ACCIDENTOLOGY OF TRAMWAYS

Analysis of reported events

• year 2014
• evolution 2005 – 2014
History of document versions

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Case followed by

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valérie de Labonnefon - STRMTG</td>
<td></td>
</tr>
<tr>
<td>Tel.: 04 76 63 78 78 / Fax: 04 76 42 39 33</td>
<td></td>
</tr>
<tr>
<td>Email: <a href="mailto:valerie.de-labonnefon@developpement-durable.gouv.fr">valerie.de-labonnefon@developpement-durable.gouv.fr</a></td>
<td></td>
</tr>
</tbody>
</table>

Author

Valérie de Labonnefon – Tramways Division
Jean-Michel Passelaigue – Tramways Division (requests, graphics and translation)
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INTRODUCTION

The purpose of this report is to present the results from the analysis of the tram accident database for 2014 and the evolution of accidentology on the last ten years. This national database is populated by declarations of accidents provided by operators.

The "tram" term covers here rail-guided systems on rails and on tyres.

The statistical analysis is not intended to make a comparison between networks or present a ranking based on safety levels. The different configurations, in terms of number of crossings, infrastructure layout and urban design would make such a comparison meaningless.

On the other hand, a comparative analyses of the accidentology of the various predefined and codified urban layouts, and its evolution over the period 2005-2014, is one of the main subjects of the report.

During 2014, evolutions to the database led to certain analysis being updated (crossing by road vehicles according to the type of road signals, aggravating factors following collision, breakdown of passengers who are victims of emergency braking according to the different causes of this braking in particular).

In some graphs there are often discrepancies in relation to the 2013 graphs, which are explained mainly by the corrections that the operators and STRMTG are continually making to the database in order to ensure that its data is reliable.

In addition, regarding on chapter 5 - Configuration analysis, we were able to present in our previous report more detailed analyses for some configurations.

As we stated in this report, certain trends which stood out needed to be consolidated. This work was able to be carried out in fine detail for roundabouts and gyratories in conjunction with CEREMA (National Centre For Studies and Expertise on Risks, Environment, Mobility, and Urban and Country planning).

Given this observation, for the other studied configurations (simple crossings, residents' access and turns), as their data could not be consolidated in 2014, their analysis has not been carried over to this report.

FRANCE - Accidentology of tramways 2014 – Analysis of reported events
1 - Reminder on the database construction

1.1 - Fields in the database

The database fields contain the following information:

- Network identification (urban area)
- Type of event, based on a predefined list of undesirable events
- Temporal position (date and time)
- Geographical situation (line, tram track, location of event)
- Configuration of the site of the event, using a predefined coding system
- Environment of the event (external conditions: adherence, visibility, degraded operation, works, etc.)
- Consequences on persons, materials, operation (duration of disruption)
- Record of system parameters (according to driver’s statement and/or data from tachymetric system, tram number)
- Police report (yes/no)
- Circumstances of the event (summary of event, act of suicide, aggravating fixed obstacle, third party manoeuvre, etc.) with details of the third party
- Follow-up on actions undertaken (investigation in progress, planned modification, action plan, etc.)

1.2 - Codification of tram lines

The codification consists of describing the various tram line configurations through 14 codified digits in order to create a descriptive database common to all the lines. It makes possible the analysis of events on all networks according to the characteristics of the sites where they occur, to make comparisons between configurations and to identify the most accident-prone.

The codification allows to characterise 9 types of configurations:

- stop/station
- on street/off street section
- simple junction
- turn left or right
- roundabout with or without traffic lights
- pedestrian / cyclist crossing
- resident's access
- general traffic entry section
- complex junction

Signalling is detailed for each of these configurations: 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 part of codified information.

Detailed principles of the codification can be found in the guide « Codification des lignes de tram, nouvelle édition 2010 » on the STRMTG website.
1.3 - Events data

The events data come from declarations of tram operators.

The major effort made by operators to fill in the database and codify their lines must be emphasised.

However, the declarative uses are still not completely identical from one network to another: some declare all events while others only declare the events likely to lead to a claim to their insurance company.

As for previous years, once again we can see a certain level of heterogeneity between networks, which leads us to consider the unprocessed annual results carefully and to favour analysis of their evolution.

From this year, we will present the operating events over 10 sliding years.

\[\text{It should be specified that for 2014, one network declared its passenger events unlike in previous years. Consequently, this affects certain graphs which use the number of events data.}\]
2 - Scope of study

2.1 - Systems in operation
The tramways into operation in 2014 are present in 28 urban areas and cover 68 lines, 62 tram on rails lines and 6 tram on tyres lines.

2.2 - Systems analysed
Network lines are taken into account for the accident analysis are ones which production in km or journeys is declared. So, certain lines whose very short commercial operation over a year did not generate a production declaration, are excluded from the analysis for the year in question. This is the case for lines T6 and T8 in Paris for 2014.

The analysed networks are summarised in the table below.

<table>
<thead>
<tr>
<th>Urban area</th>
<th>Type</th>
<th>No. of lines</th>
<th>Mkm</th>
<th>Mjourneys</th>
<th>Opening</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angers</td>
<td>Tram on rails</td>
<td>1</td>
<td>0.90</td>
<td>8,55</td>
<td>25/06/2011</td>
<td></td>
</tr>
<tr>
<td>Aubagne</td>
<td>Tram on rails</td>
<td>1</td>
<td>0.05</td>
<td>0,02</td>
<td>01/07/2014</td>
<td></td>
</tr>
<tr>
<td>Besançon</td>
<td>Tram on rails</td>
<td>2</td>
<td>0.36</td>
<td>2,98</td>
<td>01/09/2014</td>
<td></td>
</tr>
<tr>
<td>Bordeaux</td>
<td>Tram on rails</td>
<td>3</td>
<td>4.71</td>
<td>75,18</td>
<td>20/12/2003</td>
<td></td>
</tr>
<tr>
<td>Brest</td>
<td>Tram on rails</td>
<td>1</td>
<td>1.15</td>
<td>9,30</td>
<td>23/06/2012</td>
<td></td>
</tr>
<tr>
<td>Caen</td>
<td>Tram on tyres</td>
<td>2</td>
<td>1.26</td>
<td>8,64</td>
<td>18/11/2002</td>
<td></td>
</tr>
<tr>
<td>Clermont-Ferrand</td>
<td>Tram on tyres</td>
<td>1</td>
<td>1.29</td>
<td>15,97</td>
<td>13/11/2006</td>
<td></td>
</tr>
<tr>
<td>Dijon</td>
<td>Tram on rails</td>
<td>2</td>
<td>2.11</td>
<td>22,60</td>
<td>02/09/2012</td>
<td></td>
</tr>
<tr>
<td>Grenoble</td>
<td>Tram on rails</td>
<td>5</td>
<td>4.28</td>
<td>51,06</td>
<td>05/09/1987</td>
<td>Line C: May 2006 Line D: October 2007 Line E: June 2014</td>
</tr>
<tr>
<td>Le Havre</td>
<td>Tram on rails</td>
<td>2</td>
<td>1.15</td>
<td>14,49</td>
<td>12/12/2012</td>
<td></td>
</tr>
<tr>
<td>Le Mans</td>
<td>Tram on rails</td>
<td>2</td>
<td>1.55</td>
<td>15,76</td>
<td>14/11/2007</td>
<td></td>
</tr>
<tr>
<td>Lille</td>
<td>Tram on rails</td>
<td>2</td>
<td>1.50</td>
<td>9,40</td>
<td>04/12/1909</td>
<td></td>
</tr>
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<td>Marseille</td>
<td>Tram on rails</td>
<td>2</td>
<td>1.21</td>
<td>17,61</td>
<td>01/06/2007</td>
<td></td>
</tr>
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<td>Montpellier</td>
<td>Tram on rails</td>
<td>4</td>
<td>5.43</td>
<td>61,14</td>
<td>01/07/2000</td>
<td>L2: December 2006 L3, L4: April 2012</td>
</tr>
<tr>
<td>Mulhouse</td>
<td>Tram on rails</td>
<td>3</td>
<td>1.27</td>
<td>13,49</td>
<td>12/05/2006</td>
<td>Tram-train: December 2010</td>
</tr>
<tr>
<td>Nancy</td>
<td>Tram on tyres</td>
<td>1</td>
<td>0.99</td>
<td>9,72</td>
<td>28/01/2001</td>
<td></td>
</tr>
<tr>
<td>Nantes</td>
<td>Tram on rails</td>
<td>3</td>
<td>5.30</td>
<td>72,51</td>
<td>07/01/1985</td>
<td></td>
</tr>
<tr>
<td>Nice</td>
<td>Tram on rails</td>
<td>1</td>
<td>1.30</td>
<td>29,51</td>
<td>26/11/2007</td>
<td></td>
</tr>
<tr>
<td>Orléans</td>
<td>Tram on rails</td>
<td>2</td>
<td>2.37</td>
<td>20,03</td>
<td>24/11/2000</td>
<td>Line B: June 2012</td>
</tr>
<tr>
<td>Reims</td>
<td>Tram on rails</td>
<td>2</td>
<td>1.03</td>
<td>7,59</td>
<td>16/04/2011</td>
<td></td>
</tr>
<tr>
<td>Rouen</td>
<td>Tram on rails</td>
<td>1</td>
<td>1.47</td>
<td>17,57</td>
<td>16/12/1994</td>
<td></td>
</tr>
<tr>
<td>Urban area</td>
<td>Type</td>
<td>No. of lines</td>
<td>Mkm</td>
<td>Mjourneys</td>
<td>Opening</td>
<td>Observations</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------</td>
<td>--------------</td>
<td>-----</td>
<td>----------</td>
<td>-------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Saint-Etienne</td>
<td>Tram on rails</td>
<td>3</td>
<td>1.68</td>
<td>22,00</td>
<td>01/01/1881</td>
<td></td>
</tr>
<tr>
<td>Strasbourg</td>
<td>Tram on rails</td>
<td>6</td>
<td>5.74</td>
<td>69,86</td>
<td>26/11/1994</td>
<td></td>
</tr>
<tr>
<td>Toulouse</td>
<td>Tram on rails</td>
<td>1</td>
<td>1.14</td>
<td>8,71</td>
<td>11/12/2010</td>
<td></td>
</tr>
<tr>
<td>Tours</td>
<td>Tram on rails</td>
<td>1</td>
<td>1.26</td>
<td>14,54</td>
<td>01/09/2013</td>
<td></td>
</tr>
<tr>
<td>Valenciennes</td>
<td>Tram on rails</td>
<td>2</td>
<td>1.74</td>
<td>7,17</td>
<td>03/07/2006</td>
<td></td>
</tr>
<tr>
<td><strong>28 urban areas</strong></td>
<td></td>
<td><strong>68</strong></td>
<td>0</td>
<td><strong>911,36</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 01

Network, new line or line extension not taken into account in the 2014 results given their opening date.

Network, new line or line extension opened in 2014 and taken into account in the results.
2.3 - Evolution of the set of analysed networks

These evolutions are represented in the graphs below: in terms of the number of urban areas and lines, then in km travelled and journey production.

![Graph 01: Number of urban areas and lines](image1)

![Graph 02: Elements of production](image2)
3 - Results of events data analysis

3.1 - General

3.1.1 - Overall data for 2014

The number of declarations processed is 2467 distributed according to the list of undesirable events in the table below:

<table>
<thead>
<tr>
<th>events</th>
<th>No.</th>
<th>Total</th>
<th>Casualties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Slightly injured</td>
</tr>
<tr>
<td>Fire Explosion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrocut</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derailment</td>
<td>8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Passenger accident</td>
<td>975</td>
<td>847</td>
<td>834</td>
</tr>
<tr>
<td>Collision between trains</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collision with obstacle on track</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collision with a third party</td>
<td>1414</td>
<td>434</td>
<td>397</td>
</tr>
<tr>
<td>Other event</td>
<td>38</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>End of track</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Totals</td>
<td>2467</td>
<td>1291</td>
<td>1241</td>
</tr>
</tbody>
</table>

Table 02

Most declarations are covered by two event categories: collisions with third parties and passenger accidents.

3.1.2 - Remarks concerning the victims

It is important to specify the concept of victim used in this report. Designated as victims, and declared as such by operators, are people who are not unharmed and are involved in an event. This concept does not prejudge the seriousness of people's injuries in any way. However, the seriously injured and fatal definitions are those accepted and used within the European Union.

Seriously injured = hospitalised for over 24 hours.

Fatal = death within 30 days following the event.

These statistical elements about the nature of the victims remain obviously dependent on the information available and the "awareness" of the operator.

3.1.3 - Remarks concerning the events

3.1.3.a - Fire explosion

No events in 2014.

3.1.3.b - Derailment

Eight derailment events were declared in 2014 causing 1 slightly injured person:
3.1.3.c -  Passenger accident

This event category is the subject of a detailed analysis later in the report, in chapter 3.4. No fatal events declared.

/// Remember that the number of events indicated takes account of the passenger events on a network which didn't count them beforehand (see 1.3. The data).

3.1.3.d -  Collision between trams

Seven events of this type at low speed without victim:

- 3 cases of trains colliding with a stopped train when the train was being placed into storage.
- 2 cases of trains colliding with a stopped train in the station.
- 2 cases of trains colliding with a stopped train during a reversing manoeuvre.

3.1.3.e -  Collision with obstacle on track

Twenty one collisions, with no victims, with obstacles on track such as: trolleys, bins, barriers (construction site or not), site pipes, metal or concrete pads, pieces of wood, iron bars and so on.

3.1.3.f -  Collision with a third party

This category is analysed in more detail in chapters 4 and 5 of the report. Here we will relate the circumstances of the 6 fatal events.

- 6 collisions with a third party
  - 5 cases of collision with a pedestrian
    => 4 cases of pedestrians crossing in front of the tramway who did not see (or saw poorly) the arrival of the tramway.
    => 1 pedestrian fall from the platform and passing under the tram
  - 1 case of collision with a car => this event seems to be a suicide (the driver of a car “threw” himself onto the tram and caught fire)

3.1.3.g -  Other event

Thirty eight other events, causing 5 slightly injured people: vandalism, hooking of the overhead line, anchor cable breaking, collisions of third parties with the tramway system infrastructure, etc.. The “tram surfing” particular event appears (2 events).

2 cases of bicycles circulating on the platform. The driver avoided collision with the cyclist, but the bicycle was jammed under the train.

3.1.3.h -  End of track

Four cases of track end stops overruns were observed, causing 4 light injuries (2 due to loss of rail adhesion, 2 that may be put down to a lack of vigilance by the tram driver).
3.2 - Events

3.2.1 - Breakdown by type - evolution 2005-2014

3.2.1.a - All events - unprocessed data
The resurgence in the number of events declared in 2014 must be correlated with the increase in production by millions of km.

//\ The "peak" observed concerning passenger events for 2014 also comes from the events declared by a network which didn't declare them beforehand (see 1.3 The data).

3.2.1.b - All events - relative distribution
The breakdown remains globally the same over period 2005-2013.

The “peak” observed concerning passenger events for 2014 also comes from the events declared by a network which didn't declare them beforehand (see 1.3 The data).

Nevertheless, we see an increase in the proportion of passenger accidents and a slight fall in the proportion of collision with a third party.

Several elements are put forward by the operators to explain this:

- Observation of a trend by passengers to make less use of the grip resources available in the tram given the softer driving of the tramways, unlike buses.
- Tendency to claim for compensation.
- Communication campaigns carried out by urban areas dealing more often with the risks of collisions with third parties than the risks of passengers falling.
- Observation of customer growing older into trams (given the accessibility of the tramways).
- Increase in soft mode journeys (pedestrians / cyclists) causing emergency braking to avoid collisions and consequently leading to passengers falling into trams.

3.2.2 - Event monitoring indicator - comparison with bus systems

The number of events per 10 000 km is a usual monitoring indicator for tramway and bus network operators.

This year, we were able to obtain the bus production and accident type elements for the 5 most significant tramway networks only (whereas for previous years we had data for 8 networks).

The events taken into account for the buses are clearly identical to those defined for the tramways: collisions with third parties and passenger accidents mostly.

Applied to national level, we obtain the following table:

<table>
<thead>
<tr>
<th>Year</th>
<th>Bus</th>
<th>Tram</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>0.89</td>
<td>0.468</td>
</tr>
<tr>
<td>2006</td>
<td>0.84</td>
<td>0.465</td>
</tr>
<tr>
<td>2007</td>
<td>0.85</td>
<td>0.454</td>
</tr>
<tr>
<td>2008</td>
<td>0.84</td>
<td>0.390</td>
</tr>
<tr>
<td>2009</td>
<td>0.79</td>
<td>0.379</td>
</tr>
<tr>
<td>2010</td>
<td>0.77</td>
<td>0.346</td>
</tr>
<tr>
<td>2011</td>
<td>0.74</td>
<td>0.356</td>
</tr>
<tr>
<td>2012</td>
<td>0.76</td>
<td>0.346</td>
</tr>
<tr>
<td>2013</td>
<td>0.71</td>
<td>0.334</td>
</tr>
<tr>
<td>2014</td>
<td>0.66</td>
<td>0.367</td>
</tr>
</tbody>
</table>

The tram maintains a ratio in its favour, in comparison with buses.
3.3 - Events – analysis of STPG lines

3.3.1 - Introduction - definition of the panel

We designate "STPG" lines as opposed to "traditional" lines. This is a term used to easily identify the tramway lines built under the STPG decree of 2003.

These STPG lines are the lines for which commercial operation was launched from 2006.

Over the years 2007-2014, they represent the following production elements:

<table>
<thead>
<tr>
<th>Year</th>
<th>Km</th>
<th>Journeys</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>2007</td>
<td>22%</td>
<td>20%</td>
</tr>
<tr>
<td>2008</td>
<td>27%</td>
<td>27%</td>
</tr>
<tr>
<td>2009</td>
<td>28%</td>
<td>28%</td>
</tr>
<tr>
<td>2010</td>
<td>29%</td>
<td>29%</td>
</tr>
<tr>
<td>2011</td>
<td>33%</td>
<td>31%</td>
</tr>
<tr>
<td>2012</td>
<td>38%</td>
<td>34%</td>
</tr>
<tr>
<td>2013</td>
<td>44%</td>
<td>40%</td>
</tr>
<tr>
<td>2014</td>
<td>47%</td>
<td>43%</td>
</tr>
</tbody>
</table>

Table 03

3.3.2 - STPG lines - event monitoring indicator

The stabilisation of the last 4 years is not observed for 2014. It is correlated to the increase in passenger events observed for 2014.

/!/ However, this evolution should be tempered given the inclusion of passenger events for a "traditional line" network which did not count them beforehand (see 1.3. Events data).
3.4 - Breakdown of victims

3.4.1 - Year 2014

3.4.1.a - All victims

The number of victims from the events of 2014 stands at 1291; its breakdown according to the nature of the events is illustrated in the table below.

<table>
<thead>
<tr>
<th>Casualties</th>
<th>Third party victims</th>
<th>Passenger victims</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>%</td>
</tr>
<tr>
<td>Fire Explosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrocution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derailment</td>
<td>1</td>
<td>0.1%</td>
</tr>
<tr>
<td>Passenger events</td>
<td>847</td>
<td>65.6%</td>
</tr>
<tr>
<td>Collision between trams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collision with obstacle on track</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other event</td>
<td>5</td>
<td>0.4%</td>
</tr>
<tr>
<td>End of track</td>
<td>4</td>
<td>0.3%</td>
</tr>
<tr>
<td>Totals</td>
<td>1291</td>
<td>100%</td>
</tr>
</tbody>
</table>

The two main event categories that create victims are passenger events and collisions with third parties. Most victims observed are passengers.

However, collisions with third parties present a higher degree of seriousness since they are the origin of 36 severe victims observed (including 6 fatalities).

3.4.1.b - Passengers victims of passenger events

<table>
<thead>
<tr>
<th>Passenger event subtype</th>
<th>No. of events</th>
<th>Passenger victims</th>
<th>Subtype vict./total passenger vict.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall in the tram</td>
<td>712</td>
<td>645</td>
<td>80.44%</td>
</tr>
<tr>
<td>Fall from the tram on line</td>
<td>14</td>
<td>15</td>
<td>2.05%</td>
</tr>
<tr>
<td>Fall from the tram in station</td>
<td>54</td>
<td>46</td>
<td>4.24%</td>
</tr>
<tr>
<td>Fall from the platform</td>
<td>45</td>
<td>36</td>
<td>3.69%</td>
</tr>
<tr>
<td>Jamming in the tram</td>
<td>117</td>
<td>76</td>
<td>5.61%</td>
</tr>
<tr>
<td>Pulled along by the tram</td>
<td>7</td>
<td>5</td>
<td>0.68%</td>
</tr>
<tr>
<td>Total</td>
<td>975</td>
<td>847</td>
<td>86.87%</td>
</tr>
</tbody>
</table>

Concerning falls in the tram, 330 passenger victims, i.e. 51.1% of victims of passenger events are caused following emergency braking (proportion down compared to 2013).

We can see that the passengers who are victims of passenger events are mainly concerned by falling in the tram.
3.4.2 - Evolution 2005 – 2014

3.4.2.a - All victims

- Unprocessed data

Passenger victims accounts for the most significant share of victims.

As mentioned earlier, the "peak" observed concerning passenger events for 2014 also comes from the events declared by a network which didn't declare them beforehand (see 1.3 The data).

- Annual breakdown of victims according to event categories

Passenger events and collisions with third parties remain the most common events.

We observe an increase over the last three years in victims of passenger events and a slight fall in the proportion of victims of collision with a third party. This trend must be placed in correlation with the evolution in the number of passenger events and the number of collisions with third parties observed in 3.2.1.b. and with the declaration of passenger events by the network which did not declare them beforehand (see 1.3 Event data).
3.4.2.b - “Severe” victims

The severe victims are people who died within 30 days or who spent over 24 hours in hospital.

- Annual breakdown of severe victims according to event categories

The share of severe victims remains low overall. Collisions with third parties are the events which generate the most severe victims.

- Annual breakdown in the share of severe victims, distinguishing between seriously injured and fatalities

We will emphasise here again that the share of serious victims is low: around 4% of all victims in 2014. It should be remembered here that these statistical elements about the nature of the victims remain dependent on the information available and the awareness of the operator.

In addition, most of the annual evolution are due to the variation in seriously injured people, without which we cannot see a trend over these eight years.
3.4.2.c - Passenger victims

The graph below shows the annual evolution over the period 2005-2014 for passenger victims, distinguishing between the victims generated by emergency braking and the victims due to other causes.

![Graph showing annual evolution of passenger victims with and without emergency braking from 2005 to 2014.]

A significant share of the passenger victims is generated by emergency braking.

As mentioned earlier, the "peak" observed for 2014 also comes from the events declared by a network which didn't declare them beforehand (see 1.3 The data).

3.4.2.d - Passengers victims of emergency braking

We felt that it was interesting to analyse the cause of these emergency braking operations in more detail, while emphasising that this analysis depends on the information provided by the operators in their declarations.

The graph below illustrates the breakdown of passengers who are victims of emergency braking according to the different causes of these braking operations as well as their evolution over the period 2005-2014.

![Graph illustrating the distribution of passenger victims by emergency braking cause from 2005 to 2014.]

FRANCE - Accidentology of tramways 2014 – Analysis of reported events
The increase observed in 2014 must still be placed in correlation with the declaration of passenger events by the network which did not declare them beforehand.

In the declarations of events, we have identified six categories of emergency braking causing passenger victims:

- The "Controller handle action" category covers all emergency braking operations provoked by travelling in the urban environment; these are driving actions intended to avoid an accident (in particular collision with third parties).
- The “Automatic braking device” (or Automatic Train Protection - DAAT) category is an automatic train stopping system which can be found on a few networks with specific configurations such as tunnels, single track, or whose operating speed limit exceeds 80 km/h. Networks (or parts of these networks) equipped with this system have mainly been in commercial operation since 2008. The highest number of emergency braking activations took place during the debugging period (2008-2009); a few were caused by driving errors.
- The "Alarm Handle" category is for the device available to passengers when tram is leaving the station.
- The "Doors" category corresponds to the emergency braking provoked by a door opening detection, either by passengers (forcing) or due to a setting adjustment.
- The "Underrun device" category is for the device preventing bodies from being trapped under the tram or detecting obstacles on tracks.
- The "Technical" category denotes the technical malfunctions encountered on the rolling stock. Declarations from operators do not enable their nature to be defined accurately.
- Finally, the "Dead man device" category is the emergency braking following absence of activation of the dead man's switch by the driver.

Driving actions are by far the main cause of emergency braking operations with a rate that is always higher than 75%.

The share of the different technical causes, such as the "Automatic braking device (DAAT)" or the doors varies from one year to the next according to how the problems appear and/or are resolved (and as stated earlier, the accuracy of the operators' declarations).

It remains that the "Dead man device" category is a cause identified by operators for all years since 2005 and which has been increasing regularly since 2008 and represents around 8% of the causes of victims of emergency braking for 2014. However, it must be emphasised that the origin of the lack of activation of the dead man device is still unclear. They may be linked to improper handling by the tram driver, his drowsiness or his cognitive overload.

In addition, the share of severe victims within passengers who are victims of emergency braking operations is very low, between 0.2% and 2.6% over the period 2005-2014 (0.89 % in 2014).
3.4.3 - Monitoring of victims indicators

3.4.3.a - Overall results

The slight drop in third party victims is tending to stabilise.

The significant increase observed in 2014 must still be placed in correlation with the declaration of passenger events by the network which did not declare them beforehand.

3.4.3.b - Results for severe victims

The previous indicators calculated for severe victims remain within the same proportions in relation to all victims (from 1 to 100 for passengers and from 1 to 10 for third parties).

We do not observe any specific evolution over the period, considering that the increase observed in 2014 for the passengers/10Mjourneys must still be correlated to the declaration of passenger events by a network which did not declare them beforehand.
3.5 - Serious events

For the database statistical analysis requirements, we have defined, in agreement with the profession, the serious events category according to the following criteria:

- Serious bodily injury: fatality or seriously injured person or more than 5 victims,
- Significant material damage (including for the third party) or derailment of the tram after collision,
- Derailment during commercial operation in zone shared with third parties.

3.5.1 - Evolution 2005 – 2014

The serious events only represent a low share of all of the declared events, but a slightly higher proportion of the victims.

It must be specified here that not all of the victims are seriously injured.

If we put the specific nature of 2006 for the victims of serious events to one side, which is emphasised in § 4.1.2.b, we can see a drop in the share of serious events and victims of serious events since 2011.

3.5.2 - STPG lines - serious events

These lines started operating during 2006 (see § 3.3.1). The graph below characterises the evolution in the share of serious events for these lines.

No marked trend over the period.
4 - Collisions with third parties

4.1 - Breakdown by third parties

4.1.1 - Year 2014

With 1414 collisions in 2014, collisions with third parties represent 61.3% of all declared events and 36.9% of victims.

The graph below illustrates the breakdown of collisions and the victims caused according to the type of third party.

Collisions with private cars represent the vast majority of case; collisions with pedestrians, while much fewer, still generate a significant share of victims.

4.1.2 - Evolution 2005 – 2014

4.1.2.a - Collisions - overall results

The global variation in the breakdown of collisions according to third parties is low over the period analysed.
4.1.2.b - Victims of collisions - overall results

The breakdown of victims is different: we observe more marked variations for pedestrians and private cars, with an upward trend for this category since 2007. One specific feature in 2006 should be noted in the public transport, heavy goods category. Three collisions with this category, 29 victims in total.

4.1.2.c - Severe victims of collisions

The share of severe victims remains at a low level over the period - less than 7% of all victims for pedestrians.

However, this last category represents the most significant part of severe victims.
4.2 - Causes of collisions - evolution 2005-2014

4.2.1 - Disrespect for traffic signals
For this report, the "red light/stop" category was split into two.
It shows an increase in the proportion of red lights crossed, a trend which is not observed for the R24 light (see § 7 - Appendix - Reminder of the main road signals).

* The "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.

4.2.2 - Specific circumstance - crossing a tram coming from the opposite direction
The graph below presents the share of collisions with third parties whose circumstances show crossing of a tram coming from the opposite direction.
This circumstance remains low for all collisions with third parties, with less than 4% of cases. We do not observe a specific trend over the period.

4.3 - Monitoring of collisions indicators

4.3.1 - STPG lines – Monitoring of collisions indicators

In § 3.3.2 we presented a monitoring indicator for events per 10,000 km. We also know that not all networks adopt the same procedures in declaring certain events such as passenger accidents; 2014 was very specific in terms of this point of view (see 1.3 The data).

However, we are reasonably confident into the declarations of the collisions with a third party, both between the networks and in their continuity over time. A monitoring indicator for events per km seemed to us to be more relevant than the indicator presented in 3.3.2.

The graph below presents the evolution in the number of collisions per 10,000 km; the specific evolution for the STPG lines, defined in § 3.3 is also represented.

The general trend remains down overall, even if it is less marked over later years; the better "performance" of the STPG lines over these last few years should be noted, especially in 2014 (lowest ratio obtained since 2006) unlike traditional lines.
4.3.2 - Collisions at the beginning of operation

Some STPG lines are starting to have a significant number of years of operation (for some up to 8 years in 2014).

We felt that it was interesting to compare the rate of collisions for 10 000km of STPG lines in their first year of operation and for STPG lines in their fifth year of operation (period for which we estimated that start of operation difficulties are no longer encountered).

This shows that the number of collisions per 10 000 km for STPG lines falls by 60% between the first year of operation and the fifth year of operation.

Remember that the 2014 average ratio for the collisions per 10 000 km for an STPG lines is 0.177.

We see the same trend for the ratio related to the events.

**Graph 09**

10,000 km ratio of STPG lines - first and fifth year of operation

- First year: 0.289
- Fifth year: 0.178
- First year (All events): 0.434
- Fifth year (All events): 0.28
4.4 - Consequences of collisions - evolution 2005-2014

4.4.1 - Material consequences - derailment

We saw the physical consequences of collisions with third parties in the previous paragraphs. The graph below illustrates the material consequences of collisions: the significant consequences for third parties and for the system and the derailment of the tramway.

![Graph showing collisions with third parties - consequences ratio]

The share of significant material consequences remains below 15%. It does not present any significant evolutions over the period analysed. The increase observed until 2011 is not confirmed.

The share of derailments following a collision with a third party is very low, less than 1%.

4.4.2 - Aggravating factors

The graph below represents the share or aggravating factors involved in collisions with third parties.
Collisions with third parties, for which an aggravating factor was identified, constitute a very low share of all collisions; the maximum was reached in 2012 with a little over 1.5% of the total number of collisions concerning third party speeds.

Four aggravating factors are identified in the operators’ declarations:

- the "brake abuse" category denotes braking practices that use the magnetic brakes instead of emergency braking. By extending the braking times and distances, this practice leads to higher tramway speeds during impacts with third parties.
- the “tram speed” is considered excessive when it significantly exceeds the maximum speed for the zone in question or that of the instruction to be followed in relation to the accident scenario.
- the “third party speed” as an aggravating factor is assessed by the operator in relation to the tramway driver's declaration.
- finally, an "immovable object" aggravates the consequences of a collision by jamming the third party between the object and the tramway. The “immovable object” aggravating factor is present over the whole period, without necessarily being paramount every year.

We do not observe a marked trend over the period.
5 - Configuration analysis

The codification of tram lines enables the events to be distributed according to the different line configurations and so to identify the most accident prone zones, in particular for junctions.

We were able to present more detailed analysis 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 roundabouts and gyratories in conjunction with CEREMA (National Centre For Studies and Expertise on Risks, Environment, Mobility, and Urban and Country planning).

Given this observation, for the other configurations studied (simple crossings, residents’ access and turns) whose data could not be consolidated in 2014, analysis of data has not been carried over to this report.

The events taken into account in this chapter are collisions with a third party.

5.1 - Breakdown of collisions according to predefined configurations

5.1.1 - Evolution of collision breakdown 2005-2014

The graph below represents the breakdown of the collisions according to ten configurations: stations - without distinguishing between the different types, the on-street/off-street section, and the eight types of intersection.

Given their different operating mode, the distinction between the roundabouts (without the tram, the intersection operates as a conventional roundabout with give-way signs and priority to the ring) and the gyratories (even in the absence of a tram, all the conflicts between road vehicles are managed by traffic lights) is made. This is identified using the codification of tram lines by the selection of the "R11v" type (red, yellow, flashing yellow) for the entrance light signal of the roundabout / gyratory.

The collisions with third parties mostly occur in "turn" type intersections, in on street/off street sections, in simple junctions then for 2014 in pedestrian/cycle intersections, before the roundabouts.

We observe a fall in the proportion of accidents in roundabouts and an increase in the proportion in pedestrian/cycle intersections, in particular in 2014, that should be monitored.

No marked trend for the other types of intersection.
5.1.2 - Evolution in the breakdown of collision victims 2005-2014

The breakdown of victims is slightly different from the breakdown of collisions, with a higher share for stations.

![Distribution of breakdown of victims of collision per configuration](graph51)

For the evolution in victim breakdown over the period in question, the fall observed for collisions on roundabouts is confirmed in relation to the victims. In the same way, the upwards trend for the pedestrian/cycle intersection collisions is confirmed for the victims.

5.1.3 - Relative breakdown of the collisions according to the configurations

The graph below represents the 2005-2014 evolution for the share relating to collisions according to the configurations.

![Relative breakdown of collisions according to configuration](graph52)

The share for roundabouts and gyratories remains predominant in the collision risk across the period.
5.2 - Global analysis of the different intersection configurations

The configuration history must be kept when a new codification of a tram line is produced and monitored over time. In fact, during the life of a tramway system, its urban environment develops; in particular, this is the case for intersections whose characteristics may have been modified: their geometry, their illuminated signs or other components.

We therefore 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).

All of the graphs which will be presented in the following paragraphs use bars to represent the number of intersections (scale on the left) and curves to represent the number of collisions with third parties per intersection (scale on the right) over the period 2005-2014.

=> the intersections taken into account relate to the active sections (valid at the end of 2014 in the database).

=> the events taken into account relate to the collisions with a third party assigned to these sections.

Where possible (enough samples), we have also analysed the data relating to the "logged" sections.

5.2.1 - All intersections

The graph below illustrates the significant quantitative gap between the different types of intersection (scale on the left). The blue curve (scale on the right) represents for each type of intersection the ration of the number of collisions with third parties per intersection for the whole period 2005-2014.

We observe the same trend as graph 52.
If we take the sections which have been logged in the database since 2005, we have the following data:

<table>
<thead>
<tr>
<th>Type of intersection</th>
<th>No. «logged» intersections</th>
<th>No. associated collision with third parties</th>
<th>No. collisions with third parties per configuration on «logged» sections</th>
<th>As a reminder – No. collisions with third parties per configuration on active sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple junction</td>
<td>75</td>
<td>140</td>
<td>1.87</td>
<td>1.74</td>
</tr>
<tr>
<td>Turn left/right</td>
<td>89</td>
<td>331</td>
<td>3.72</td>
<td>2.22</td>
</tr>
<tr>
<td>Roundabout</td>
<td>89</td>
<td>517</td>
<td>5.81</td>
<td>4.54</td>
</tr>
<tr>
<td>Gyratory</td>
<td>4</td>
<td>19</td>
<td>4.75</td>
<td>5.51</td>
</tr>
<tr>
<td>Pedestrian cyclist crossing</td>
<td>141</td>
<td>29</td>
<td>0.21</td>
<td>0.13</td>
</tr>
<tr>
<td>Resident's access</td>
<td>16</td>
<td>20</td>
<td>1.25</td>
<td>0.78</td>
</tr>
<tr>
<td>General traffic section entry</td>
<td>141</td>
<td>29</td>
<td>0.21</td>
<td>0.13</td>
</tr>
<tr>
<td>Complex junction</td>
<td>30</td>
<td>58</td>
<td>1.93</td>
<td>2.27</td>
</tr>
</tbody>
</table>

This table enables us to see that the “number of collisions per logged configuration” ratio is higher than the current configurations ratio (except for the “general traffic entry” and "other intersection" categories). This enables us to demonstrate globally (for the data for which the sample size is large enough) the effectiveness of the modifications implemented by the City Authorities and the tram operating companies.

Throughout the document, the impact of signalling is analysed for the roundabouts. Please refer to § 7 - Appendix - Reminder of the main road signals for a summary explaining the different types of panels and light signals.

5.2.2 - Roundabouts and gyratories

5.2.2.a - Impact of geometric characteristics

Size of the roundabout/gyratory

The roundabouts or gyratories are codified in five main categories according to their size.

The curve for the number of collisions per type of roundabout or roundabout with lights in the graph below enables us to identify three “families” according to size: small roundabouts (R<14m), medium-sized roundabouts (14m<R<22m) and large roundabouts (R > 22m).

This graph also highlights the low number of mini roundabouts and double roundabouts, for which any statistic analyses must be interpreted carefully.

The data for gyratories must also be considered carefully given the lower number of configurations than roundabouts.

However, even the comparison on certain groups (example: roundabouts with a radius of under 14m) according to this variable is still of little relevance due to the incidence of other factors (e.g. entrance signs).

Given the low number of configurations for mini roundabouts, double roundabouts and crossable gyratories, these have not been studied in more detail.
Size of the roundabout ring (criterion only analysed for roundabouts as the sample for gyratories was too low)

The graph below distinguishes the ring width for each size of roundabout.

Regardless of the roundabout size, the best ratios are observed for the roundabouts whose ring is under 6m.

We also observe that the small roundabouts have the best ratios.
**Number of entrance lanes** *(analysis only made for roundabouts, sample for gyratories being too low)*

The graph below distinguishes the number of entrance lanes in the roundabout for each roundabout size.

Regardless of the roundabout size, the best ratios are observed for the roundabouts with a single entrance lane. Given the results displayed in the graphs above, it appears that the small roundabouts have the best ratios in terms of collisions with third parties. This ratio is better the smaller the ring size or the fewer entrance lanes there are. **This seems logical as this type of geometry limits the speeds around the tram tracks. We have not been able to analyse any link with with the traffic data in their absence.**

**5.2.2.b - Impact of traffic lights**

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

**Case of roundabouts**

As the codification for roundabout was verified in full this year, we wanted to observe the sections in finer detail, distinguishing between:
- the active sections whose coding did not change (no logging),
- the active sections which had logging to determine and evaluate the impacts of the evolutions made on the networks.

**A - The active sections whose coding did not change (no logging)**

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

For each of them, we have restated the number of active configurations and the "number of collisions by configuration" ratio.
The boxes with a red background correspond to the configurations for which the samples are the largest.

We observe the following elements:

- A diversity of configurations making detailed statistical analysis difficult (for example by integrating the size of the roundabout).

- With static sign for entrance, the ratio obtained with "reinforced R24" for crossing sign (2.36) is much better than with simple R11v (4.91) or the simple R24 (6.25) for crossing sign.

B - The active sections whose codification changed (logged)

In order to understand the impact of the evolutions to the sections, first of all we determined the types of evolution observed with an impact on traffic lights.

We studied the evolutions for the entrance sign (ES) and crossing sign (CS).

The following 10 categories appear:

<table>
<thead>
<tr>
<th>Category</th>
<th>Entrance Sign</th>
<th>Crossing Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>cat0</td>
<td>Unchanged</td>
<td>Unchanged</td>
</tr>
<tr>
<td>cat1</td>
<td>Unchanged (nothing or static)</td>
<td>R24</td>
</tr>
<tr>
<td>cat2</td>
<td>Nothing or static</td>
<td>R11j</td>
</tr>
<tr>
<td>cat3</td>
<td>R11j</td>
<td>Nothing or static</td>
</tr>
<tr>
<td>cat4</td>
<td>R11j</td>
<td>R24</td>
</tr>
<tr>
<td>cat5</td>
<td>Unchanged</td>
<td>R11v</td>
</tr>
<tr>
<td>cat6</td>
<td>Unchanged (R11j)</td>
<td>R24</td>
</tr>
<tr>
<td>cat7</td>
<td>R11j</td>
<td>R24</td>
</tr>
<tr>
<td>cat8</td>
<td>Unchanged (nothing or static)</td>
<td>R11j</td>
</tr>
<tr>
<td>cat9</td>
<td>Unchanged (nothing or static)</td>
<td>Nothing or static</td>
</tr>
<tr>
<td>cat10</td>
<td>Unchanged (nothing or static)</td>
<td>R11j</td>
</tr>
</tbody>
</table>

Category 0 means that the roundabouts saw a change in codifications that did not concern the traffic lights. These are often evolutions for visibility conditions (visual mask or visibility of the tram track).
The table below presents by category:

- The number of sections concerned (validity of the sample)
- The number of events on active section
- The number of events on logged section
- The ratio for "number of collisions per configuration" on active section.
- The ratio for "number of collisions per configuration" on logged section.

![Table 10 - The active sections whose coding changed](image)

The boxes with a red background correspond to the configurations for which the samples are the largest. We can therefore analyse categories 1 and 3 which lead to no traffic light for entrance of the roundabout and "R24 (reinforced)" for crossing sign in place of the simple R24.

We observe that the ratios observed with "R24 reinforced" for crossing sign enable a significant improvement in the number of collisions per configuration than with R24 simple for crossing sign.

**Case of gyratories**

The table below summarises the overall results for all possible configurations on gyratories.

For each of them, we have restated the number of active configurations and the "number of collisions by configuration" ratio.

![Table 11 - Active sections](image)

The boxes with a red background correspond to the configurations for which the samples are the largest. No specific trends emerge for the gyratories, especially as the samples are small. It seems that having reinforces traffic lights for crossing sign does not improve the ratios. We have not carried out the analysis on the logged sections as only four sections were modified.

It should be specified that these elements must still be considered carefully in that they do not take account of the local context, in particular the traffic data.
6 - Conclusions

6.1 - Constant factors
- The collision with third parties and passenger events are in the majority.
- The seriousness of victims is mostly observed during collisions with third parties.
- The place of roundabouts, gyratories and turn left or right in risky configurations.

6.2 - Reasons for satisfaction
- The low share of serious victims: less than 4% of all victims since 2007, as well as the stability of indicators of serious victims for passengers and third parties.
- The downward trend in the number of collisions per 10 000 km indicator for all tram networks.
- The favourable comparison of this indicator with a few bus networks.
- The low share of aggravating factors, including fixed obstacles and tramway speed, in collisions with third parties: less than 1.5% of the overall in 2014.

6.3 - Confirmations
- The share of the "crossing tramway' phenomenon is low in the accident type analysis: around 3% of collisions.
- The share of serious passengers victims involving emergency braking remains below 3% (0.89% in 2013).
- The increase in the proportion of events in pedestrian/cycle intersections.
- The increase in the share of passengers victims involving emergency braking related to dead man device which was observed in 2013.
- The following points were confirmed in relation to roundabouts :
  - For criteria related to geometry, better "No. of collisions/configurations" ratios appear for small roundabouts with a radius of under 14 m. The potential link with traffic data cannot be established due to a lack of data.
  - For criteria related to signalling, given the samples, only a global analysis was able to be carried out (without integrating the roundabout size). We observe that the ratios "No. of collisions/configurations" is better with "ReinforcedR24" for crossing sign and is a significant improvement compared to “simple R 24" for crossing sign, for roundabouts without traffic light for entrance sign.

6.4 - What remains of concern
- The proportion of pedestrian serious victims.
7 - Appendix – Reminder of the main road signs
<table>
<thead>
<tr>
<th>Type of signal</th>
<th>Name of signal</th>
<th>Number</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority signs</td>
<td>Give way (position sign)</td>
<td>AB3a</td>
<td><img src="image" alt="Give way sign" /></td>
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<td>Stop sign (position sign)</td>
<td>AB4</td>
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<td>Mandatory signs</td>
<td>Trams only</td>
<td>B27b</td>
<td><img src="image" alt="Trams only sign" /></td>
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<tr>
<td>Information signs</td>
<td>Trams crossing (position sign)</td>
<td>C20c</td>
<td><img src="image" alt="Trams crossing sign" /></td>
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<td>Warning signs</td>
<td>Trams crossing ahead</td>
<td>A9</td>
<td><img src="image" alt="Warning sign" /></td>
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<tr>
<td>Intersection traffic light signals</td>
<td>Intersection signals</td>
<td>R11v : red, yellow, green</td>
<td><img src="image" alt="R11v signal" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>R11j: red, yellow, flashing yellow</td>
<td><img src="image" alt="R11j signal" /></td>
</tr>
<tr>
<td>Type of signal</td>
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<td>Number</td>
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<td>Intersection traffic light</td>
<td>Intersection pedestrian</td>
<td>R12</td>
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<td>signals</td>
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<td>Bus intersection signals</td>
<td>R13b</td>
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<td>Cycle intersection signals</td>
<td>R13c</td>
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<tr>
<td>Directional signals</td>
<td>R14tg : turn left</td>
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<td><img src="image1.png" alt="Image" /></td>
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<tr>
<td></td>
<td>R14dtg : go straight and turn left</td>
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<td><img src="image2.png" alt="Image" /></td>
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<tr>
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<td>R14d: go straight</td>
<td></td>
<td><img src="image3.png" alt="Image" /></td>
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<tr>
<td></td>
<td>R14dtd: go straight and turn right</td>
<td></td>
<td><img src="image4.png" alt="Image" /></td>
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<td>R14td: turn right</td>
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<td><img src="image5.png" alt="Image" /></td>
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<td>Anticipation signals with</td>
<td>R16tg : go straight and turn left</td>
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<td><img src="image6.png" alt="Image" /></td>
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<td>flashing arrows</td>
<td>R16d: go straight</td>
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<td><img src="image7.png" alt="Image" /></td>
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<td>R16dtd: go straight and turn right</td>
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<td>R16tg : turn left</td>
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<td>R16td: turn right</td>
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<td>Public transport signals</td>
<td>R17</td>
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<tr>
<td>Public transport directional signals</td>
<td>R18g : left, R18d : right</td>
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<tr>
<td>Flow control signals</td>
<td>R22j : red, yellow, flashing yellow</td>
<td><img src="image3.png" alt="Image" /></td>
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<tr>
<td>Stop signal for all road users</td>
<td>R24 flashing red</td>
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<tr>
<td>Warning signal for all road users</td>
<td>R1 flashing yellow</td>
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<td>Public transport line crossing - pedestrian/cyclist signals</td>
<td>R25</td>
<td><img src="image6.png" alt="Image" /></td>
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<td>Intersections with barriers</td>
<td>IB</td>
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