ACCIDENTOLOGY OF TRAMWAYS

Analysis of reported events
- year 2011
- evolution 2004 - 2011
Case followed by

Michel ARRAS - STRMTG
Tel: 04.76.63.78.78. / Fax: 04.76.42.39.33.
E-mail: michel.arras@developpement-durable.gouv.fr

Authors

Michel ARRAS – Tram Division
Jean-Michel PASSELAIGUE – Tram Division (requests, graphics and translation)
1 - REMINDER ON THE SUBJECT OF THE DATABASE ........................................................................7
  1.1 - The fields in the database ........................................................................................................7
  1.2 - The codification of tram lines ....................................................................................................7
  1.3 - Data ............................................................................................................................................7

2 - SCOPE OF STUDY .......................................................................................................................8
  2.1 - Systems in operation ................................................................................................................8
  2.2 - Systems analysed .....................................................................................................................8
  2.3 - Evolution of the systems analysed ..........................................................................................9

3 - RESULTS ..................................................................................................................................10
  3.1 - General ....................................................................................................................................10
    3.1.1 - Overall data for 2011 .........................................................................................................10
    3.1.2 - Remarks concerning the victims .......................................................................................10
    3.1.3 - Remarks concerning the events ........................................................................................10
      3.1.3.a - Fire - explosion .............................................................................................................10
      3.1.3.b - Derailment .....................................................................................................................11
      3.1.3.c - Accidents to passengers .................................................................................................11
      3.1.3.d - Collision between trams ..............................................................................................11
      3.1.3.e - Collision with obstacle on track ....................................................................................11
      3.1.3.f - Collision with third parties ............................................................................................11
      3.1.3.g - Other events .................................................................................................................11
  3.2 - Events .....................................................................................................................................12
    3.2.1 - Breakdown by type – evolution 2003-2011 ......................................................................12
      3.2.1.a - All events - raw data ....................................................................................................12
      3.2.1.b - All events - relative distribution ..................................................................................12
    3.2.2 - Possible indicator for event monitoring: comparison with bus systems..........................12
  3.3 - Events – analysis of “STPG lines” .........................................................................................13
    3.3.1 - Introduction – definition of panel ......................................................................................13
    3.3.2 - STPG lines – event monitoring indicator ..........................................................................13
  3.4 - Breakdown of victims .............................................................................................................14
    3.4.1 - Year 2011 ...........................................................................................................................14
      3.4.1.a - All victims ......................................................................................................................14
      3.4.1.b - Passenger victims of passenger accidents ..................................................................14
    3.4.2 - 2004-2011 evolution ..........................................................................................................14
      3.4.2.a - All victims ......................................................................................................................14
      3.4.2.b - “Serious” victims .........................................................................................................15
INTRODUCTION

The purpose of this report is to present the results of the operation of the tram accident database for 2011, with the evolution of accidentology since 2004. This national database is created from declarations by operators. The “tram” term covers urban systems on rails or rail-guided tyres.

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 the number of crossings, the layout of various platform types and the 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 2004-2011, is one of the subjects of the report. As we announced in our previous report, tram operators have begun a new codification of their lines. This codification is more accurate and better suited to a more detailed analysis of configurations, including the intersections of roads with the trams.

Unfortunately, it was delayed and all the necessary checks have not been carried out. The analysis does not exploit all the potential resources of this codification.

In contrast, we will make a presentation of new analysis on issues revealed by the feedback experience or from the BEA-TT (land transport investigation office) during its work on accidents and observations contained in its reports.

It is, for example, the origins and consequences of emergency braking on passengers, opposite direction trams scenario, derailments consequences of collisions with third parties as well as the aggravating factors of these collisions.
1 - Reminder on the subject of the database

More detailed information on the database is provided in the 2004 tram accidentology report and the present Report will merely reiterate the essential points.

1.1 - The fields in the database

The database fields contain the following information:
- Network identification (city)
- 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.)
- Bodily, material and operating consequences (duration of disruption)
- Record of system parameters (according to driver’s statement or data from tachymetric system, tram number)
- Police report (yes or no)
- Circumstances of the event (summary of event, act of suicide, aggravating fixed obstacle, third part manoeuvre, etc.) with details of the third party if relevant
- Follow-up action taken (investigation in progress, planned modification, action plan launched, etc.)

1.2 - The codification of tram lines

Codification consists of describing the various tram line configurations in order to create a descriptive database common to all the lines. The system makes it possible to analyse events in 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 main changes introduced by the new codification concern intersections. Seven types of intersection were selected:
- simple junction
- turns
- gyratory or roundabout with traffic lights
- pedestrian / cycle
- resident's access
- ordinary site entry
- other intersection

Signalling is detailed for each of these configurations: static signals, light signals, upstream, dam, etc.. The possible presence of visual masks and ease of identification of the tram platform are also new codified information.

Detailed principles of the new codification in the guide « Codification des lignes de tram, nouvelle édition 2010 » on the STRMTG website.

1.3 - Data

The information comes from operator declarations. The serious efforts by operators to complete the database and codify their lines should be underlined. However, not all the information to be entered in the database is yet available for all networks, and declaration procedures differ from one network to another: some declare all events, while others declare only those events which are likely to result in a claim against their insurers.

As in previous years, we again see significant differences between networks, which leads us to remain prudent in considering the raw annual results and to give priority to analysing their evolution.
2 - Scope of study

2.1 - Systems in operation

Operational trams were present in 22 urban areas in 2011, representing 51 tram lines – 47 tram on rails and 4 tram on tyres.

2.2 - Systems analysed

In the analysis of accidentology, account was taken of the network lines for which production in km or journeys was declared. Thus certain lines which were operated commercially for only a very short period in the year and for which no production declaration was made are excluded from analysis for the year concerned. This was the case in 2006 for Clermont-Ferrand Line 1, T3 in Lyon and Paris, Montpellier Line 2, etc.

The networks analysed are summarised in the following table:

<table>
<thead>
<tr>
<th>Urban area</th>
<th>Type</th>
<th>Number of lines</th>
<th>Mkm</th>
<th>Mjourneys</th>
<th>Opening</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angers</td>
<td>tram on rails</td>
<td>1</td>
<td>0,47</td>
<td>3,60</td>
<td>25/06/2011</td>
<td></td>
</tr>
<tr>
<td>Bordeaux</td>
<td>tram on rails</td>
<td>3</td>
<td>4,78</td>
<td>66,52</td>
<td>20/12/2003</td>
<td></td>
</tr>
<tr>
<td>Caen</td>
<td>tram on tyres</td>
<td>2</td>
<td>1,27</td>
<td>8,62</td>
<td>18/11/2002</td>
<td></td>
</tr>
<tr>
<td>Clermont-Ferrand</td>
<td>tram on tyres</td>
<td>1</td>
<td>1,11</td>
<td>13,95</td>
<td>13/11/2006</td>
<td></td>
</tr>
<tr>
<td>Grenoble</td>
<td>tram on rails</td>
<td>4</td>
<td>3,94</td>
<td>44,65</td>
<td>05/09/1987</td>
<td>C line may 2006</td>
</tr>
<tr>
<td>Le Mans</td>
<td>tram on rails</td>
<td>2</td>
<td>1,41</td>
<td>13,07</td>
<td>14/11/2007</td>
<td></td>
</tr>
<tr>
<td>Lille</td>
<td>tram on rails</td>
<td>3</td>
<td>1,53</td>
<td>9,40</td>
<td>04/12/1909</td>
<td></td>
</tr>
<tr>
<td>Lyon</td>
<td>tram on rails</td>
<td>5</td>
<td>5,44</td>
<td>60,84</td>
<td>18/12/2000</td>
<td>T4 : 04/09</td>
</tr>
<tr>
<td>Marseille</td>
<td>tram on rails</td>
<td>2</td>
<td>1,24</td>
<td>15,69</td>
<td>26/06/2007</td>
<td></td>
</tr>
<tr>
<td>Montpellier</td>
<td>tram on rails</td>
<td>2</td>
<td>3,41</td>
<td>43,43</td>
<td>01/07/2000</td>
<td>T2 : 12/06</td>
</tr>
<tr>
<td>Mulhouse</td>
<td>tram on rails</td>
<td>3</td>
<td>1,26</td>
<td>13,30</td>
<td>12/05/2006</td>
<td>Tram-train : 12/10</td>
</tr>
<tr>
<td>Nancy</td>
<td>tram on tyres</td>
<td>1</td>
<td>1,00</td>
<td>10,11</td>
<td>28/01/2001</td>
<td></td>
</tr>
<tr>
<td>Nantes</td>
<td>tram on rails</td>
<td>3</td>
<td>4,66</td>
<td>66,60</td>
<td>07/01/1985</td>
<td></td>
</tr>
<tr>
<td>Nice</td>
<td>tram on rails</td>
<td>1</td>
<td>1,24</td>
<td>27,80</td>
<td>26/11/2007</td>
<td></td>
</tr>
<tr>
<td>Orléans</td>
<td>tram on rails</td>
<td>1</td>
<td>1,54</td>
<td>11,07</td>
<td>24/11/2000</td>
<td></td>
</tr>
<tr>
<td>Paris Île-de-France</td>
<td>tram on rails</td>
<td>3</td>
<td>3,80</td>
<td>106,87</td>
<td>06/07/1992</td>
<td></td>
</tr>
<tr>
<td>Reims</td>
<td>tram on rails</td>
<td>2</td>
<td>0,67</td>
<td>5,50</td>
<td>16/04/2011</td>
<td></td>
</tr>
<tr>
<td>Rouen</td>
<td>tram on rails</td>
<td>1</td>
<td>1,40</td>
<td>14,66</td>
<td>16/12/1994</td>
<td></td>
</tr>
<tr>
<td>Saint-Etienne</td>
<td>tram on rails</td>
<td>3</td>
<td>1,67</td>
<td>21,80</td>
<td>01/01/1881</td>
<td></td>
</tr>
<tr>
<td>Strasbourg</td>
<td>tram on rails</td>
<td>6</td>
<td>5,72</td>
<td>68,32</td>
<td>26/11/1994</td>
<td></td>
</tr>
<tr>
<td>Toulouse</td>
<td>tram on rails</td>
<td>1</td>
<td>0,85</td>
<td>4,36</td>
<td>11/12/2010</td>
<td></td>
</tr>
<tr>
<td>Valenciennes</td>
<td>tram on rails</td>
<td>1</td>
<td>1,18</td>
<td>6,21</td>
<td>03/07/2006</td>
<td></td>
</tr>
<tr>
<td><strong>22 urban areas</strong></td>
<td><strong>51</strong></td>
<td><strong>49,58</strong></td>
<td><strong>636,36</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3 - Evolution of the systems analysed

The evolution is represented by the graphs below: in numbers of urban areas and lines, then in production in km travelled and journeys.

**Number of urban areas and lines**

Graph 01

**Elements of production**

Graph 02
3 - RESULTS

3.1 - General

3.1.1 - Overall data for 2011
The number of declarations processed was 1758, breaking down as follows in accordance with the established list of undesirable events:

<table>
<thead>
<tr>
<th>Events</th>
<th>No</th>
<th>Total</th>
<th>Slightly injured</th>
<th>Seriously injured</th>
<th>Fatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire, explosion</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Panic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrocution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derailment</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Passenger accidents</td>
<td>522</td>
<td>519</td>
<td>512</td>
<td>7</td>
<td>512</td>
</tr>
<tr>
<td>Collision between trams</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Collision with obstacle on track</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collision with third parties</td>
<td>1176</td>
<td>409</td>
<td>372</td>
<td>35</td>
<td>299</td>
</tr>
<tr>
<td>Other events</td>
<td>23</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Totals</td>
<td>1758</td>
<td>940</td>
<td>896</td>
<td>42</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 03

Two categories of event account for the majority of declarations: collisions with third parties and passenger accidents.

3.1.2 - Remarks concerning the victims
It is important to define what is meant by a “victim” in this report.

Persons who do not emerge unharmed from an event are designated as victims and declared as such by the operators. This concept in no way prejudges the seriousness of personal injuries.

The definitions of serious injuries and fatalities are however those accepted and used within the European Union.

Serious injury = duration of hospitalisation more than 24 h.

Fatal = death within the 30 days following the event.

These statistical elements on the nature of the victims clearly depend on the information available and the extent of the operator's knowledge.

3.1.3 - Remarks concerning the events

3.1.3.a - Fire - explosion
3 events in 2011 without victims:

- Short circuit in a ground power supply system after heavy rain flooded the platform. Automatic disconnection of the traction current supply. On site, an explosion causes ejection of the protective metal plate of the cabinet.
- Bogie fire start due to a brake block following malfunction of a pressure relief valve.
- Smoke near a drawing room following a failure of electrical insulation of a feeder cable.
3.1.3.b - Derailment

Ten derailment events were reported in 2011:

- 4 derailments on line:
  A derailment caused by the presence of a post in the groove of the rail. The derailment led to a small offset in the first place of a train bogie through nearly three stations. This offset is not detected either by the driver or by travellers. Then it becomes much more important when passing a switch, and led to collide with several vehicles on the adjacent lane and the appearance of traction problems for the driver.
  A guiding default detected, but not taken into account, followed by a collision with a small wall (2 passengers shocked).
  A derailment following a closed signal crossing.
  A derailment due to a remote control error: passing a switch diverging route at the direct route speed.

- 6 events in terminus:
  Four crossings of an track end due to the drowsiness of drivers (a driver shocked).
  Two derailments when manoeuvring trains due to mechanical failures: breaking of a point blades spacer and point blades undetected bad plating.

3.1.3.c - Accidents to passengers

This category of event is analysed in the remainder of this document (Chapter 3.4).

3.1.3.d - Collision between trams

3 events in 2011:

- in degraded mode on a single track, almost frontal collision between two trains as a result of operating manager error.
- A driver slides on the brake pedal and collides with the preceding tram.
- A distracted driver collided with a train stopped at the terminus.

3.1.3.e - Collision with obstacle on track

21 collisions with various objects (trees, barriers, pedestrian bollards, metal or concrete studs, caddies, paving or other beams).

3.1.3.f - Collision with third parties

A detailed analysis of the category can be found in Chapters 4 and 5 of this Report. We now relate the circumstances of 2 fatal pedestrian events.

- Delayed reaction of tram driver surprised by the progress of a pedestrian which continues despite warnings of the driver using tram gong.
- The driver of the tram is surprised by an unexpected crossing of an elderly person, at night and out of a pedestrian crossing.

3.1.3.g - Other events

Twenty-three other events: vandalism, hanging overhead contact line, collisions of third party with tram system infrastructure, etc...
3.2 - Events

3.2.1 - Breakdown by type – evolution 2003-2011

3.2.1.a - All events - raw data

The increase in the number of events reported in 2011 was mainly due to operating of three new networks.

3.2.1.b - All events - relative distribution

Distribution remains homogeneous over the period 2004-2011, with no evident trend.

3.2.2 - Possible indicator for event monitoring : comparison with bus systems

The number of events per 10,000 km is a routine indicator for certain tram and bus systems. We obtained bus accident data for 8 tram networks. The events taken into account for buses are broadly the same as those for trams: essentially collisions with third parties and passenger accidents.
Applying this to all the networks which declared their production, we obtain the following graph:

Graph 06

According to this indicator, the steady decline observed for trams since 2004, gets interrupted in 2010. The comparison with buses gives advantage to the tram system.

3.3 - Events – analysis of "STPG lines"

3.3.1 - Introduction – definition of panel

We use the term “STPG lines” by contrast with “conventional lines”. This a linguistic device to allow easy identification of tram lines built in accordance with the STPG Decree of 2003.

This means that STPG lines are those which entered commercial operation from the year 2006.

They are all on the years 2007-2011, the following production elements :

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Km</td>
<td>5 %</td>
<td>22 %</td>
<td>27 %</td>
<td>28 %</td>
<td>29 %</td>
<td>33 %</td>
</tr>
<tr>
<td>Journeys</td>
<td>4 %</td>
<td>20 %</td>
<td>27 %</td>
<td>28 %</td>
<td>29 %</td>
<td>31 %</td>
</tr>
</tbody>
</table>

Table 07

3.3.2 - STPG lines – event monitoring indicator

After a period of steady decline since 2004, the number of events to 10 000 km indicator increases slightly in 2011, for the conventional lines as for STPG lines.
3.4 - Breakdown of victims

3.4.1 - Year 2011

3.4.1.a - All victims

The number of victims resulting from events in 2011 amounts to 940. It breaks down as follows according to the nature of the events and the victims:

<table>
<thead>
<tr>
<th>Victims</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>3</td>
<td>0,3 %</td>
</tr>
<tr>
<td>Passenger accidents</td>
<td>519</td>
<td>55,2 %</td>
</tr>
<tr>
<td>Collision between trams</td>
<td>3</td>
<td>0,3 %</td>
</tr>
<tr>
<td>Collision with fixed obstacles</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Collision with third parties</td>
<td>409</td>
<td>43,5 %</td>
</tr>
<tr>
<td>Other events</td>
<td>6</td>
<td>0,6 %</td>
</tr>
<tr>
<td>Totals:</td>
<td>940</td>
<td>100 %</td>
</tr>
</tbody>
</table>

The two main events which give rise to victims are passenger accidents and collisions with third parties. The majority of victims observed are passengers.

Collisions with third parties are however more serious and account for the 37 serious injuries observed (2 fatalities and 35 seriously injured).

3.4.1.b - Passenger victims of passenger accidents

Falls in the tram | 409 | 78,8 % | Including 320 78% after emergency braking
Falls from the tram at the station | 24 | 4,6 % |
Falls from the platform | 14 | 2,7 % |
Trapping in the tram | 60 | 11,6 % |
Dragging by the tram | 11 | 2,1 % |
Vandalism | 1 | 0,2 % |

3.4.2 - 2004-2011 evolution

3.4.2.a - All victims

- Raw data

Passenger victims have the largest share of victims.
Passenger accidents and collisions with third parties continue to be the predominant events resulting in victims. No significant change over the period 2004-2011.

### 3.4.2.b - "Serious" victims

Seriously injured victims correspond to fatalities within 30 days or more than 24 hours of hospitalisation.

On the whole, the proportion of serious victims among all victims remains small. Collisions with third parties create a greater proportion of serious victims than passenger accidents.

Moreover, the essential part of the annual change concerns the variation in the number of seriously injured, although it is not possible to discern a trend over these five years.
### 3.4.2.c - Passenger victims

The graph below shows the annual change over the period 2004-2011 of passenger victims distinguishing those generated by an emergency braking of those with other causes.

Graph 09bis

### 3.4.2.d - Passenger victims of emergency braking

It seems interesting to analyze in more detail the cause of the emergency braking, while this analysis is dependent on the accuracy provided by operators in their declared events.

The graph below shows the distribution of passengers victims of emergency braking according to the different causes of these breakings and their evolution over the period 2004-2011.

Graph 09ter

We identified in the declarations of events six cases of emergency braking causing passenger victims:

- **The “Others” category** includes all emergency braking caused by traffic in urban areas, it includes actions of tram drivers designed to avoid a collision with third parties.
- **Some networks with specific configurations have trams equipped with automatic braking systems,** for example tunnels or on single track or whose operating speed exceeds 80 km/h. Networks (or parts of these networks) equipped with this device have been in commercial operation since 2008. The largest number of emergency braking occur during the testing period, some were caused by driving error.
- **The “Doors” category** is the emergency braking caused by opening doors, either because of travelers (forcing) or due to maladjustment of door system.
- **“Alarm Handle” category** is for the device available to passengers when tram is leaving the station.
- **“Technical” category** means technical malfunctions during testing periods. The event declarations of operators do not allow to identify the nature.
- **Finally, the “Dead man system” category** is for the emergency braking resulting from the absence of activation of the dead man handle by the driver.

Driver actions are by far the leading cause of emergency braking at a rate still above 75%.
The chart below shows the breakdown of passenger victims of emergency braking by the last three causes identified above.

Graph 09ter%

The share of various technical reasons, such as doors or automatic breaking system 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).

Nevertheless, the dead man system is an identified cause by operators for all years since 2005 and has for the past five years a significant cause of victims of emergency braking. It should be noted that the origin of the lack of activation of dead man systems remains unclear. They may be related to the drowsiness of the tram driver, his cognitive overload or improper handling.

Moreover, the proportion of serious victims among passenger victims emergency of emergency braking is very low, between 0.3% and 2.6% over the period 2004-2011.

3.4.3 - Indicators for monitoring victims

3.4.3.a - Overall results

No significant change for both indicators : passenger victims and third party victims over the period 2004-2011, even if they know a slight increase on 2011.

The deaths indicator fell sharply in 2011, but based on small numbers, it is more sensitive.

3.4.3.b - Results for seriously injured victims

Previous indicators calculated for the seriously injured victims remain in the same proportions relative to all victims (1 to 100 passengers and 1 to 10 for the third).

The indicator of seriously injured victims does not follow the evolution of the indicator of all victims, but we do not see evolution characteristic of the period.
3.5 - Serious events

For the purposes of a statistical analysis of the database, we have, with the agreement of the profession, defined serious events in terms of the following criteria:

- Serious bodily injury: fatality or serious injury or more than 5 victims
- Significant physical damage (including for the third party) or derailment of the tram
- Derailment event during commercial operation in a zone shared with third parties

3.5.1 - 2004-2011 evolution

Serious events represent only a small proportion of all declared events, but a larger proportion of victims.

We should state here again that not all victims were seriously injured.

If we disregard the peculiarity in the year 2006 concerning the victims of serious events, a point underlined in § 4.1.2.b we observe a rising trend in the proportion of serious events and victims while that of victims does not show a firm trend.

3.5.2 - STPG lines - serious events

These lines entered service in 2006 (cf. § 3.3.1). The following graph shows the evolution of serious events for these lines.

No marked trend over the period.

However please note that the proportion of serious events STPG lines shows a significant increase in 2011.
4 - COLLISIONS WITH THIRD PARTIES

4.1 - Breakdown by third party

4.1.1 - Year 2011
With 1176 events in 2011, collisions with third parties represent 67% of all reported events and 44% of victims.
The breakdown of these collisions and the resulting victims according to the type of third party is shown in the following graphic.

Graph 18

Collisions with private cars account for the great majority of cases. Collisions with pedestrians are much less numerous but create an equivalent proportion of the victims.

4.1.2 - 2004-2011 evolution

4.1.2.a - Collisions - Overall results

Graph 19
The overall variation in the breakdown of collisions according to the third party was small for the period analysed.

4.1.2.b - Victims of collisions - Overall results

Graph 20
The breakdown of victims is different: We see more marked variations for pedestrians and private cars. We note lorries as a particular feature in 2006 for the public transport category. Three collisions in this category resulted in a total of 29 victims.
4.1.2.c - Serious victims of collisions

The proportion of serious victims in collisions remains low (less than 6% of total pedestrian victims). For this most represented category, the upward trend observed until 2010 is not confirmed.

4.2 - Causes of collisions - 2004-2011 evolution

4.2.1 - Respect for signals

No significant trend is seen in the evolution of the proportion of crossings according to the type of signalling. Non-compliance with R17 signals (a few cases per year) by tram drivers still occurred in 2011, even though the offence represents a very low proportion of causes of collision in the last 5 years.

4.2.2 - Special circumstance - opposite direction tram

The graph below shows the proportion of collisions with third parties whose circumstances show an opposite direction tram.

This circumstance remains low for all collisions third with less than 4% of cases. However we note an upward trend since 2007.

The population of pedestrians and cyclists is more concerned with about half of all the other third parties.
4.3 - Indicators for monitoring collisions

We presented in § 3.3.2 an indicator for monitoring events reported to 10 000 km. We also know that all the networks do not adopt the same procedure in the declaration of certain events such as passenger accidents.

However, we are reasonably confident in the consistency of statements collision with third parties, as between the networks and as their continuity over time. A monitoring indicator consisting in collisions reported to kilometres therefore seems more relevant than the one which was presented in 3.3.2.

The graph below shows the evolution of the number of collisions at 10 000 km, as well as evolution of STPG clean lines, defined in § 3.3.

The general trend is a reduction: note the better performance of STPG lines over the last years. In contrast, traditional lines show a rise in this indicator for the year 2011.

4.4 - Collisions when starting operation

Many lines have been operated in recent years, in cities that already have a tram network (4 cities), or in cities those for whom it was the first line (10 cities).

The following analysis focuses on the number of intersection collisions occurred during the first 24 months of operation.
4.5 - Consequences of collisions - evolution 2004-2011

4.5.1 - Physical impact - derailment

We have seen the consequences of collisions with third parties in the preceding paragraphs. The graph below illustrates the physical impact of collisions: the important consequences for third parties as to the system, and the tram derailment.

![Graph 51](image)

The share of important physical impact remains below 15%, it tends to grow over the period 2004-2011. The share of derailments in a collision with a third party is very low, less than 1%, it does not change significantly over the analysed period.

4.5.2 - Aggravating factors

The graph below shows the share of aggravating factors involved in collisions with third parties.

![Graph 52](image)

Collisions with third parties for which an aggravating factor has been identified is a very small proportion of all collisions, the maximum is reached in 2010 with 1% of the total number of collisions. Four aggravating factors are identified in the declarations of operators:

- The "breaking pad abuse" means the practice of using the magnetic brake pads instead of an emergency braking. This practice extends the time and braking distances, thus leading to higher speed of tram during impacts with third parties.
- Speed tram is considered excessive when it greatly exceeds the speed limit of the area or of the set point to follow considering the accident scenario.
- The "third party speed" does not require details.
- Finally, a "fixed obstacle" aggravates the consequences of a collision, jamming third party vehicles between the obstacle and the tram.

The fixed obstacle is the aggravating factor present throughout the period without being dominant each year.
5 - ANALYSIS OF CONFIGURATIONS

The codification of lines allows an analysis of the breakdown of events according to the various configurations of lines, and thus allows identification of the most accident prone zones, particularly for intersections.

Recodifying tram lines has been initiated, but it has been delayed as pointed out in the introduction, and we are now in a phase of verification and correction. The present analysis is not complete and does not exploit all the possibilities, especially in comparison configurations according to the signals. Complement will be made during the first half of 2013 in the analysis of configurations.

5.1 - Breakdown of collisions according to predefined configurations

5.1.1 - Evolution of the breakdown of collisions for 2004-2011

The following graphic shows the breakdown of collisions and victims observed (passengers + third parties) according to the various configurations adopted.

Graph 28

Collisions with third parties occur mainly in the intersections with “turn” type, roundabouts and simple crossings and reserved lane.

We observe no significant trend in the evolution of the breakdown of collisions over the period.

5.1.2 - Evolution of the breakdown of victims for 2004-2011

Graph 29

The breakdown of victims is slightly different from that of collisions, with a greater proportion of stations.

We also observe no significant trend in the evolution of the breakdown of victims over the period.
5.1.3 - Relative breakdown of collisions according to configuration

The following graphic shows the 2004-2011 evolution in the relative proportion of collisions according to configuration.

We observe that the proportion of roundabouts is predominant in the collision risk over the entire period.

5.2 - Overall analysis of various configurations of intersections

The construction of a new codification must be accompanied by the conservation of historical configurations. Indeed, during the life of a tram system, the urban environment evolves, in particular we have intersections whose characteristics have been modified: geometry, light signals or other components. In preceding codification, these changes were taken into account by adding new sections which were assigned new events.

Checks and corrections mentioned above concern history of sections as well as the proper allocation of events and environment as it was when this event occurred.

In the absence of a full feedback of the tram operators on these checks, it is impossible to have a detailed analysis of the different types of configuration, eg depending on their signaling.

However, an overall analysis over the period 2004-2011 is possible in order to identify some interesting configurations layouts regarding to their accident rate.

5.2.1 - All intersections

This graph complements the previous graphic illustrating the difference between the number of different types of intersection (left scale).

The blue curve (right scale) is for each type of intersection, the number of events per intersection for the entire period 2004-2011.
5.2.2 - Impact of the C20c sign

C20c sign is a position sign for a tram line crossing. The codification identifies this sign for some "simple" intersections.

The following graphs represent the number of intersections (left scale) with bars, the number of events per intersection (right scale) with a curve.

**5.2.2.a - Simple crossing**

![Graph 42a](image)

**5.2.2.b - Resident's access**

![Graph 42b](image)

These two graphs show the low influence of the C20c sign on the ratio for these types of intersection. This information will allow us to assess the impact of the light signaling independently of static signage.

5.2.3 - Impact of geometrical characteristics of roundabouts

**5.2.3.a - Size of roundabouts**

Roundabouts or gyratories are coded into five main categories according to their size.

The curve of the number of events per type of roundabout on the graph below allows us to identify two "families" according to size: small roundabouts (radius <14m) and medium or large roundabouts (radius>14m).

This graph also highlights the low number of mini roundabouts and double roundabouts, for those any statistical analysis should be interpreted with caution.

![Graph 47](image)
5.2.3.b - Size of ring
The three graphs below distinguish the number of lanes on the ring of each roundabout size.

- Roundabouts < 14m

![Graph 48a](image)

- Roundabouts 14m – 22m

![Graph 48b](image)

- Roundabouts > 22m

![Graph 48c](image)

The impact of number of lanes in a roundabout ring is very similar for medium and large roundabouts, with a radius greater than 14m. This effect is slightly more pronounced for small circles of radius less than 14m. Both families previously identified by roundabout size are confirmed by the width of the ring.

5.2.4 - Impact of the position of the tram platform in the "turn" type configuration
The chart below illustrates the impact on the ratio of events relative to the position of the platform from adjacent roads, into “turn type” intersections.

![Graph 43](image)

For “turn” type intersections, either if the position of the platform in the tram remains axial or lateral, or it changes of type in the intersection, the event ratio remains almost identical (between 2.34 and 2.56 events per type of configuration).
6 - Conclusions

➢ **Constant factors**
  - The breakdown of events according to their type (passenger accident, collision with third party, etc.)
  - The breakdown of events according to various line configurations
  - The position of roundabouts/gyratories in hazardous configurations

➢ **Reasons for satisfaction**
  - The low proportion of serious victims: fewer than 6% of all victims since 2007, and stability of indicators for these victims, passengers and third parties
  - Stability of indicators for number of events and number of collisions at 10 000 km for all lines
  - Favourable comparison of this indicator with some bus networks
  - The low proportion of aggravating factors, including fixed obstacles in collisions with third parties which remains less than 1% of the total

➢ **New teachings or confirmations**
  - The share of the "opposite direction tram" is low in the whole accidents, about 3% of collisions.
  - This share has been rising since 2007
  - The share of the passenger accidents victims caused by an emergency braking related to the dead man system remains below 10%
  - The share of the serious victims of passenger accidents caused by an emergency braking is less than 3%
  - There are two main families of roundabouts/gyratories in terms of accident: small roundabouts of radius less than 14 m and those of radius greater than 14 m

➢ **What remains preoccupying**
  - The increasing tendency on the part of serious events and the victims of these events over the period 2004-2011
  - Progression from serious physical impact about that period

➢ **Next analysis**
  - Detailed analysis of various configurations of intersections, include their signaling
  - They should be able to be made in the first half of 2013