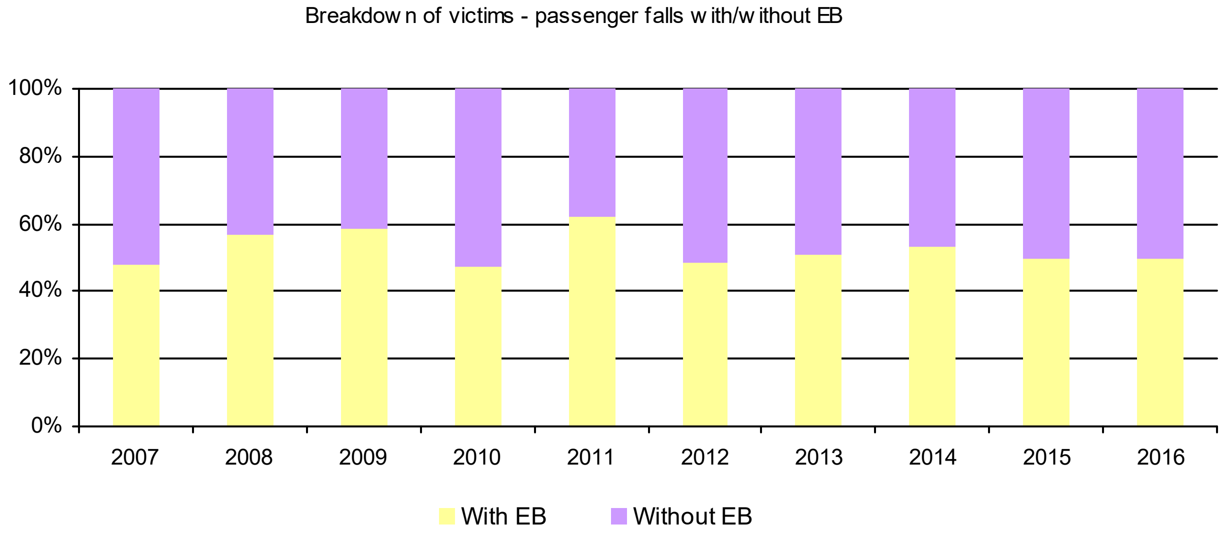

graph 24

Collisions with third parties remain the type of event generating the most severe victims. The details of the noticeable increase observed in 2016 are given later.

### 4.2.4 - Evolution of the proportion of victims of falls related to EB by the driver

The graph below shows the evolution of the proportion of passenger victims of fall events during the period 2007-2016 which is associated with an emergency braking initiated by the tram driver (Controller handle action).

The events taken into account are collisions with third-parties and passenger fall events.




graph 26

Over the last 5 years, we can observe a trend towards the stabilisation of the proportion of victims caused by a event of emergency braking by the driver.

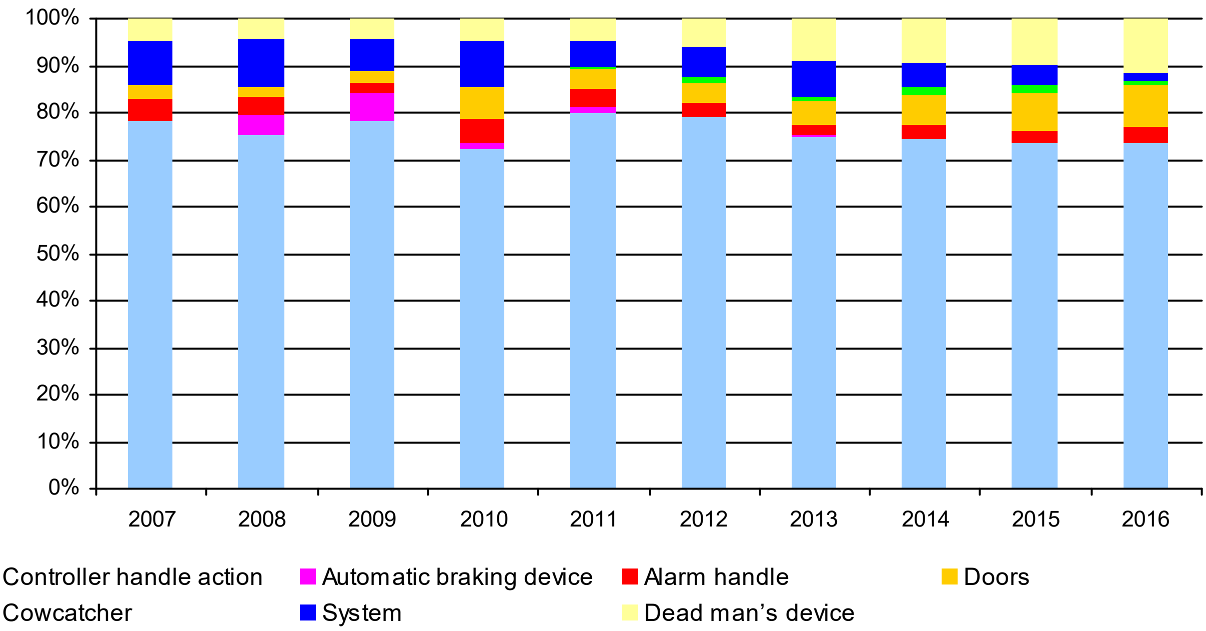
### 4.2.5 - Evolution of the proportion of passenger victims according to the nature of the emergency braking

It seems interesting to analyse, using the graph below, theevolution of the breakdown of the passenger victims, for all the events, according to the nature of the emergency braking, while this analysis is dependent on the accuracy provided by operators in their declared events.

We have identified six categories of emergency braking whose significance is given below:

- Controller handle action: includes all the emergency braking by the tram driver andinitially caused by traffic in urban areas. For the most part, it pertains to the actions made actively by tram drivers and designed to avoid a collision with third parties.
- Automatic braking device (or Automatic Train Protection - DAAT): some networks with specific configurations have "automatic braking device of trains" for example in tunnels or on single track.The networks with this device have been in commercial operation since 2008. The largest number of emergency braking occur during the testing period (2008-2009).
- Alarm Handle: refers to the device available to passengers; this device is only active when tram is leaving the station.
- Doors: is the emergency braking caused by opening doors, either because of travellers (forcing) or due to maladjustment of doors' system.
- Cowcatcher: related to emergency braking caused by the detection of obstacle on the line and cause the falling of the cowcatcher device.
- System: refers to the technical malfunctions encountered on the rolling stock and leading to emergency braking.The reports provided by the operators do not allow their nature to be defined accurately.
- Dead man's device: corresponds to the absence of activation of the dead man's switch by the driver, resulting in emergency braking when the time-out is exceeded.

Passenger victims breakdown for all events by EB cause




graph 27

**Driving actions remain the main cause of passenger victims of emergency braking, with a rate that is still higher than 70%. However, other causes are emerging like the doors or dead man**

**device emergency braking (also to be correlated with the declaration of passenger events of a network since 2014).**

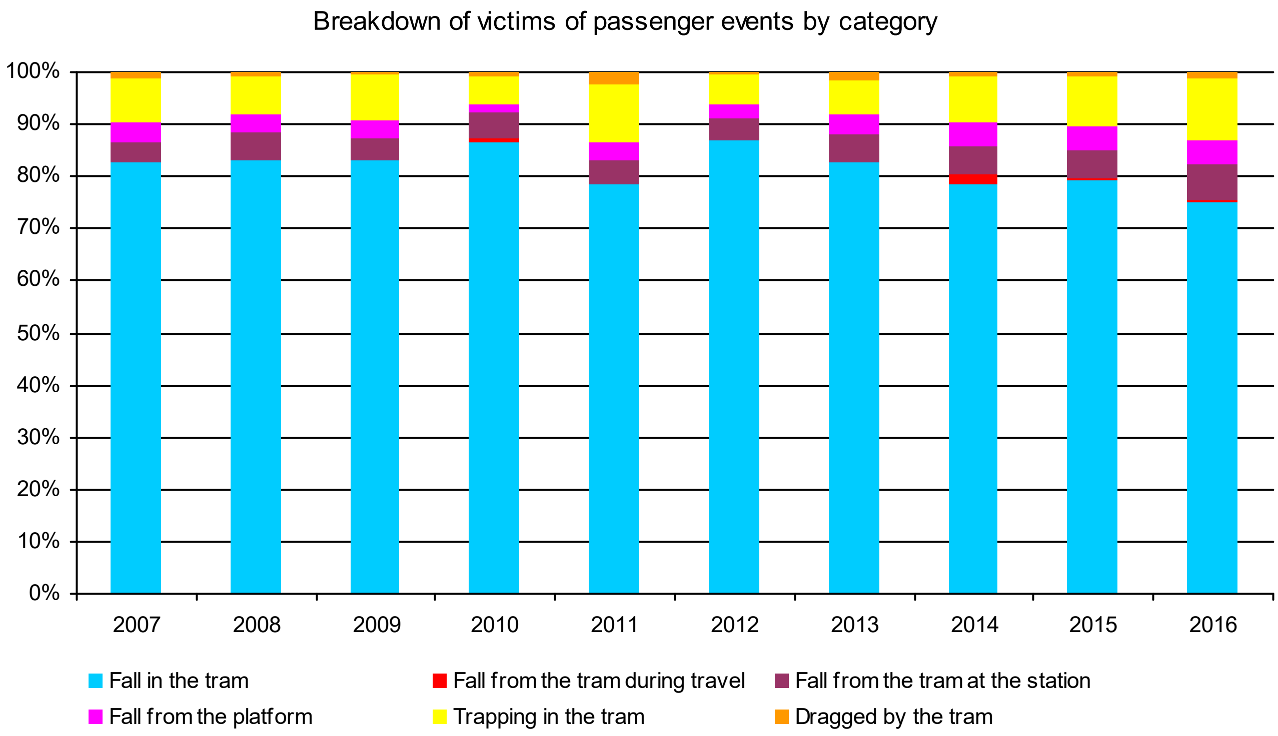
We observe that the passenger victims related to the dead man's device, a cause identified by the operators since 2006, represent more than 10% of EB victims for 2016. It should be noted that the origin of the lack of activation of the dead man device remains unclear. They may be related to the improper handling of the tram driver, his drowsiness or his cognitive overload.

The proportion of the victims related to the automatic braking device o rsystem, varies from one year to another depending on the occurrence of problems and / or resolution (and as mentioned above, the accuracy of the event declarations from operators).

Additionally, the proportion of severe victims related to an emergency braking (all EB together) amongst all passenger victims is very low; it lies between 0% and 2.61% during the period 2007-2016 (0.8 % in 2016). By removing the "Controller handle action" EB, this proportion falls to a value between 0% and 0.56% (0.2 % in 2016).

## 4.2.6 - Evolution of the proportion of victims of passenger events per category

The graph below shows the evolution over the 2007-2016 period in the proportion of passenger victims per passenger event category.




graph 15b

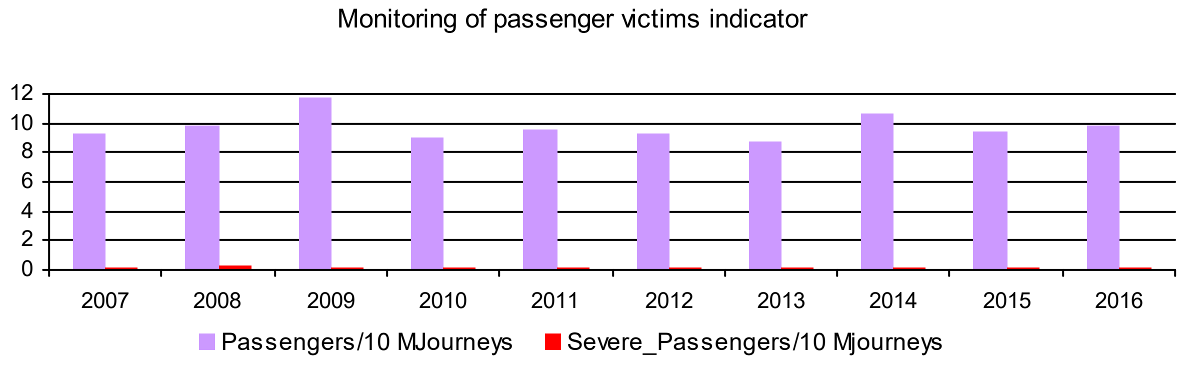
Overall, we observe that falling in the train remains the main cause of the victims of passenger events: the proportion of the victims related to a fall in the train has varied slightly over the last 10 years.

Trapping in the tram and the associated victims also increased significantly. A large part of these trappings are observed on one network and one identified rolling stock.

## 4.3 - Monitoring of victims indicators

Previous indicators but now calculated for the severe victims remain in the same proportions with respect to all victims (1 to 100 passengers and 1 to 10 for the third parties).

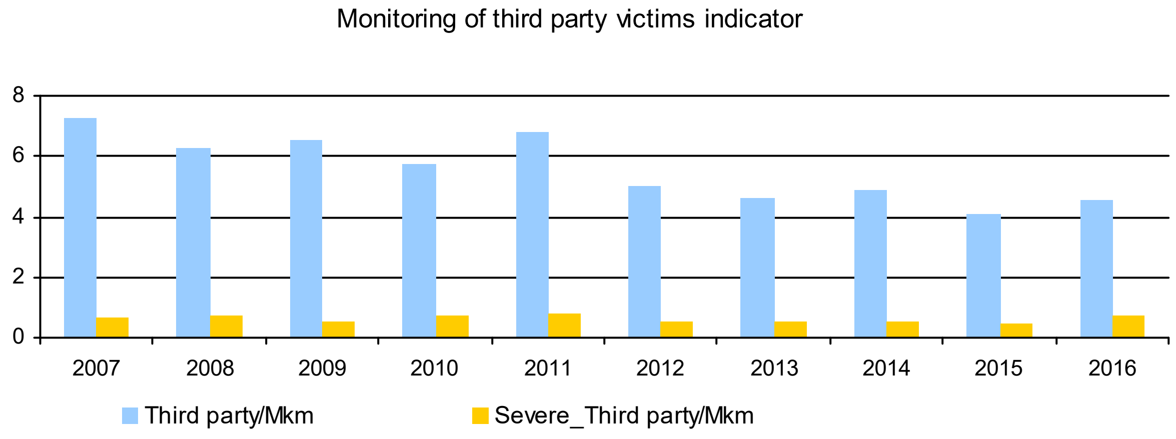
### 4.3.1 - Passenger victims per 10 million journeys




graph 30e

We observe that the proportion of severe victims remains very low over the period without a specific trend.

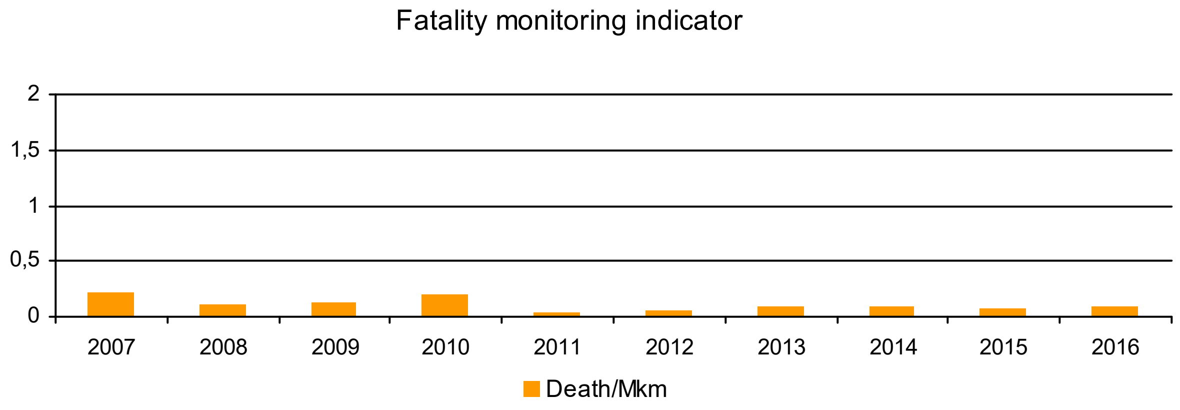
### 4.3.2 - Third-party victims per 1 million km




graph 30d

The slight decrease regarding third-party victims tends to confirm.

### 4.3.3 - Fatalities per 1 million km




graph 30

It is difficult to identify a trend in the indicator for deceased victims due to its small figures. Nevertheless, it remains at a very low level.

# 5 - Collision with third parties

## 5.1 - 2016 data

### 5.1.1 - Number of collisions and victims by type of third-party

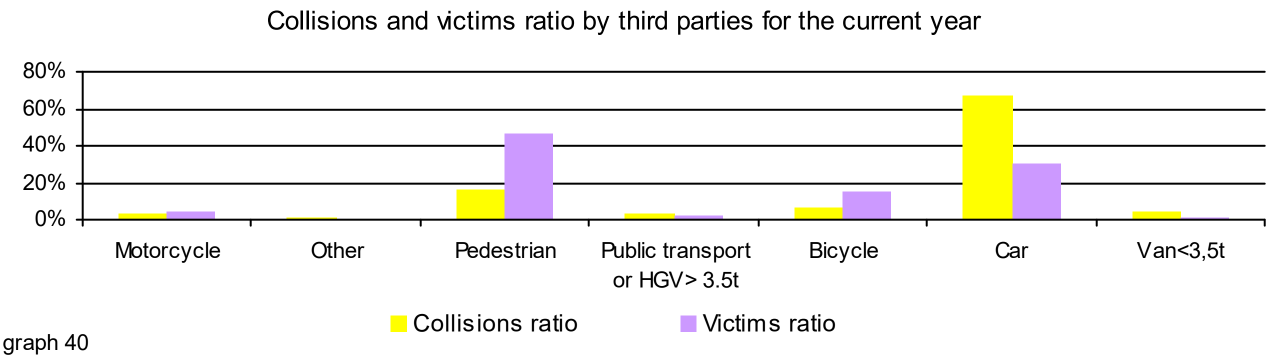
| | Third party | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Motorcycles | Other | Pedestrian | Public transport or HGV>3.5t | Bicycle | Car | Van <3.5t | Passengers | TOTAL |
| Collisions with a third-party | 49 | 10 | 230 | 43 | 87 | 964 | 56 | | 1439 |
| Victims | 13 | 1 | 154 | 6 | 51 | 101 | 4 | 111 | 441 |

Table 18a

With 1439 events in 2016, collisions with third parties represent 56.2% of all reported events (2562 events).

As regards the victims of collisions with a third-party, which number 441, they can be broken down into 330 third-party victims (24.3% victims in all events) and 86 passenger victims (6.3 % victims in all events) for a total of 1353 victims.

### 5.1.2 - Ratio of collisions and third-party victims according to the type of third-party




graph 40

Collisions with private cars account for vast majority of cases; **collisions with pedestrians, which are far fewer, however, causes the largest number of victims.**

## 5.2 - 2007-2016 evolution

### 5.2.1 - Breakdown of collisions according to third parties

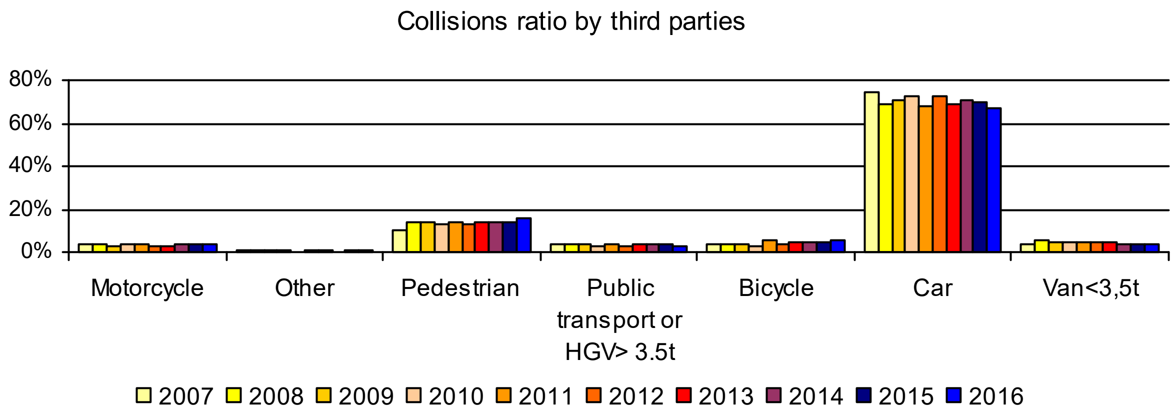
#### *5.2.1.a - Data table*

| Third party | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Motorcycles | 40 | 48 | 26 | 41 | 45 | 35 | 38 | 47 | 54 | 49 |
| Other | 7 | 11 | 7 | 8 | 4 | 7 | 14 | 5 | 14 | 10 |
| Pedestrian | 119 | 155 | 154 | 148 | 169 | 153 | 183 | 198 | 209 | 230 |
| Public transport or HGV>3.5t | 46 | 41 | 36 | 35 | 40 | 35 | 55 | 55 | 48 | 43 |
| Bicycle | 40 | 41 | 39 | 31 | 62 | 50 | 56 | 63 | 72 | 87 |
| Car | 875 | 785 | 763 | 808 | 806 | 883 | 911 | 1004 | 1027 | 964 |
| Van <3.5t | 47 | 67 | 54 | 47 | 54 | 54 | 64 | 48 | 48 | 56 |
| **Total** | **1174** | **1148** | **1079** | **1118** | **1180** | **1217** | **1321** | **1420** | **1472** | **1439** |

Table 19f

The number of collisions with a third-party showed a downward trend in 2016. However, collisions with pedestrians and bicycles have been increasing substantially since 2007.

#### *5.2.1.b -* **Evolution of the proportion of collisions according to third-parties**




graph 41

The global variation of the breakdown of collisions according to third party is small for the period analysed.

## 5.2.2 - Third-party victims of collisions

We have only taken the third party victims for the graphs shown below.As compared to the previous report, the values of the relative ratio of the victims by type of third party are thus different.

### *5.2.2.a - Data table*

| Third party | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Motorcycle | 17 | 27 | 12 | 19 | 24 | 14 | 7 | 19 | 12 | 13 |
| Other | 1 | 3 | 1 | 1 | 0 | 2 | 1 | 0 | 2 | 1 |
| Pedestrian | 104 | 136 | 137 | 120 | 125 | 115 | 138 | 134 | 139 | 154 |
| Public transport or HGV>3.5t | 5 | 2 | 19 | 3 | 5 | 1 | 4 | 2 | 3 | 6 |
| Bicycle | 19 | 25 | 24 | 22 | 39 | 29 | 25 | 35 | 28 | 51 |
| Car | 107 | 71 | 94 | 88 | 132 | 97 | 94 | 139 | 104 | 101 |
| Van <3.5t | 9 | 10 | 4 | 8 | 8 | 2 | 5 | 0 | 1 | 4 |
| TOTAL | **262** | **274** | **291** | **261** | **333** | **260** | **274** | **329** | **289** | **330** |

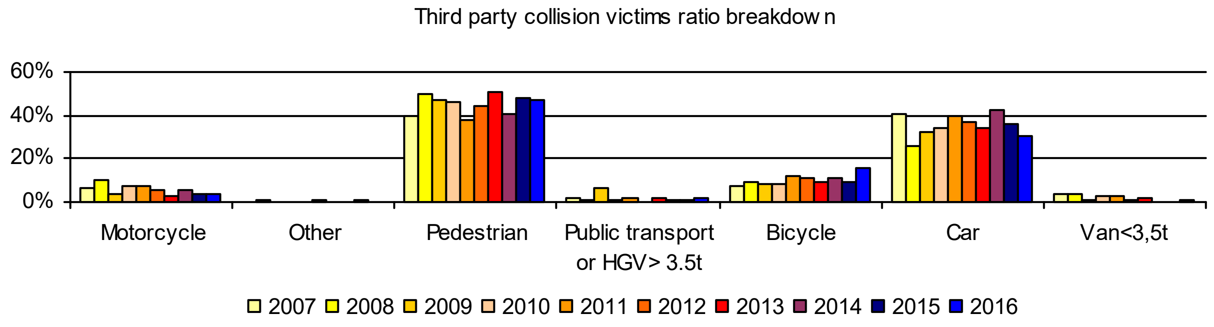
Table 19g

We generally observe a regular variation in third-party victims of collisions each year.

For the year 2016, in spite of a decrease in the number of collisions, the number of victims shows an upward trend.

It is mainly the pedestrian and cyclist victims that are increasing significantly, which can be explained by the increase in the modal proportion of active modes of transport.

### *5.2.2.b - Evolution of the proportion of victims of collisions according to the third-party*




graph42

We observe that the breakdown of the third party victims by type of third party differs significantly every year, with marked variations for pedestrians and cars.

This graph confirms that the the category that is most vulnerable to collisions and that, on average, they represent half the victims of collisions.

### 5.2.3 - Third-party severe victims of collisions

#### *5.2.3.a - Data table*

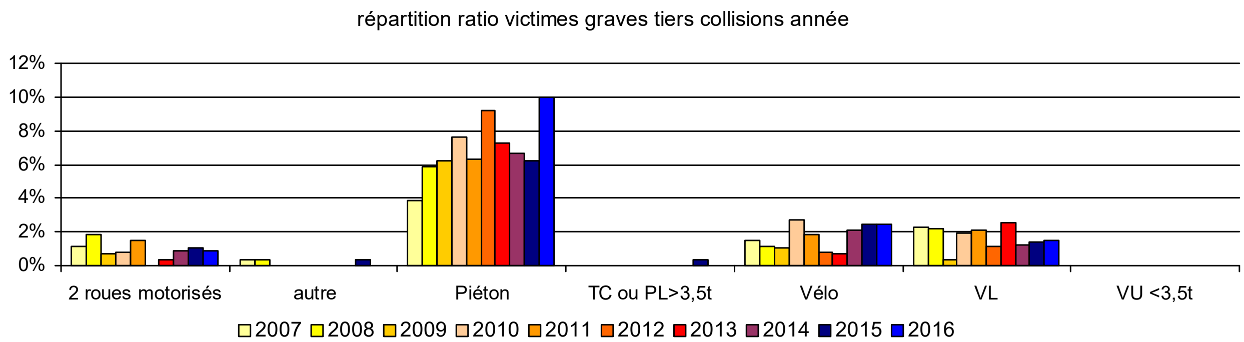
| Third party | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Motorcycle | 3 | 5 | 2 | 2 | 5 | 0 | 1 | 3 | 3 | 3 |
| Other | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Pedestrian | 10 | 16 | 18 | 20 | 21 | 24 | 20 | 22 | 18 | 33 |
| Public transport or HGV>3.5t | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Bicycle | 4 | 3 | 3 | 7 | 6 | 2 | 2 | 7 | 7 | 10 |
| Car | 6 | 6 | 1 | 5 | 7 | 3 | 7 | 4 | 4 | 5 |
| Van <3.5t | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | **24** | **31** | **24** | **34** | **39** | **29** | **30** | **36** | **34** | **51** |

Table 19i

This table confirms the vulnerability of pedestrian third-parties, who represent the majority of severe victims of collisions with a third-party.

For 2016, we highlight a significant increase in the number of severe victims involving the pedestrians and cyclists.

#### *5.2.3.b - Evolution of the proportion of third-party severe victims of collisions according to the third-party*




graphique 43

| repartition ratio victims graves tiers collisions anné | Severe victims ratio breakdown |
|---|---|
| 2 roues motorisés | Motorcycle |
| autre | Other |
| piéton | Pedestrian |
| TC ou PL<3,5t | Public transport or HGV> 3.5t |
| Vélo | Bicycle |
| VL | Car |
| VU<3,5t | Van<3,5t |

We observe that the proportion of severe victims involving pedestrians remains lower than 10% of all victims during the period.

### 5.2.4 - Passenger victims of collisions

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| passengers | 45 | 66 | 88 | 66 | 79 | 80 | 104 | 106 | 86 | 111 |

Table 19h

We also observe a significant variation in the passenger victims of collisions each year with an increase in 2016. The passenger victims represent between a fifth and a quarter of the victims of collisions with third party.

### 5.2.5 - Data on the causes of collisions with a third-party involving motorcyclist third-parties

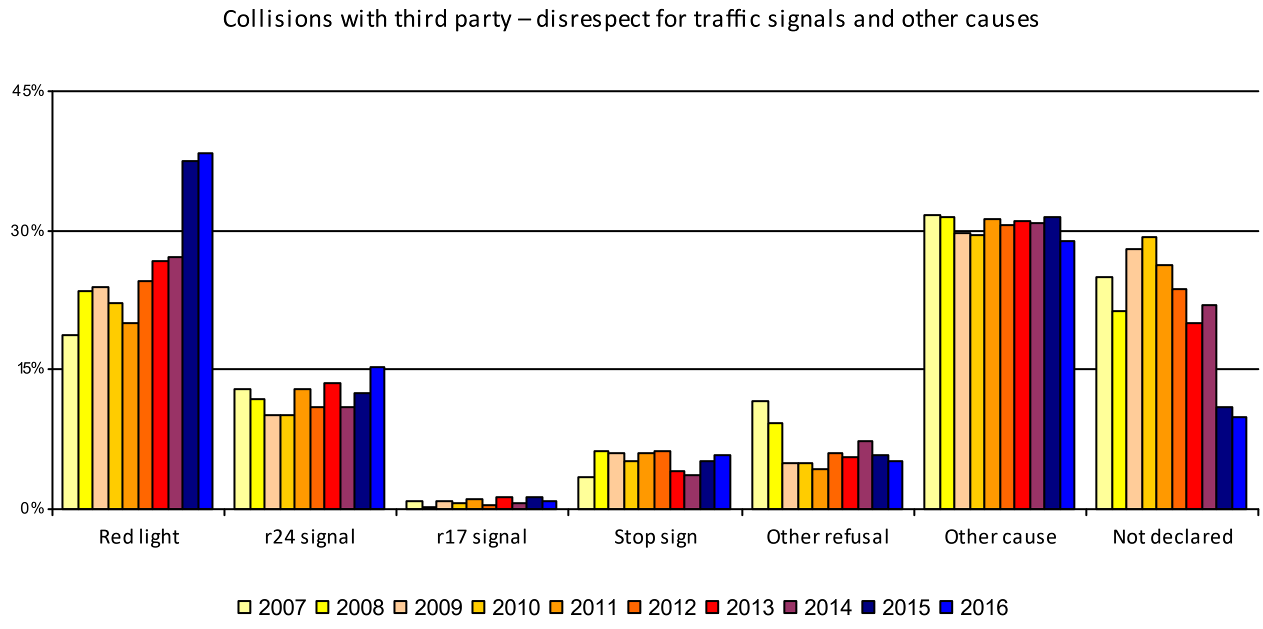
From the previous analysis report of reported events, we have retained only the collisions with a third-party involving a motorcyclist or a cyclist. **The graph ratios below are thus different from those presented for the previous periods.**

The main cause of collisions with a third-party is non-compliance with signals by the motorcyclist and cyclist third parties.

Following this is prohibited operations on the platform, and encroachment of the platform by the third party, which mostly results in material consequences only**.**

#### *5.2.5.a - Disrespect for traffic signals by motorised third parties, bicycles and trams*

The graph below shows the ratio of the number of collisions with a third-party to the disrespect for traffic signals by motorised third parties , bicycles and by comparison, the tram driver.




graph 29b

The "other refusal" category takes account of the C20c, the give-ways and also the case of a crossroads in degraded mode where the traffic lights signals are in flashing amber.

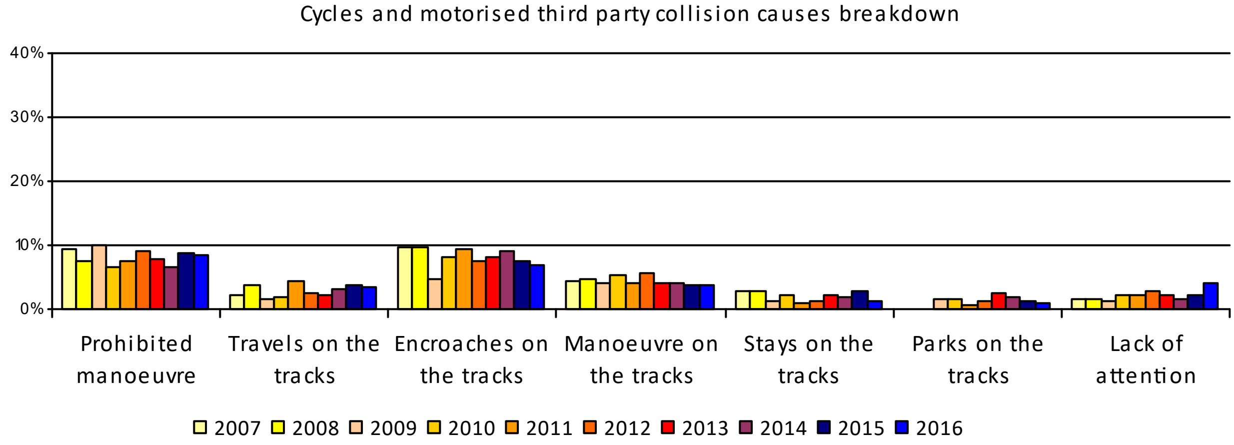
The other causes pertain to events that are not related to traffic signals. The details about the breakdown of these events are given in the graph below.

The signals concerning the tram driver are the R17 signals (See Appendix – Main road signals).

We observe a marked increase in the proportion of red lights crossed in 2016. As in the previous year,this can be explained by a better quality of declaration by the operators.

#### *5.2.5.b - Other causes for bicycles and motorised third parties*

In addition to the previous graph, the graph below provides a representation, for the collisions that are not related to traffic signals, of the ratio of the number of collisions with third party that are related to the behaviour of the bicycle and motorised third parties. This mainly concerns the prohibited movements, U-turns, encroachment of the platform, etc.



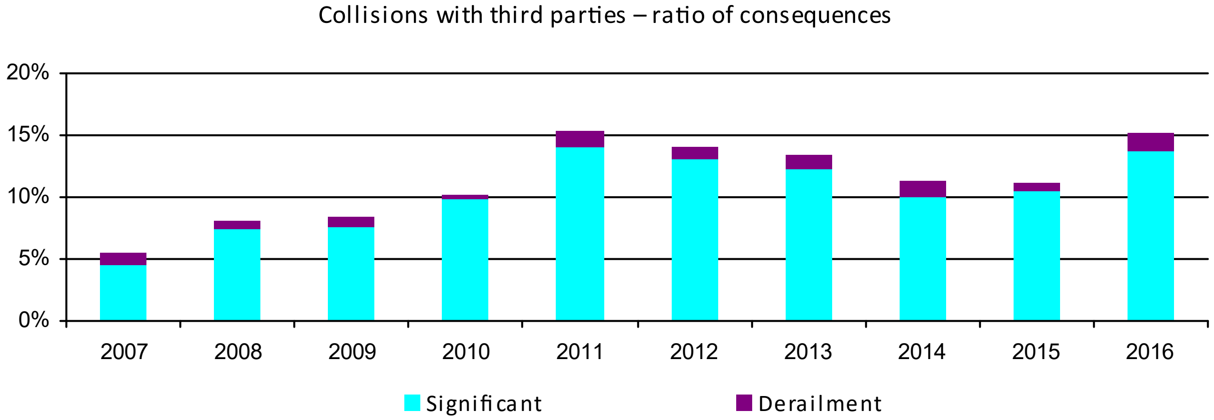

graph 46b

We observe that the main causes of collisions with a third-party, which are not related to the disrespect of traffic signals, concern prohibited operations and encroachment of the platform (when the track clearance of the trams is occupied by third-party vehicles).No specific trend is observed over the period.

### 5.2.6 - Material consequences of collisions with a third-party – derailment

The graph below illustrates the material consequences of collisions with third-party: significant damage to third parties as well as to the system, and/or the derailment of the tram.

For this report, only collisions with motor vehicles were taken into account.



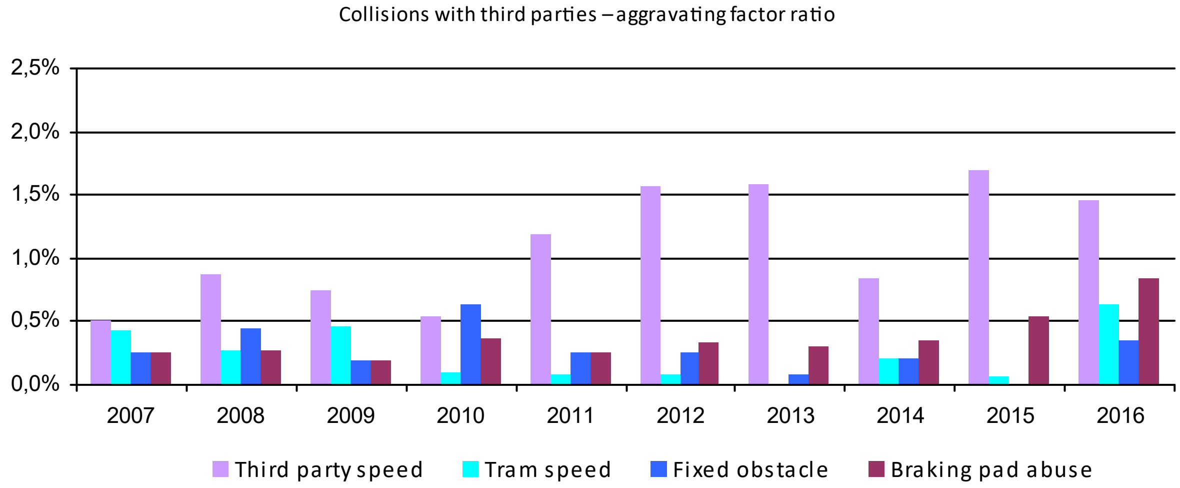

graph 48

The proportion of significant material consequences remains lower than 15%. The downward trend observed since 2011 reversed in 2016.

The proportion of derailments following a collision with a third party involving a car remains very low, lower than 1%.

### 5.2.7 - Aggravating factors

As per the assessment of the operators, the graph below shows the breakdown of aggravating factors involved in collisions with a third-party.




graph 49

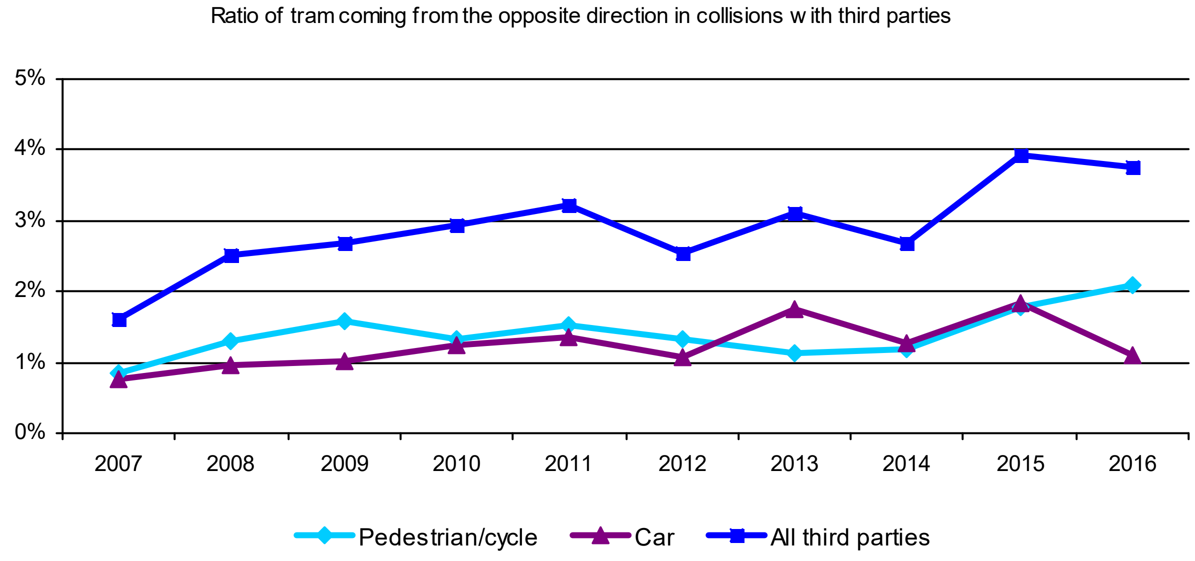
| Aggravating factor | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Braking pad abuse | 3 | 3 | 2 | 4 | 3 | 4 | 4 | 5 | 8 | 12 |
| Fixed obstacle | 3 | 5 | 2 | 7 | 3 | 3 | 1 | 3 | | 5 |
| Tram speed | 5 | 3 | 5 | 1 | 1 | 1 | | 3 | 1 | 9 |
| Third party speed | 6 | 10 | 8 | 6 | 14 | 19 | 21 | 12 | 25 | 21 |

Four categories of aggravating factors were identified:

- Third-party speed: corresponds to a speed assessed as excessive in view of the declaration of the tram driver and if it aggravated the consequences of the collision
- Tram speed: similarly, the tram speed is considered to be excessive when it significantly exceeds the maximum speed of the considered area or that of the instructions to be followed in view of the event scenario
- Fixed obstacle: corresponds to collisions where the consequences were aggravated when the third-party was trapped between the obstacle and the tram
- Braking pad abuse: refers to the practice of using the magnetic brake pads instead of an emergency braking. This practice extends time and braking distances, thus leading to higher speed of trams when striking third parties.

The collisions with third-parties for which an aggravating factor was identified constitute a very small proportion of all collisions; the maximum was reached in 2013 with slightly more than 1.5% of the total number of collisions concerning the third-party speed.

## 5.2.8 - 5.2.10 - Opposite direction tram




graph 47

The graph below shows the proportion of collisions with third parties whose circumstances appear to involve a tram coming from the opposite direction while crossing a first tram.

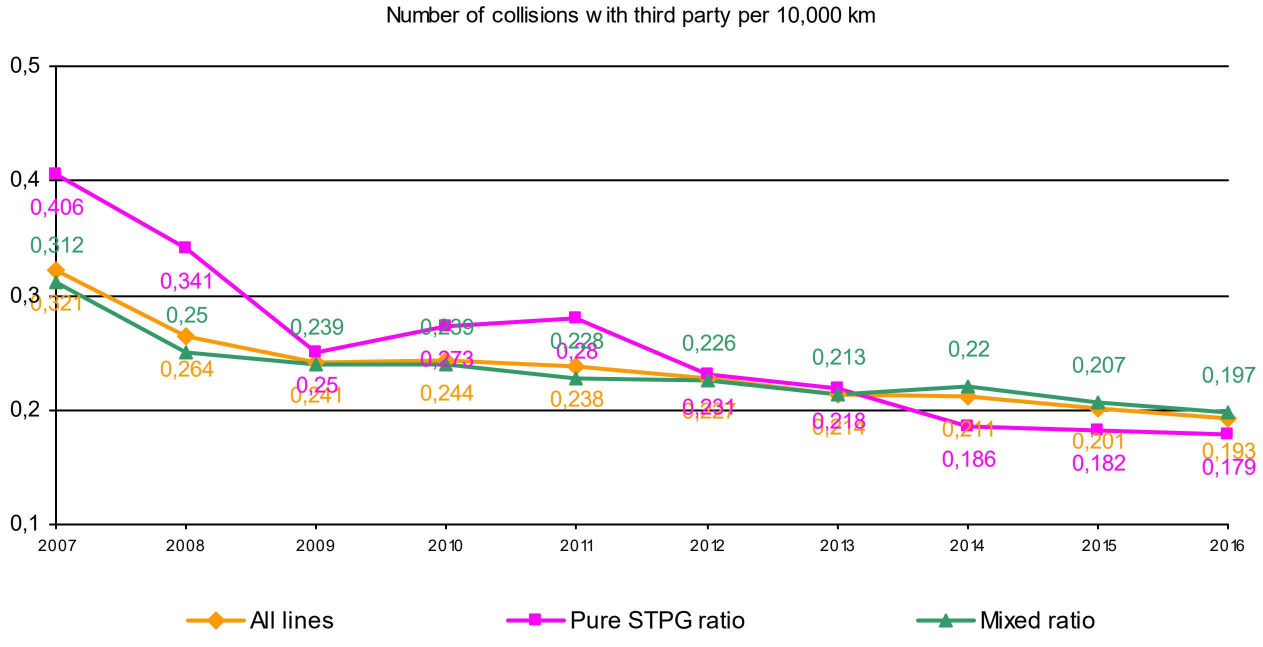
With a stable ratio and to a higher level in 2015 and 2016, although it represents a small proportion of collisions with third-parties, it is an indicator that must be observed, with an increase in the common core line operations (predominantly corresponding to the city-centre) and active modes.

## 5.3 - Monitoring of collisions indicators

### 5.3.1 - Collisions per 10,000 km travelled

In § 3.3.2 we presented a monitoring indicator for events per 10,000 km. We also know that all networks do not adopt the same methods in reporting certain events such as passenger events, the year of 2014 being particularly distinct from this point of view.

On the contrary, we are reasonably sure of the homogeneity of the reports of the collisions with a third-party; this results in an improved reliability of the change in the number of collisions per 10,000 km travelled.




graph 08

The general trend continues to be downward.

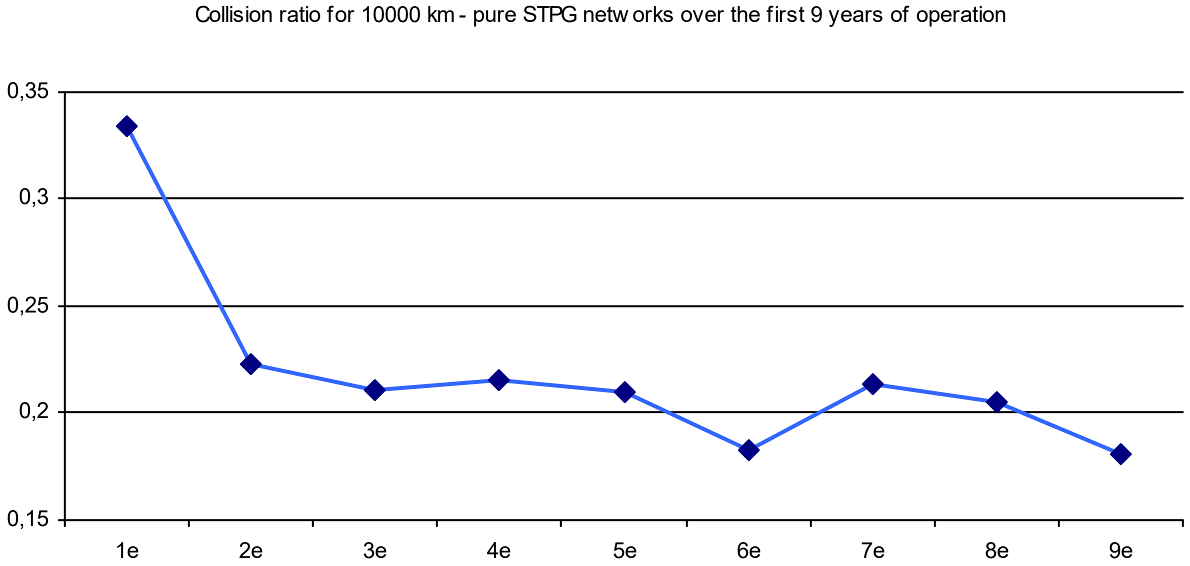
It is important to note a more significant decrease, mainly since 2014, of the ratio of collisions per 10,000 travelled km for the “pure STPG” networks (the lowest ratio since 2006).

***/!** From the analysis report for the reported events during the period 2006-2015, we retained the comparison between the mixed networks, put into operation before the STPG Decree of 2003, and "pure STPG" networks put into operation in accordance with the STPG Decree (refer to 1.3 - The adopted principles and definitions) . The indicated ratios are not comparable with the “STPG lines” and “classic lines” ratios presented in the previous annual reports.*

### 5.3.2 - Collisions at the beginning of operation

Some STPG lines have now a significant number of years of operation (up to 10 years in 2016). We found it interesting to observe the rate of collisions at 10,000 km of “pure STPG” networks in the first 9 years of operation.

In order to determine this ratio, we have considered the date of the event and the date of opening of the section. As regards the production in km, it is always the complete year production that is used. As these two elements of information are not on the same temporal base, this rate is to be considered as an estimate.




graph 09

For the first five years of operation, it was found that the collision ratio per 10,000 km, after a significant decline in the first three years, observed a slight increase in the following year, declined again and then stabilised, decreasing by about 50% overall.

Observing the evolution of the annual rate for each network, we can see this increase for the fourth or fifth year for most of the networks.

For the record, the 2016 average ratio of number of collisions per 10,000 km for the pure STPG networks is 0.179.

# 6 - Analysis of configurations

The codification of lines, implemented since 2005, allows describing the configurations present on the tram networks and therefore allows analysing the breakdown of events according to the various configurations. The codification defines nine types ofconfigurations: the stations, the on-street/off-street sections and seven types of intersections.

The distinction between roundabouts (without the tram, this intersection works like a conventional roundabout with give-way signs and priority to the ring) and gyratories (for this intersection, conflicts between road vehicles, and between road vehicles and tram are managed by traffic lights, without give-way signs and no priority to the ring) was done taking into account their different way of working. It is done by selecting the "R11v” type for the entrance sign for gyratories (and other signals for roundabouts).

By refining the characteristics of the configurations, our objective is also to identify the configurations related to the most accident-prone places ,especially for the intersections.

## 6.1 - Panel of the sections

The table below shows the number of sections (according to the codification) in operation on 31 December of the year under consideration  and their evolution over the last 10 years.

| | Configuration | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Station | 725 | 860 | 885 | 913 | 952 | 1033 | 1195 | 1306 | 1412 | 1441 |
| | On-street/off-street section | 2382 | 2856 | 2966 | 3054 | 3153 | 3536 | 4136 | 4555 | 4947 | 5066 |
| Intersections | Simple junction | 357 | 476 | 487 | 491 | 498 | 540 | 604 | 652 | 692 | 711 |
| | Turn left/right | 807 | 951 | 991 | 1037 | 1065 | 1175 | 1411 | 1563 | 1733 | 1790 |
| | Gyratory | 117 | 129 | 133 | 140 | 160 | 178 | 189 | 178 | 186 | 188 |
| | Roundabout | 31 | 31 | 31 | 31 | 31 | 35 | 44 | 49 | 50 | 50 |
| | Pedestrian cyclist crossing | 2973 | 3549 | 3677 | 3803 | 3897 | 4304 | 5169 | 5677 | 6215 | 6385 |
| | Resident's access | 201 | 253 | 264 | 275 | 292 | 306 | 379 | 413 | 454 | 459 |
| | General traffic section entry | 23 | 29 | 32 | 32 | 33 | 55 | 71 | 83 | 87 | 88 |
| | Complex junction | 226 | 264 | 272 | 279 | 290 | 308 | 353 | 374 | 412 | 422 |
| | TOTAL | 7842 | 9398 | 9738 | 10055 | 10371 | 11470 | 13551 | 14850 | 16188 | 16600 |

Table 30f

In 2016 and since the previous changes in the codification method, the pedestrian/cycle intersections and the on-street/off-street sections are represented the most.

Amongst the road crossings, those with turning movements (the turn left/right) are highest in number, followed by the road junctions of the type “simple intersection”.

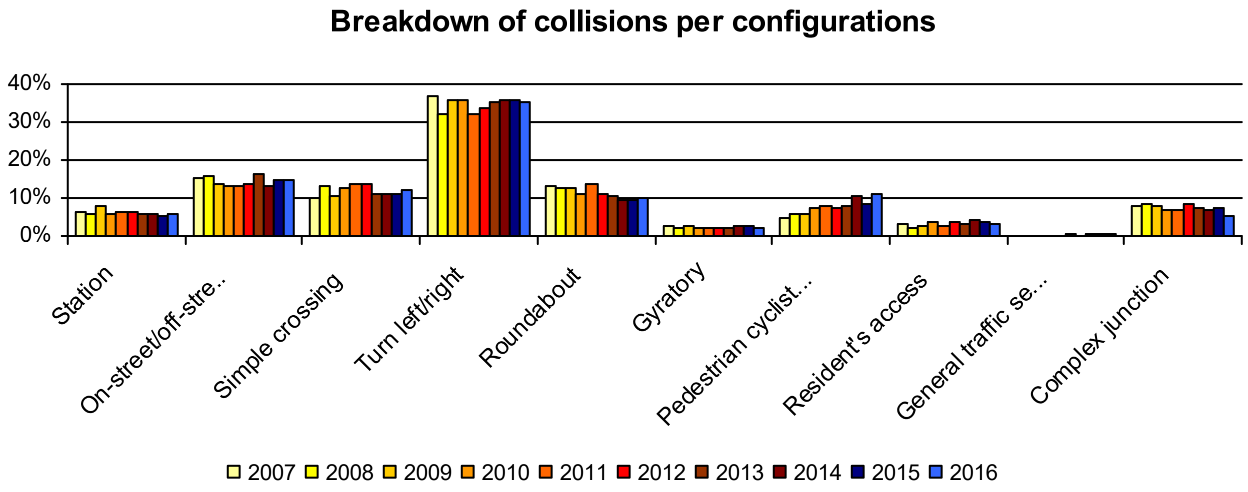
## 6.2 - 2007-2016 evolution

We were able to present more detailed analyses in our previous report.However, certain trends which emerged needed to be consolidated.This work was able to be carried out in fine detail for gyratories and roundabouts in conjunction with CEREMA.

For the “turn left/right” configurations, STRMTG has been able to consolidate the data as well in 2017 in cooperation with the operators and the detailed analysis found later in the report.

**Events considered in this chapter are collisions with a third-party.**

### 6.2.1 - Evolution of the proportion of the number of collisions according to the configuration

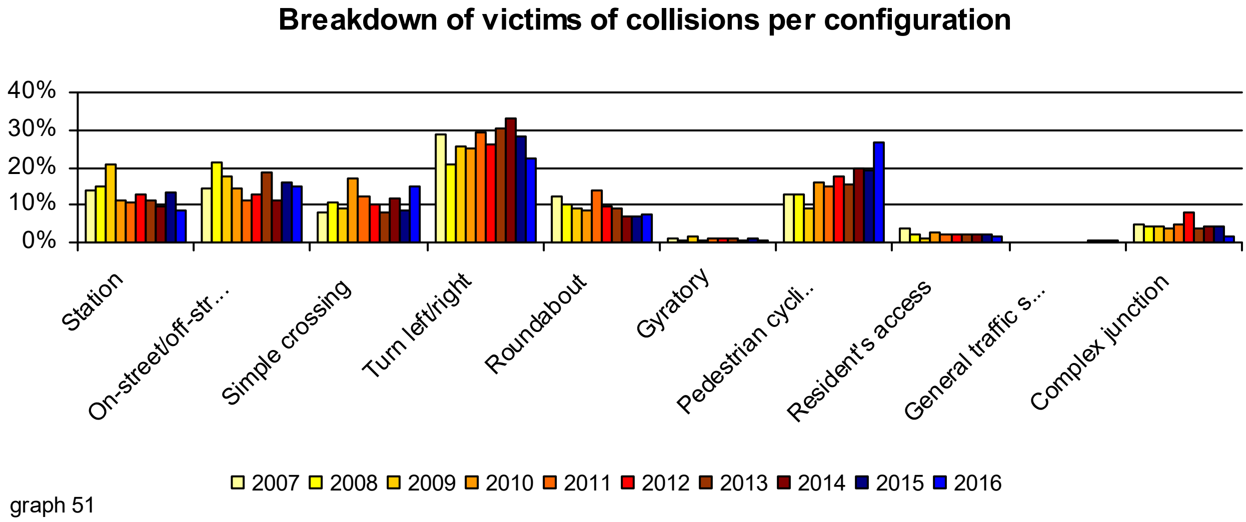



graph 50

Collisions with third-parties mostly occur at the “turn left/right” junctions, on-street/off-street sections, simple crossings, followed by at the roundabouts, and lastly by the pedestrian/cycle intersections. We observe an upward trend in the pedestrian/cycle intersections which must be monitored. There is no marked trend for the other types of intersection.

### 6.2.2 - Evolution of the proportion of victims of collisions according to the configuration

All the victims of collisions with a third party are taken into account in this graph (third party and travellers).

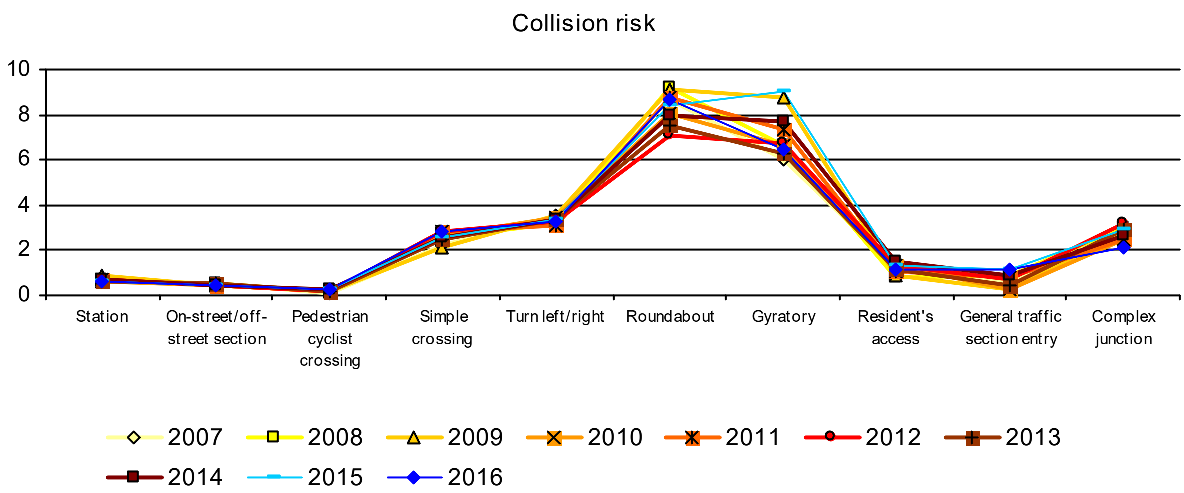



graph 51

The upward trend in the proportion of collisions at the pedestrian/cycle intersections is confirmed by that of the victims. For the year 2016, this configuration experienced the largest proportion of victims of collisions with a third-party.

## 6.2.3 - Estimated risk

The estimated collision risk corresponds to the ratio between the relative proportion of the collisions for each type of intersection, with the relative proportion of the number of intersections for each type of intersection.




graph 52

We observe that the estimated collision risk ofthe roundabouts and gyratories clearly remains above the other intersections over the entire period.

## 6.2.4 - Logged and active sections

### *6.2.4.a - Definitions*

We define "**active**" sections which correspond to the sections in service with their current configuration and "**logged**" sections which correspond to their configuration before modification (or abandoned)

This is necessary to ensure the monitoring of accidentology according to the evolution of the urban environment of the tram during its life. This is mainly the case of road crossings whose characteristics are led to be modified: geometry, traffic signals or other components.

For this, the codification allows the conservation of historical configurations.

The collisions are taken into account for the period 2006-2016 (11 years) and the active sections at the end of 2016.

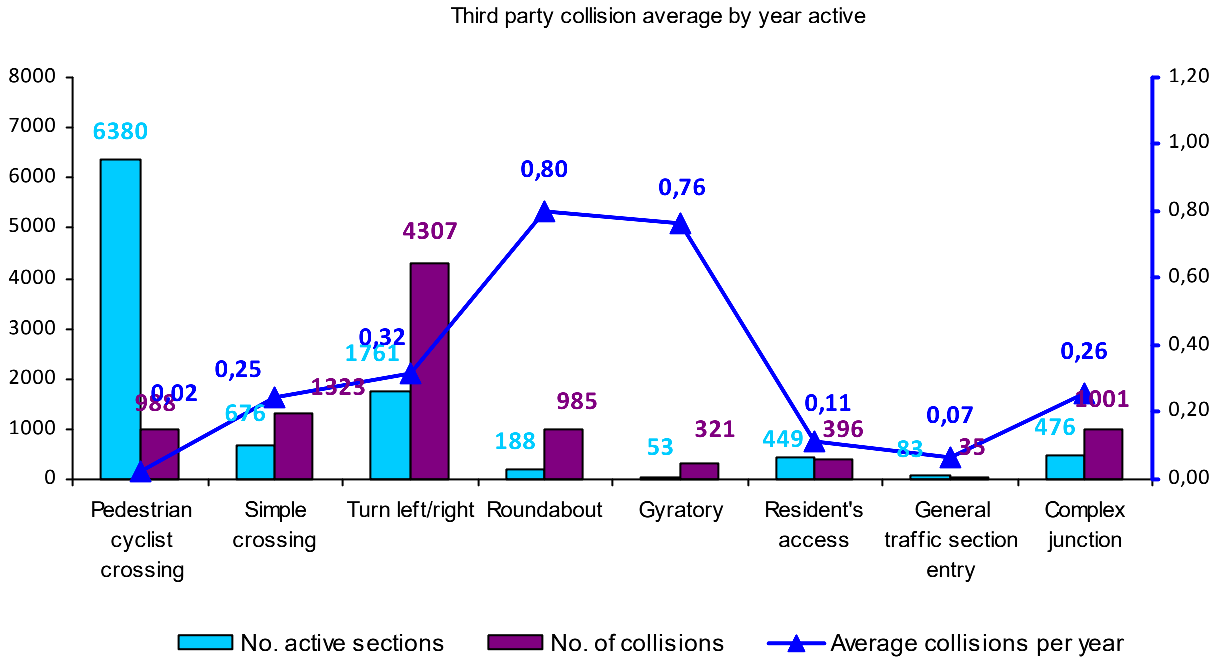
### *6.2.4.b - Average of the number of collisions with a third party per year and per type of active configuration*

The graph below represents the following data:

- left scale: number of sections and collisions with a third-party allocated to these sections

- right scale: curve of the average number of collisions per year and per type of intersection

*/!\ The calculation of the ratio for accidentology has changed since the previous report, and hence the ratios indicated in this chapter cannot be compared with the values of the reports generated before 2005-2016.*




graph 54b

We observe a significant quantitative difference between the numbers of the different intersection types.

In addition, the trend for the average of the number of collisions per year is the same as the one observed in graph 52.

### *6.2.4.c - Comparison of the average number of collisions with a third-party per year*

For the section panel that has been historised in the database since 2007, and according to the category of intersection, the table below indicates the number of logged sections, the yearly average number of collisions for the logged sections, aswell as the yearly average number of collisions for the active sections.

| Type of intersection | Number of “logged” intersections | No. of associated collisions | Average collisions per year by configuration on "logged" sections | Average collisions per year by configuration on active sections |
|---|---|---|---|---|
| Pedestrian-cyclist crossing | 120 | 26 | 0,04 | 0,04 |
| Simple crossing | 55 | 187 | 0,69 | 0,26 |
| Turn left/right | 80 | 372 | 0,75 | 0,4 |
| Gyratory | 92 | 584 | 1,35 | 0,88 |
| Resident's access | 13 | 26 | 0,28 | 0,12 |
| General traffic section entry | 2 | 0 | 0,00 | 0 |
| Complex junction | 27 | 62 | 0,37 | 0,17 |

Table200a2

This table allows us to see that the "number of collisions per logged configuration" ratio is higher than the one for the current configurations (except for the pedestrian/cycles).This will **globally** demonstrate (with data for which the sample size is sufficient) the effectiveness of changes implemented by the tram networks.

**In the following part of the document, the impact of signalling is analysed for the roundabouts and gyratories. For this purpose, a summary explaining the different types of traffic signs and light signals can be found at Appendix – Main road signals. For this purpose, a summary explaining the different types of traffic signs and light signals can be found at**

## 6.3 - Roundabouts and gyratories

**It should be noted at the beginning that we have not been able to analyse the possible link between the average rate of events per year, size parameters of roundabout and gyratories, width of the ring and the number of entrance lanes, and the road traffic volumes, in the absence of traffic data.**

The average collision figures per year represent the average of the number of collisions observed for the configuration, divided by the number of observation years of the configuration.

The collisions are taken into account for the period 2006-2016 (11 years) and the active sections at the end of 2016.

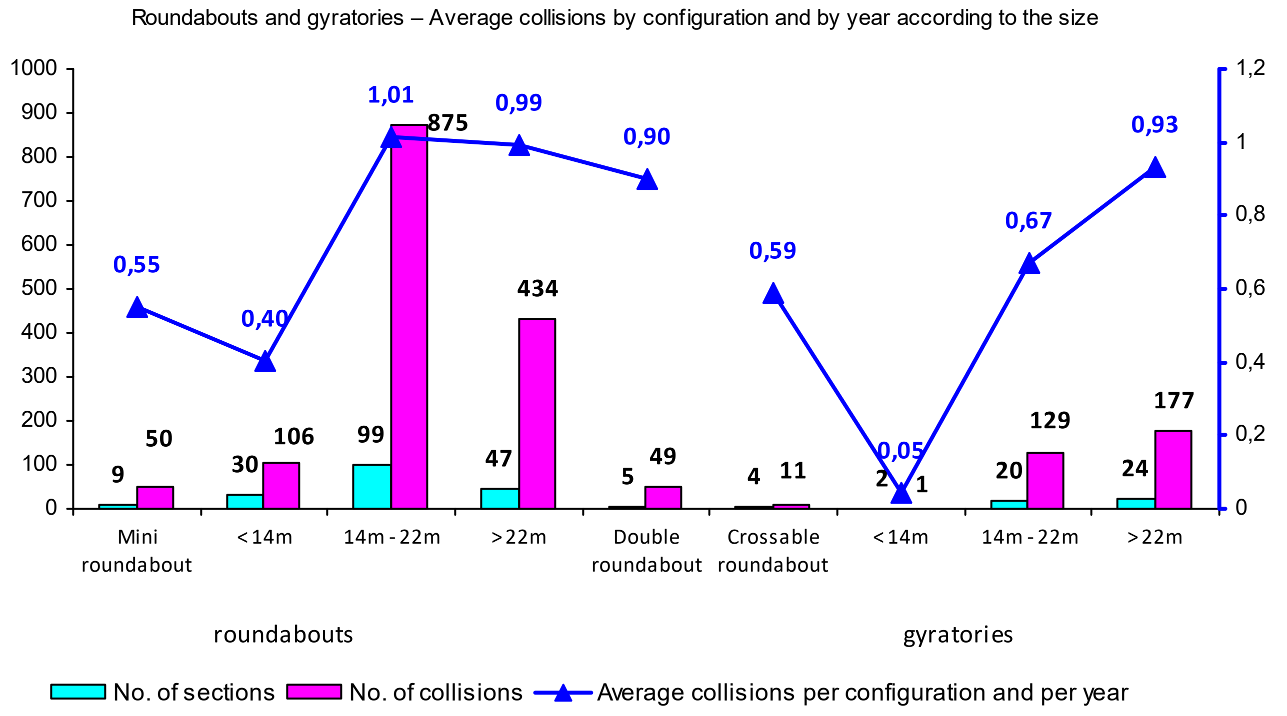
***/!*** *As the calculation of the ratio for accidentology has been changed in this report, the ratios indicated in this chapter are not comparable with the values of the reports generated before 2005-2016.*

### 6.3.1 - Average collision ratio for all the roundabouts and gyratories

In the graph below, the gyratories are divided into five main categories according to their size, and the roundabouts are divided into four categories.

At the start, we observe the low number of mini roundabouts and double roundabouts, as well as for the gyratories with crossable island and size < 14m.

For these categories, **the values of the statistical analyses should be interpreted carefully.**




graph 90a

We observe that the average of the number of collisions by configuration and by year for the roundabouts becomes higher for the roundabouts with radius > 14m.

However, comparing some combinations according to this single criterion of size remains irrelevant due to the impact of other criteria in the database (for example: entrance signs).

In the next "Codification of tram lines" guide, which will be drawn up in 2018, the division of the current category 14-22 m into two categories 14-16 m and 16-22 m will make it possible to refine the results related to the size of roundabouts.

We will provide details in the following paragraphs about the influence of the size of the ring and the number of entrance lanes for the roundabouts, with a breakdown by roundabout size, as well as the influence of the entrance sign and crossing sign (and their evolution), for roundabouts and gyratories.

Overall, the results presented in this chapter will be analysed in-depth during 2018 by STRMTG and CEREMA to provide a better understanding of the factors influencing the accident rates of roundabouts.

## 6.3.2 - Impact of the geometry for roundabouts

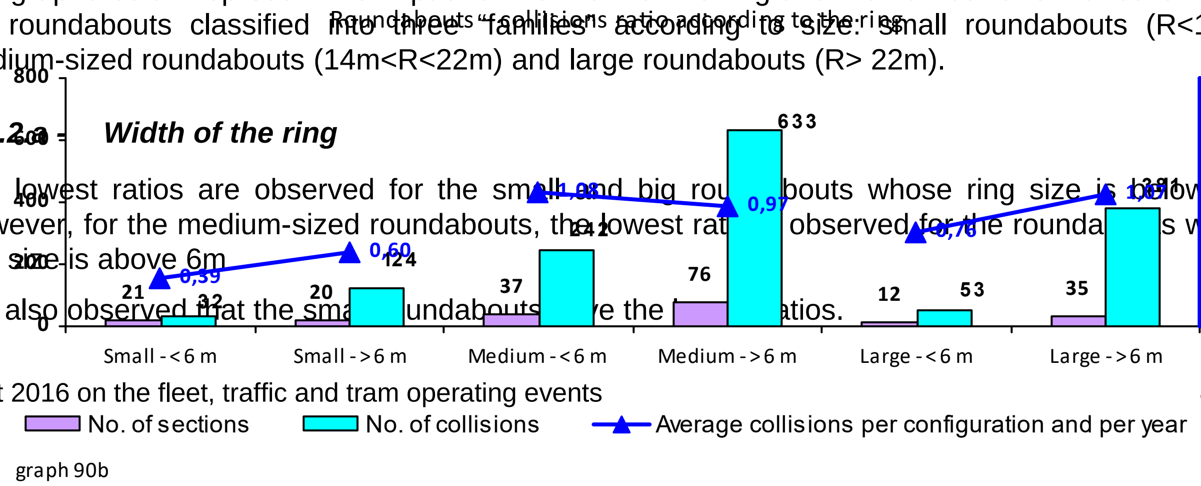
The criteria of the width of the ring and the number of entrance lanes are only analysed for the roundabouts as the sample relating to the gyratories is very low.

The graphs below represent the impact of the width of the ring and the number of entrance lanes for the roundabouts classified into three "families" according to size: small roundabouts (R<14m), medium-sized roundabouts (14m<R<22m) and large roundabouts (R> 22m).

### *6.3.2.a - Width of the ring*

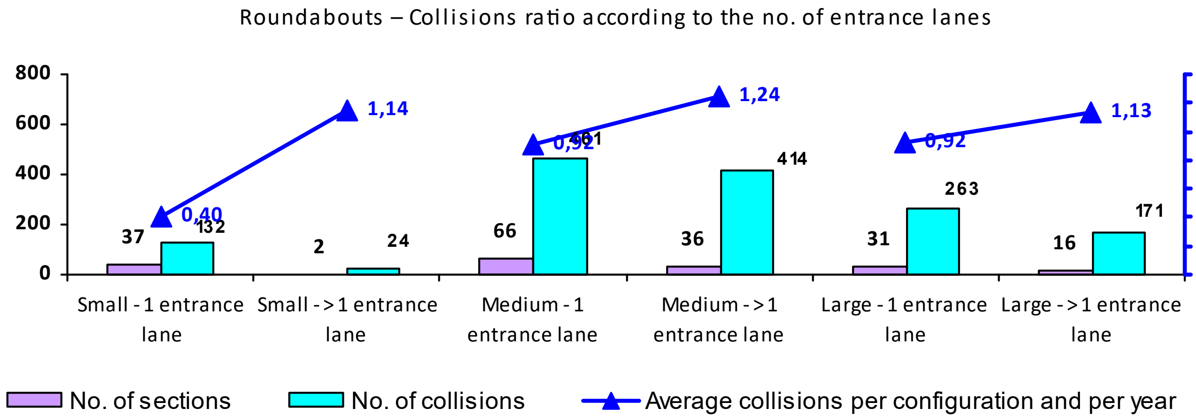
The lowest ratios are observed for the small and big roundabouts whose ring size is below 6m. However, for the medium-sized roundabouts, the lowest ratios are observed for the roundabouts whose ring size is above 6m.

It is also observed that the sma[…]undabouts […]e the […]atios.




graph 90b

#### 6.3.2.b - *Number of entrance lanes*




graph 90c

Whatever the size of the roundabouts, the lowest ratios areobserved for the roundabouts with a single entrance lane. Beyond the configuration itself, this could be partly explained, particularly by the traffic data, with the sizing of the number of tracks entering the roundabout possibly being linked to this data.

#### 6.3.2.c - *Conclusion*

The results shown in the graphs above notably demonstrate that small roundabouts have lower ratios in terms of collisions with third parties. This ratio decreases as the width of the ring becomes smaller or the number of entrance lanes reduce. This seems logical because such a geometry limits the traffic and speed near the platform.

### 6.3.3 - Impact of traffic lights for roundabouts

**In the following, the concept of "reinforced signalling" means more than 2 signals per crossing.**

As the codification of the roundabouts has been fully verified in the previous year, we are committed to understand the impact of the evolutions of the sections for the upstream (entrance) (SA) and crossing (SB) signalling. For this, we have determined the following 10 categories:

| Category | No. of sections | ES_earlier | CS_earlier | ES_present | CS_present |
|---|---|---|---|---|---|
| cat0 | 127 | unchanged | unchanged | unchanged | unchanged |
| cat1 | 26 | nothing or static | R24 | nothing or static | R24 reinforced |
| cat2 | 1 | nothing or static | R24 reinforced | R24 reinforced | R11j |
| cat3 | 28 | R11j | R24 | nothing or static | R24 reinforced |
| cat4 | 2 | R11j | unchanged | R24 | unchanged |
| cat5 | 1 | unchanged | R11v | unchanged | R24 |
| cat6 | 1 | R11j | R24 | R11j | R24 reinforced |
| cat7 | 1 | R11j | R24 | R24 | R24 reinforced |
| cat8 | 1 | nothing or static | R11j | nothing or static | R11v |
| cat9 | 1 | nothing or static | nothing or static | nothing or static | R24 |
| cat10 | 1 | nothing or static | R11j | nothing or static | R24 reinforced |

Table 09 – Signalling evolution category

This made it possible to observe the roundabouts in greater detail by distinguishing between the sections without any evolution in signalling and those that have had an evolution in signalling.

### *6.3.3.a - The roundabouts whose signals did not change*

The roundabouts concerned are those of category 0: this means that the roundabouts may have undergone a change in codification but without any change in the traffic lights.The other changes often pertain to the visibility conditions (visual mask or visibility of the tram track).

The summary table below shows the overall results for the sections in this category.

For each upstream and crossing signal configuration, we have given the number of sections active at the end of 2016, and the average number of collisions per configuration and per year.

The boxes in red correspond to configurations for which the samples are the most important

| | Upstream sign | | | | | |
|---|---|---|---|---|---|---|
| Crossing sign | nothing or static | | R11j | | R24 | |
| nothing or static | 3 | 0,91 | 10 | 0,51 | 3 | 0,12 |
| R1 | 1 | 2,00 | | | | |
| R24 simple | 19 | 1,06 | 3 | 0,74 | | |
| R24 reinforced | 37 | 0,60 | | | 1 | 0,00 |
| R11v simple | 26 | 0,76 | 8 | 0,91 | | |
| R11v reinforced | 4 | 1,25 | | | | |
| R11j simple | 2 | 0,33 | 5 | 0,74 | | |
| R11j reinforced | 2 | 0,82 | 1 | 0,00 | | |

Table 210a

We observe the following elements:

- A variety of configurations making a detailed statistical analysis difficult (e.g. by including the size of the roundabout).

- for the roundabouts without light signalling upstream, the ratio obtained with “R24 reinforced” signalling for crossing sign (0.60 collisions by configuration and by year on average) is clearly lower than the one with R11v simple (0.76 collisions by configuration and by year on average) or the R24 simple for crossing sign (1.06 collisions by configuration and by year on average).

### *6.3.3.b - 6.3.3.b - The sections whose signalling has changed*

The table below presents the following data for the roundabouts of category other than 0 and whose number is statistically significant:

- the number of active sections concerned (sample validity) at the end of 2016
- the average of the number of collisions per configuration and per year, before and after the modification of signalling

| Categ. | No. of sections | Sig. before (upstream + crossing) | Avg. before | Sig. after (upstream + crossing) | Avg. after |
|---|---|---|---|---|---|
| cat1 | 26 | nothing or static + R24 simple | 1,67 | nothing or static + R24 reinforced | 1,44 |
| cat3 | 28 | R11j + R24 simple | 1,07 | nothing or static + R24 reinforced | 1,00 |

Table 210b

We can therefore analyse the categories 1 and 3 that pertain to the roundabouts whose upstream signalling has been changed to have no light signalling, and whose crossing sign has been changed to “R24 reinforced” in place of “R24 simple”.

**We observe that the ratios obtained with “R24 reinforced” crossing signal configuration shows a reduction in the number of collisions per configuration, with respect to that with “R24 simple” crossing signal configuration.**

### 6.3.4 - Impact of traffic lights of the gyratories

The table below shows the overall results for the gyratories whose signalling has not changed.For each crossing signal configuration, we used the number of sections and the average of the number of collisions by configuration andby year.

The boxes in red correspond to configurations for which the samples are the most important.

| Upstream sign | Crossing sign | No. of sections | Average no. of events per year |
|---|---|---|---|
| R11v | nothing or static | 10 | 0,61 |
| R11v | R24 reinforced | 2 | 1,48 |
| R11v | R11v | 17 | 0,66 |
| R11v | R11v reinforced | 6 | 1,55 |
| R11v | R11j | 12 | 0,69 |

Table210c

It appears that in the case of gyratories no trend stands out particularly as long as the samples are low. It seems that having a light signalling for crossing sign does not improve ratios.

We did not carry out an analysis of the sections with a modification in signalling insofar as only two sections were affected.

It should be noted that these elements must however be considered with caution as they do not take into account the local context and particularly the traffic data.

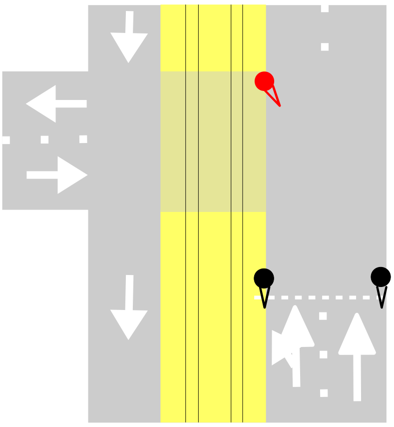
## 6.4 - Turn left/right - Impact of traffic signs type

The verification of the “turn left/right” codification having being completed at the end of 2017, with the active collaboration of operators, the reliability of data for this configuration allows to re-conduct an accident rate analysis.

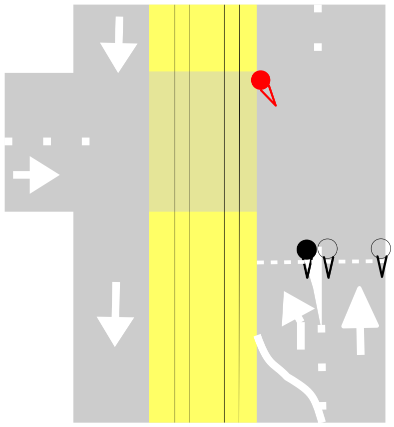
For this, in order to refine the analyses related to this category for better understanding of the risk associated to the turn left/right manoeuvre, we have taken into account only those collisions for which the third-party (car, van or public transport) in question was reported to be carrying out this operation.

This leads to retaining only 2250 collisions out of the 4340 collisions occurring on this type of intersection; for others, the reported operation is “go straight” or is not reported.

The diagram below shows what "upstream" and "crossing" positions means for traffic signs.



*Case of "turn left/right" without diverged track*



*Case of "turn left/right" with diverged track*

Crossing signalling
Upstream signalling

The "upstream" signalling concerns the car/car conflict and then possibly the car/tram conflict.

The "crossing" signalling concerns the car/tram conflict and then possibly the car/car conflict.

Thetable below shows the overall results of the possible configurations in "turn left/right", grouped into upstream and crossing signalling; for each of them, we are dealing with the number of active configurations and the average number of collisions per year.

| | crossing | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| upstream | nothing or static | | R11v | | R24 | | R24_crossings | | Others | |
| nothing or static | 0,15083176 | 93 | 0,16323 | 53 | 0,22954619 | 74 | 0,0165307971 | 12 | 0,1380328 | 15 |
| R11v | 0,11452664 | 1135 | 0,270457 | 42 | 0,18783703 | 69 | 0,0332706243 | 13 | 0,09614729 | 7 |
| R11v_diverged | 0,29826563 | 38 | 0,241155 | 8 | 0 | 4 | | | | |
| R11v_R16 | 0,40428467 | 10 | 0,395592 | 1 | 0,07893599 | 4 | | | | |
| R14 | 0,33099795 | 207 | 0,158972 | 4 | 0,18168243 | 3 | | | 0,20439273 | 4 |
| Others | 0,15417378 | 7 | | | 0,04720641 | 4 | | | | |

Table 07

The boxes in orange correspond to the configurations for which the samples appear to be sufficiently large (more than 30 configurations) to be able to conduct relevant analyses.

Overall, we observe the following items:

- the ratio obtained in configurations without upstream and crossing signalling is quite low.After examination, it appears that these configurations are mainly lateral layout configurations with a street crossing the platform giving access to general residential areas with low traffic.

- configurations without upstream sign have a better ratio with R11v as crossing sign (0,16) rather than with R24 as crossing sign (0,23).

- the ratios with R11v as upstream signs are more favourable with no crossing signs (0.11) or R24 (0.19).These configurations correspond to road crossings in which no other vehicle is permitted to pass during the tram phase (the R24 crossing sign having a vehicle adjustment function for major road junctions in case of traffic congestion situations), which ensures a better ratio.

- we also note that configurations with **R14 upstream signs do not give a very good ratio and confirm the comments of the National technical instruction for road safety on the difficulty for the user to understand it well.**

# 7 - Conclusions

## 7.1 - Constant factors

- The collision with third-parties and passenger events are in majority.
- The occurrence of severe victims is higher during the collisions with third-parties than during passenger events.
- The “roundabout”, “gyratory” and “turn left/right” configurations present the highest estimated collision risk.

## 7.2 - Reasons for satisfaction

- The low proportion of severe victims: less than 6% of all victims since 2007.
- The decreasing trend in the number of collisions per 10,000 km for all networks.
- The favourable comparison for the tram compared to the bus, as regards the number of collisions per 10,000 km, carried out on a significant sample of 5 networks.
- The low proportion of aggravating factors, including fixed obstacles and tram speed, in collisions with third-parties.

## 7.3 - Confirmations

- The proportion of the "opposite direction tram" is low in the accidentology: around 4% of collisions. This point is however to be monitored in view of its development over 2015 and 2016.
- The proportion of severe passenger victims, caused by an emergency braking (all combined EB), remains less than 3% (0.8% in 2015) of all passenger victims; the proportion of passenger victims caused by emergency braking related to the “dead man’s device” is slightly more than 10% of all victims related to emergency braking in 2016.
- Increase in the proportion of events at pedestrian/cycle intersection configuration.
- The following points are confirmed in relation to roundabouts:
  - For criteria relating to geometry, the “average of the number of collisions per year” ratio is lower for the small roundabouts with a radius less than 14 m. The possible link with traffic levels cannot be established as we have no data
  - For criteria related to signalling, considering the different samples sizes, only a global analysis of the roundabouts was made (without including the dimension of the external radius). We essentially observe that the “average of the number of collisions by configuration and by year” ratios obtained for the roundabouts without upstream light signalling, and whose signalling has not changed, are lower with “R24 reinforced” for crossing sign with respect to the configurations with “R24 simple” for crossing sign.

## 7.4 - Analysis of “turn left/right”

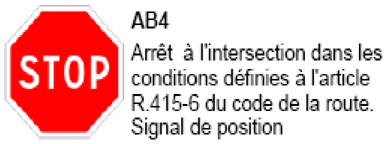
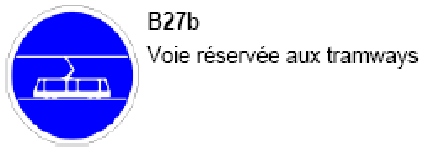
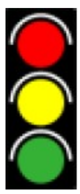
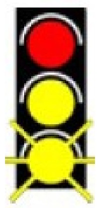
- The road crossings where no vehicle is allowed to pass during the tram phase have the lowest ratio of the “average number of collisions per year ”. This confirms the effectiveness of the “all-red interval” during the tram phase.

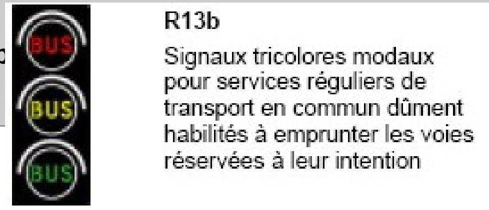
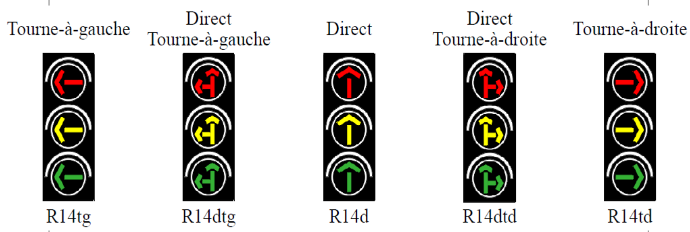
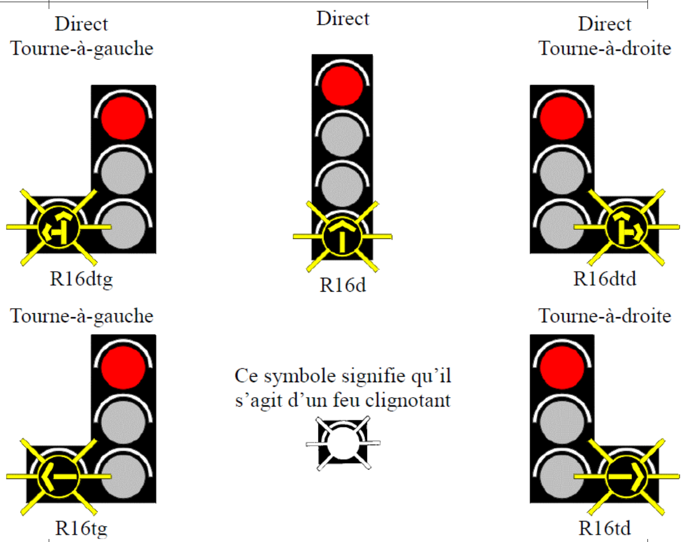
- The configurations with R14 upstream do not give a very good ratio and confirm the comments of the National technical instruction for road safety on the difficulty for the user to understand it well.

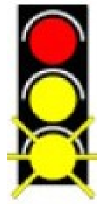
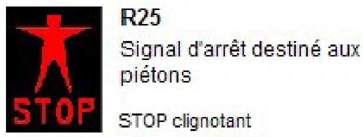
## 7.5 - Remaining cause of concern

- The severe victims involving pedestrians and cyclists (significant increase in 2016) that now account for about 13% of the third-party victims of collision.

# 8 - Appendix – Main road signals

| Type of signal | Name of signal | No. (National technical instruction for road safety) | Representation |
|---|---|---|---|
| **Priority signs** | Give way – Position sign | AB3a |  |
| | Stop sign – Position sign | AB4 |  |
| **Mandatory signs** | Trams only | B27b |  |
| **Information signs** | Tram crossing (position sign) | C20c |  |
| **Warning signs** | Trams crossing ahead (advanced sign) | A9 |  |
| **Intersection traffic light signals** | Intersection signals | R11 |  **R11v**  **R11j** |
| **Intersection traffic light signals** | Intersection pedestrian signals | R12 |  |

| Type of signal | Name of signal | No. (National technical instruction for road safety) | Rep |
|---|---|---|---|
| | Three-colour modal signals | R13b |  |
| | | R13c |  |
| | Directional signals | R14 |  |
| | Anticipation signals with flashing arrows | R16 |  |
| | Public transport signals | R17 |  R17 |
| | Public transport directional signals | R18 |  R18g  R18d |

| Type of signal | Name of signal | No. (National technical instruction for road safety) | Representation |
|---|---|---|---|
| **Other traffic light signals** | Flow control signals | R22 |  R22j |
| | Public transport line crossing - pedestrian/cyclist signals | R24 |  R24 |
| | Public transport line crossing | R 25 |   |

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