TECHNICAL GUIDE

STRMTG
SERVICE TECHNIQUE DES REMONTÉES MÉCANIQUES ET DES TRANSPORTS GUIDÉS

GUIDED TRANSPORT

TECHNICAL GUIDE FOR THE INSTALLATION OF FIXED OBJECTS NEAR TRAMWAY/ROAD INTERSECTIONS

MINISTÈRE CHARGÉ DES TRANSPORTS
Liberté
Égalité
Fraternité

Version 3 of July 2021

Subject - Scope - Recipients

This technical guide explains:

- the principles for the installation of fixed objects near tramway / road vehicle intersections for tramway networks.

It applies to the following systems under Decree STPG 2017-440:

- *tramways*;
- *mixed systems,* for the part operated using the “line-on-sight driving” principle;
- *light rail systems,* for the part operated using the “line-on-sight driving” principle.

It is intended for all professionals in the guided public transport sector: Transport authorities (AOT), owners, operators, contractors, engineering firms, qualified bodies, manufacturers of yielding objects (poles, posts, barriers, light signal masts, etc.) road managers, infrastructure managers.

The provisions of this guide are meant to provide technical solutions that are not regulatory in nature. However compliance with them implies compliance with regulatory requirements and/or the achievement of a sufficient level of safety. If they are not followed, substantiation must be provided.
The provisions of this guide in no way preclude compliance with regulations other than those relating to the safety of the system or installation concerned.

Revision history

Version number	Date	Description
Draft	February 2007	Creation of the technical guide based on the working group meetings and their minutes.
Version 1	04/04/2007	Approval of the technical guide.
Version 2	1/26/2012	Addition of Appendix 4 - guide to establishing a Yielding Object Substantiation Report for Manufacturers.
Version 3	July 2021	Guide update

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Translated into English by Connected Language Services.

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Abbreviations

CEREMA	*Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement* - Centre for Studies and Expertise on Risks, the Environment, Mobility and Urban Planning
DPS	Preliminary safety file
EB	Emergency braking[1]
TP	Tramway Path[1]
IISR	National Technical Instruction for Road Safety
RSE	Operational Safety Rules
SETRA	Road and Highway Engineering Department
SLT	Traffic lights
STRMTG	Technical Service in Charge of Safety for Ropeways and Guided Transport
TIV	Speed indicator
LV	Light vehicle[1]
ZLOF	Fixed object-free zone

1 See Glossary.

Glossary

Line-of-sight driving principle	The driving principle adopted by the driver, who adapts their speed and driving to what they see.
Emergency braking	This is EB3 according to standard EN 13452-1 on Railway applications - Braking - Mass transit brake systems, Part 1: performance requirements.
Tramway Path (TP)[2]	The tramway structure gauge is the maximum envelope, including the "Rolling Stock Manufacturer" & "Infrastructure" dynamic gauge and the air gap, in which the rolling stock is likely to be found. The static gauge is the space occupied by a tram when at a standstill. The "Rolling Stock Manufacturer" dynamic gauge uses the static gauge to take into account the displacements linked to the play and wear specific to rolling stock in motion. It is calculated in straight and curved alignment, and takes into account the following displacements: • depressions / hollows; • wear, slack and deflection due to the wheels, bogies and body; • wear and inclinations of all suspensions compressed to the stop. The "Rolling Stock Manufacturer" & "Infrastructure" dynamic gauge takes into account additional displacements due to play and wear related to the track, with respect to the "Rolling Stock Manufacturer" dynamic gauge: • track laying tolerance; • wear of the track. The Air Gap is an additional safety margin on either side of the dynamic gauge. This air gap is usually 15 cm.
Light vehicle	In this guide, a light vehicle is considered to be a motor vehicle with at least four wheels and a gross vehicle weight of 3.5 metric tonnes or less. These include the following categories of Article R 311-1 of the French Highway Code: M1 category vehicles, passenger car, N1 category vehicles, vans, general purpose vehicles weighing less than 3.5 tonnes.

2 Definition taken from the CEREMA (formerly CERTU) technical guide entitled "Tramways and pedestrians - Materialization of the tramway path" (2013)

<table>
<tr><td>Cruising speed[3]</td><td>The cruising speed is the maximum speed allowed in the zone, either by cruising speed in the Operational Safety Rules or by speed indicator (TIV) in the zone.

Its value can be modified in the following cases:
• Station with a stop near the intersection, for which a tram will be considered deadheading and not stopped;
• Speed limited by TIV or cruising speed near the zone.

For these cases, the typical tram speed can be used to define the speeds to be taken into account, considering a tram acceleration or deceleration of 1.2 m/s².</td></tr>
<tr><td>Technical speed[3]</td><td>The technical speed is the "natural" driving speed adopted by a driver taking into account the geometric characteristics and the environment of the area in question (urban area, intersection, etc.).
This could be, for example, the comfortable speed in a curve linked to a transverse acceleration of around 1 m/s².
This speed will be determined by rounding the calculated speed up to the next 5 km/h.</td></tr>
<tr><td>Credible speed[4]</td><td>A speed limit in an area is considered credible (followed by drivers) if it is close to the technical speed of the area.

The following empirical values should be adopted for the relationship between technical speed and expert credible speed:

<table>
<tr><td>Technical speed</td><td>Maximum decrease for an imposed speed to be credible</td></tr>
<tr><td>V ≥ 50 km/h</td><td>– 20 km/h</td></tr>
<tr><td>30 km/h ≤ V < 50 km/h</td><td>– 15 km/h</td></tr>
<tr><td>20 km/h ≤ V < 30 km/h</td><td>– 10 km/h</td></tr>
<tr><td>V < 20 km/h</td><td>– 5 km/h</td></tr>
</table></td></tr>
</table>

3 Concept inspired by the "Safety of tramway maneuvering areas" working group

4 Concept defined by the "Safety of tramway maneuvering areas" working group

Introduction

There are hundreds of collisions between light vehicles and trams at intersections every year on French tramway networks.

While the impacts are not always major, they can be significantly worsened by the intersection's design. In particular, when an object is located directly downstream of the intersection in relation to the tram's direction of travel, the light vehicle may be crushed between the tram and the object.

This has already happened several times and has often led to very serious injuries and even death.

In the remainder of this guide, the term "tramway" will be used interchangeably for tramway systems, and for mixed systems and light rail systems operated using the line-of-sight driving principle.

1 - Purpose and limitations of the guide

1.1 - Purpose of the guide

Without undermining any other regulations or rules of practice in force, this guide defines the concept of fixed objects and the rules for their installation in order to limit the impacts of a collision between a tram and a light vehicle at an intersection. Only the aggravation by a light vehicle being crushed between the tram and the fixed object is covered.

This guide defines the zones that must be free of fixed objects.

1.2 - Scope of the guide

1.2.1 - Systems concerned

The recommendations defined in this guide apply to the following projects for which the Preliminary Safety File (DPS) has not yet been approved as of the last revision date of the guide:

- any new tramway lines;
- any extension of a tramway line;
- any substantial changes which create a new fixed object-free zone (ZLOF) or change the geometry of an existing ZLOF.

For the above-mentioned projects not yet commissioned but for which the DPS has been approved at the date of the last version of this guide, the recommendations of this guide must be taken into account wherever possible. Otherwise, the recommendations of Version 2 of January 26, 2012 of the Guide for the Installation of Fixed Objects near Tramway/Roadway Intersections shall apply.

In the event of non-substantial changes to an intersection of a system in service that result in the creation of a new ZLOF or a change in the geometry of an existing ZLOF, the changes must take into account how existing fixed objects are to be handled. If they are not addressed, this must be duly substantiated on a case-by-case basis.

In the event of non-substantial or substantial changes to an intersection of a system in service not involving the creation of a new ZLOF or changes to the geometry or length of an existing ZLOF, the changes must, wherever possible, take into account how existing fixed objects are to be handled.
In the case of networks with an active Regularized Safety File, the time required to process the project will be given priority.

For guided transportation systems in service not subject to Decree STPG 2017-440 as of April 1, 2017, if safety issues related to fixed objects at intersections are identified during the assessment of the safety files (see Article 105 of the STPG Decree), solutions will need to be explored. Among the possible solutions, it is reasonable to consider that actions on urban planning and integration (improvement of the legibility and understanding of the sites) aimed at reducing the occurrence of collisions must be given priority. If not, actions targeting the location of fixed objects must be considered and the guide can then be considered as the reference.

1.2.2 - Types of intersections concerned

The intersections concerned are those between the tramway tracks and public or private roadways, including neighboring accesses and general traffic area entries/exits.

Intersections with barriers are included in the scope.

Intersections between tramways and pedestrian and/or cycle-only lanes do not fall within the scope of the guide.

2 - Concept of fixed objects

2.1 - Definition of fixed object

A “fixed object” means any rigid object with a height, in relation to the running surface of light vehicles, of more than 0.20 m, with a resisting torque of more than 570 daN.m [5].

2.2 - Catalog of fixed objects (non-exhaustive list)

The purpose of this section is to provide examples of various objects that may be considered fixed objects and which need to be dealt with, for example by making them yielding, or which should be removed from the ZLOF.

Illustrations of the items below are provided in APPENDIX B .Fixed objects.

2.2.1 - Trees

Trees, whose diameter, measured at the base of the trunk, is (or will be) greater than 0.10 m, are considered fixed objects.
Species planted near intersections that are likely to encroach on ZLOFs due to their growth should also be taken into account.

At the design stage, it must be demonstrated that the tree species is not likely to become a fixed object.

2.2.2 - Traffic sign/signal structures, public lighting

In the case of traffic signal structures, some structures must have a maximum allowable moment of 570 daN.m, in accordance with IISR[6].

2.2.3 - Telecommunication poles, gantries, overhead contact line structures, electrical cabinets

2.2.4 - Street furniture (posts, barriers, stone/concrete bollards, etc.) and barrier gate housing units

2.2.5 - Masonry

Structural piles, walls (corner or wall of a building, retaining wall), concrete structures, curbs, etc.

5 Value from the CEREMA (formerly SETRA) technical guide entitled: "Managing lateral objects on main roads outside agglomerations" (2002 edition)

6 IISR, Part I, Article. 6.

2.2.6 - Platform access area

2.2.7 - Association of yielding objects

The danger associated with the accumulation of yielding objects is detailed in Section 2.3.5-Danger related to the accumulation of yielding objects.

2.3 - Special cases

2.3.1 - Ballasted tracks

Ballast is not considered a fixed object as defined in this guide.

2.3.2 - Objects near parking spaces in mixed traffic areas in running sections

Exits from parking spaces in mixed traffic areas in running sections are not considered intersections and are not subject to the application of this guide.

2.3.3 - Anti-intrusion pits

Anti-intrusion pits are not considered fixed objects as defined in this guide.

2.3.4 - Platform access area geometry

The platform access area is understood as the portion connecting the sidewalk to the platform.
In fixed object-free zones (ZLOF), platform access areas whose geometry meets the criteria defined below are not considered fixed objects (see Figure 1, Figure 2, Figure 3).
The following two geometric criteria must be met simultaneously and in every plane:

- Altimeter characteristics:
  - the lowest point of the platform access area (Z_1) must have an elevation strictly lower than 20 cm in relation to the level of the top of the rail,
  - the α angle(s) defined by the cross-sections between the (Oxz) plane and the ramp planes passing through
    Z1, Z2, Z3...Zk must always be less than or equal to 45°,
- Cross-sectional characteristics:
  - the β angles defined by the cross-sections between the (Oxy) plane and the platform edge planes (vertical planes) passing through Y_1, Y_2, Y_3...Y_k must always be less than or equal to 45°.

Figure 1: Platform access area in 3 dimensions, with an example of two geometrical connections (Platform / Platform edge and Platform edge / Access ramp)

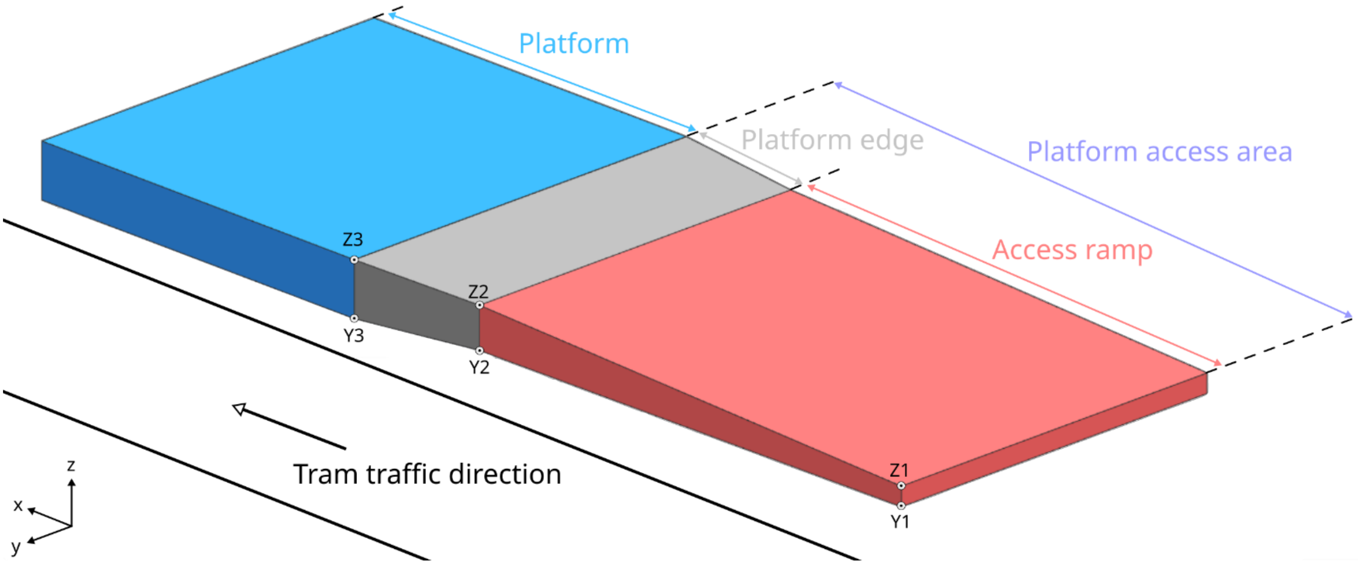


Figure 2: Platform access area in longitudinal view from the track (along the Oxz plane), with an example of two geometrical connections (Platform / Platform edge and Platform edge/ Access ramp)

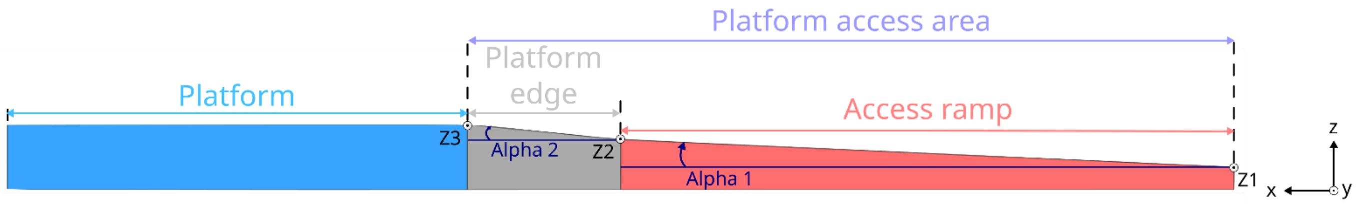
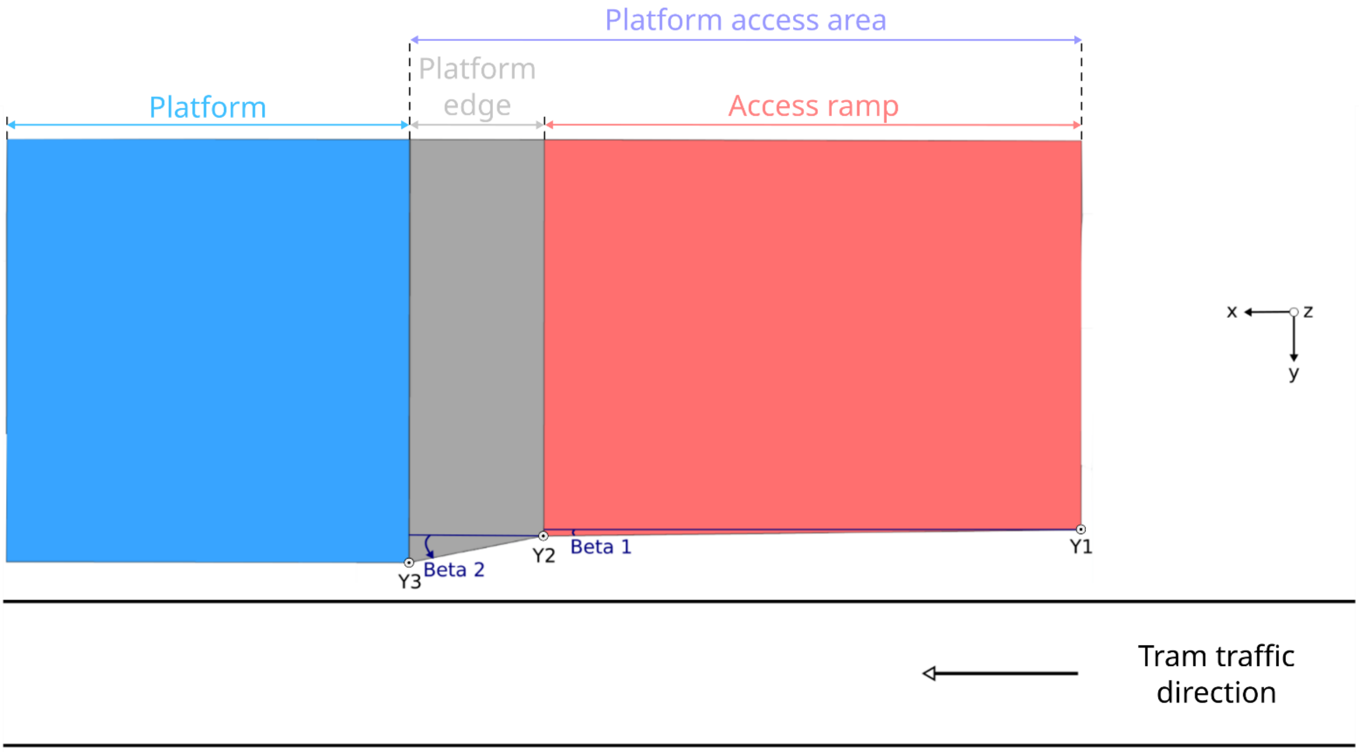


Figure 3: Platform access area in Oxy plane view, with an example of two geometrical connections (Platform / Platform edge and Platform edge / Access ramp)



Any other geometry of the platform access area will require substantiation so that it is not considered a fixed object.

2.3.5 - Danger related to the accumulation of yielding objects

Feedback from the networks shows the presence of many discontinuous objects in the ZLOF.
It should be noted that a succession of yielding objects can become a "fixed object" structure. In particular, the combination of several yielding barriers and/or posts arranged in a row does not necessarily constitute a yielding structure, according to the STRMTG guide.

The installation of several yielding objects will require substantiation of yieldability (experimental test or design note expected with the hypothesis of loading in the direction of travel of the tram).

2.3.6 - Case of association of yielding barriers

The association of yielding barriers, coplanar and parallel to the tramway platform, can form a "fixed object" structure. This association must be justified.

In the case of a tramway platform in straight alignment, a possible solution without additional substantiation consists in transversally offsetting the platform objects, without overlapping, by at least twice their thickness[7], so that the assembly retains a yielding character (see Figure 4, Figure 5).

Figure 4: Principle of offsetting barriers, in the case of associating yielding barriers

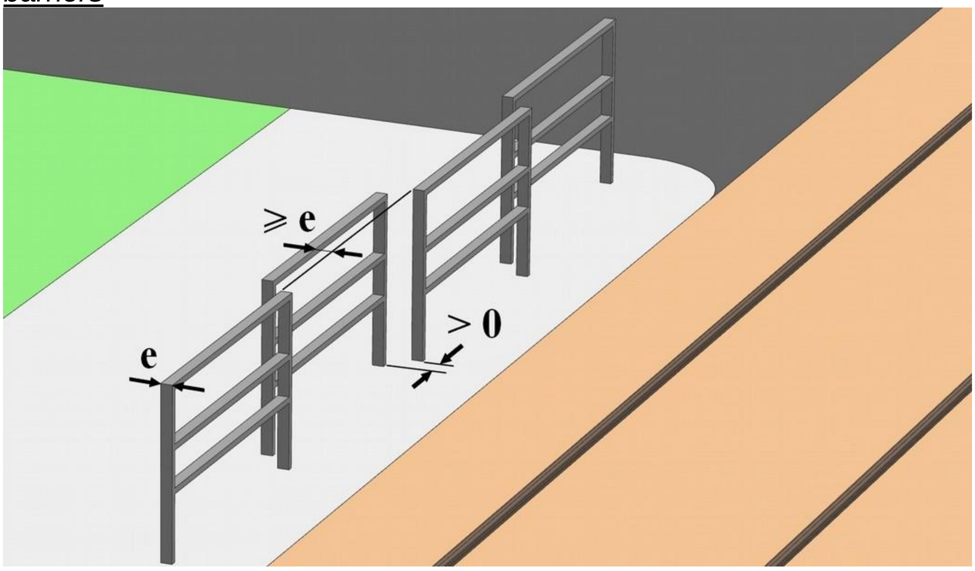
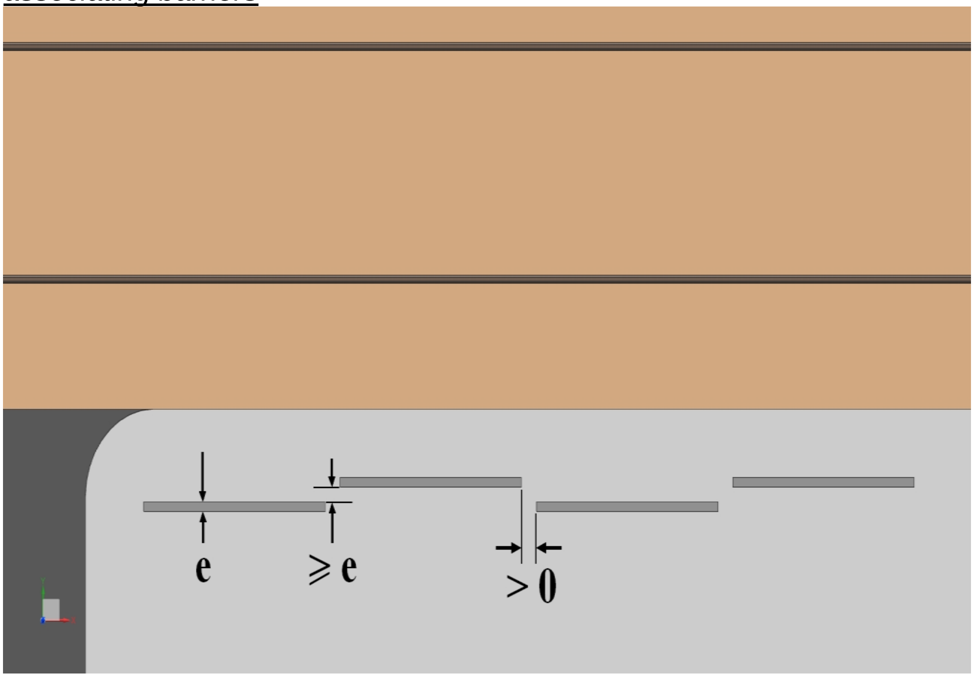


Figure 5: Principle of offsetting barriers in top view, in the case of associating barriers



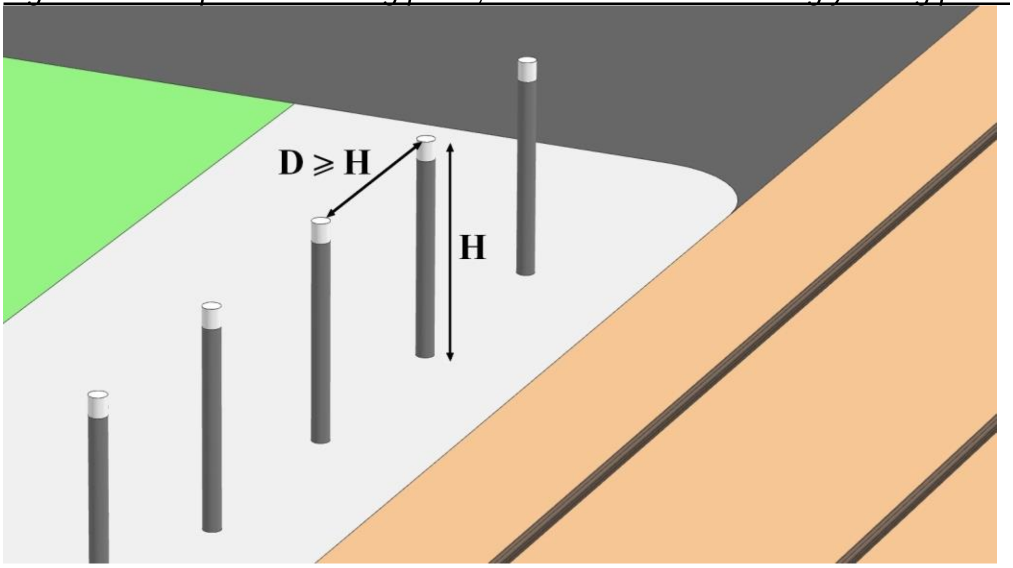
7 In the event of barriers of different thicknesses, the largest thickness should be used for the spacing.

2.3.7 - Case of association of posts

The association of yielding posts, coplanar and parallel to the tramway platform, can form a "fixed object" structure. This association must be substantiated.

A possible solution, without further substantiation, is to leave a distance between posts of at least their height so that the assembly retains a yielding character (see Figure 6).

Figure 6: Principle of offsetting posts, in the case of associating yielding posts



2.4 - Protective fixed object problems

There is a question around the potential positive role in protecting third parties which may be played by fixed objects installed in certain specific configurations, such as stations or pedestrian crossings in the immediate vicinity of intersections.

Various scenarios following a collision could illustrate the potential protective effect of the fixed obstacle in the event of:

- a LV "sweeping" (pushed by a tram in a collision) a pedestrian waiting area on a sidewalk, in front of a crossing or on a station platform;
- the projection of a light vehicle into a pedestrian waiting area.

Experience shows that the presence of a fixed object in a ZLOF is an aggravating factor for light vehicle users. No known event to date shows the protective role of fixed objects.

Consequently, the hypothesis of protective fixed objects is not taken into account, in the current state of operating feedback.

3 - Definition of Fixed Object-Free Zone (ZLOF)

3.1 - Objective

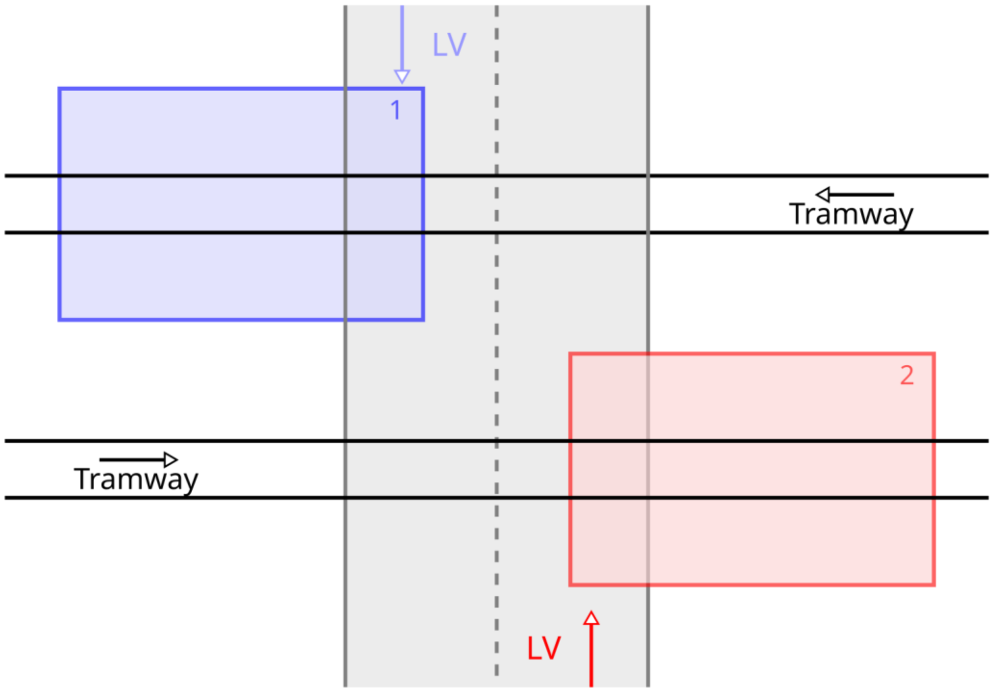
The objective is to keep a ZLOF downstream of the intersections in each direction of tram traffic and for each roadway lane[8], in order to prevent the crushing of a LV between a fixed object and a tram and not to alter its safety space.

3.1.1 - Standard intersection

The intersection of the tramway platform with a 2x1 lane road intersection creates two ZLOFs (see Figure 7):

- The blue LV traffic direction generates ZLOF number 1;
- The red LV traffic direction generates ZLOF number 2.

Figure 7: Principle of generating fixed object-free zones



8 Traffic lane: a subdivision of the roadway of sufficient width to allow a line of vehicles to circulate, according to Article R 110-2 of the French Highway Code

3.1.2 - Intersection with central island

If a central island is present, refer to Section 3.5 Special case of an intersection with a central island.

3.1.3 - Intersection with several lanes of traffic

In case of two or more lanes in the same direction, refer to Section 3.6 Case of several lanes of traffic in each direction.

3.2 - Geometry of the ZLOF

3.2.1 - Start and end of the ZLOF

To construct the start of the ZLOF, the following three points must first be defined (see Figure 8):

- First central point D1:
  - located on the axis of the tramway track,
  - 2 meters upstream from the limit of the lane normally used by LVs[9] in the direction of tramway traffic,
- Second and third endpoints D2 and D3:
  - located at 1.50 m on either side of the Structure Gauge (SG),
  - 2 meters upstream from the limit of the lane normally used by LVs in the direction of tramway traffic.

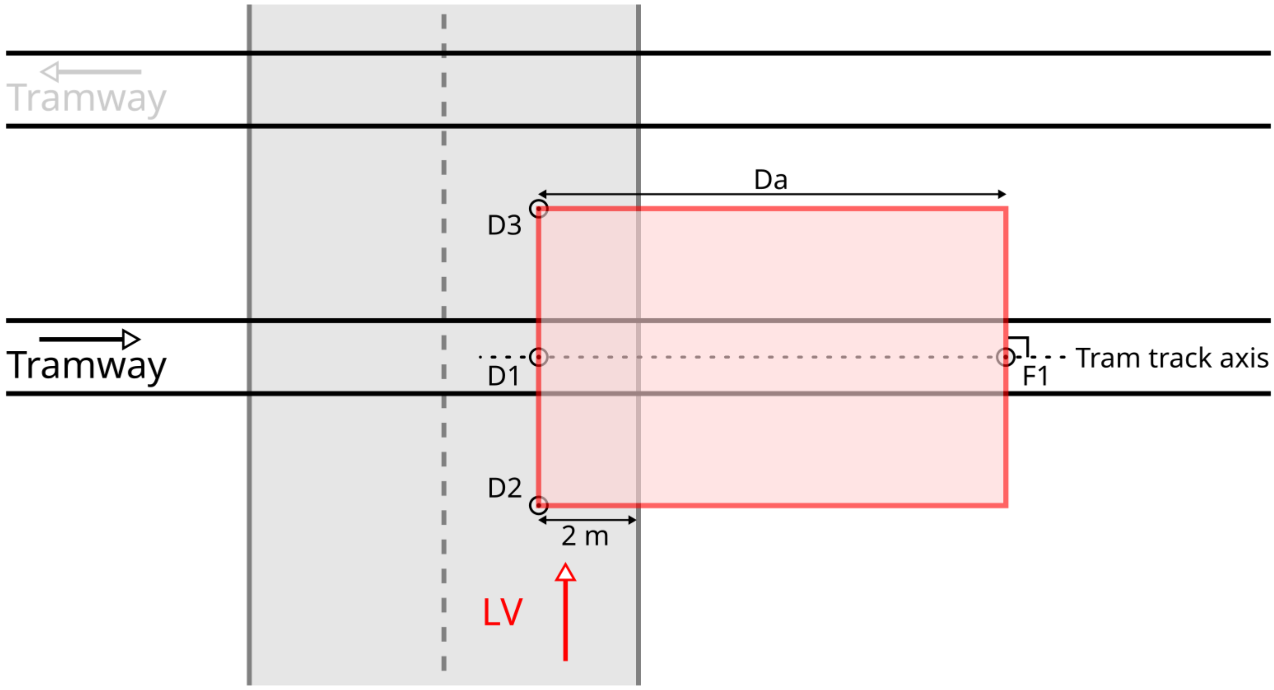
The start of the ZLOF should then be constructed by connecting each of the endpoints D2 and D3 to point D1 with two segments.

The end of the ZLOF should be constructed as follows:
- Define the following exit point F1:
  - located on the axis of the tramway track,
  - at a distance Da[10] from the central point D1, measured along the axis of the tramway track,
- Draw a line perpendicular to the axis of the tramway track passing through point F1.

9 The lane normally used by LV is defined either by marking (longitudinal line, zebra line, bike lane, etc.) or by a differentiation of materials (curbs, alert strips, etc.).

10 Tram stopping distance, corresponding to the length of the ZLOF, defined in Section 3.2.3 Length of ZLOF

<u>Figure 8: Start and end geometry of the fixed object-free zones</u>

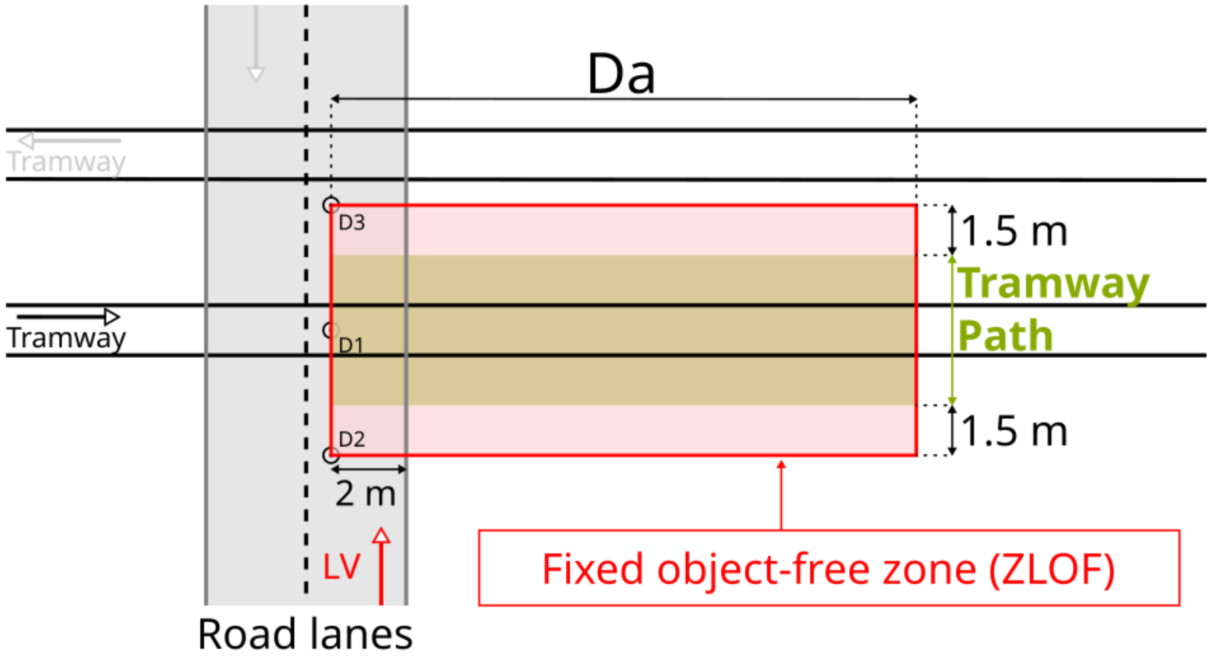


Note: In order not to overload the diagram, only one ZLOF is shown here.

3.2.2 - Width of the ZLOF

The width of the ZLOF is 1.5 m on either side of the SG (see Figure 9).

<u>Figure 9: Characteristic dimensions of the fixed object-free zone</u>



Note:

- *On a curve, the SG is neither constant nor symmetrical, and depends on the architecture of the rolling stock (cantilevered, carbody length);*
- *In order not to overload the diagram, only one ZLOF is shown here.*

3.2.3 - Length of the ZLOF

The length of the ZLOF (denoted Da in meters) is equal to the tram stopping distance and is calculated using the following equation:

$$Da = \frac{v_0^2}{2 * a_e} + v_0 * t_e$$

- $\mathbf{a_e}$ minimum equivalent deceleration (m/s²) of the tram, taken as a_e = 2.8 m/s²;
- $\mathbf{t_e}$ maximum equivalent response time (s), taken as t_e = 0.85 s;
- $\boldsymbol{v_o}$ is the tram's cruising speed[11] for crossing the intersection, in m/s. It must be credible[11] with respect to the intersection configuration in question.

The definition and value of a_e and t_e are given in standard NF EN 13452-1 on Railway applications - Braking - Mass transit brake systems, Part 1: performance requirements. These values correspond to Type 3 Emergency Braking (EB3) of the standard.
This braking standard remains the reference which is a common rule for all rolling stock manufacturers and ensures consistency for all networks and all other STRMTG references.
The decision to use the maximum stopping distances under normal adhesion conditions from the standard fixes them definitively, meaning that the ZLOF lengths do not need to be updated, for example when rolling stock is procured.

The table below gives the ZLOF lengths, denoted **Da**, as a function of the speed $\mathbf{v_0}$, with the values $\mathbf{a_e}$ and $\mathbf{t_e}$ from EB3:

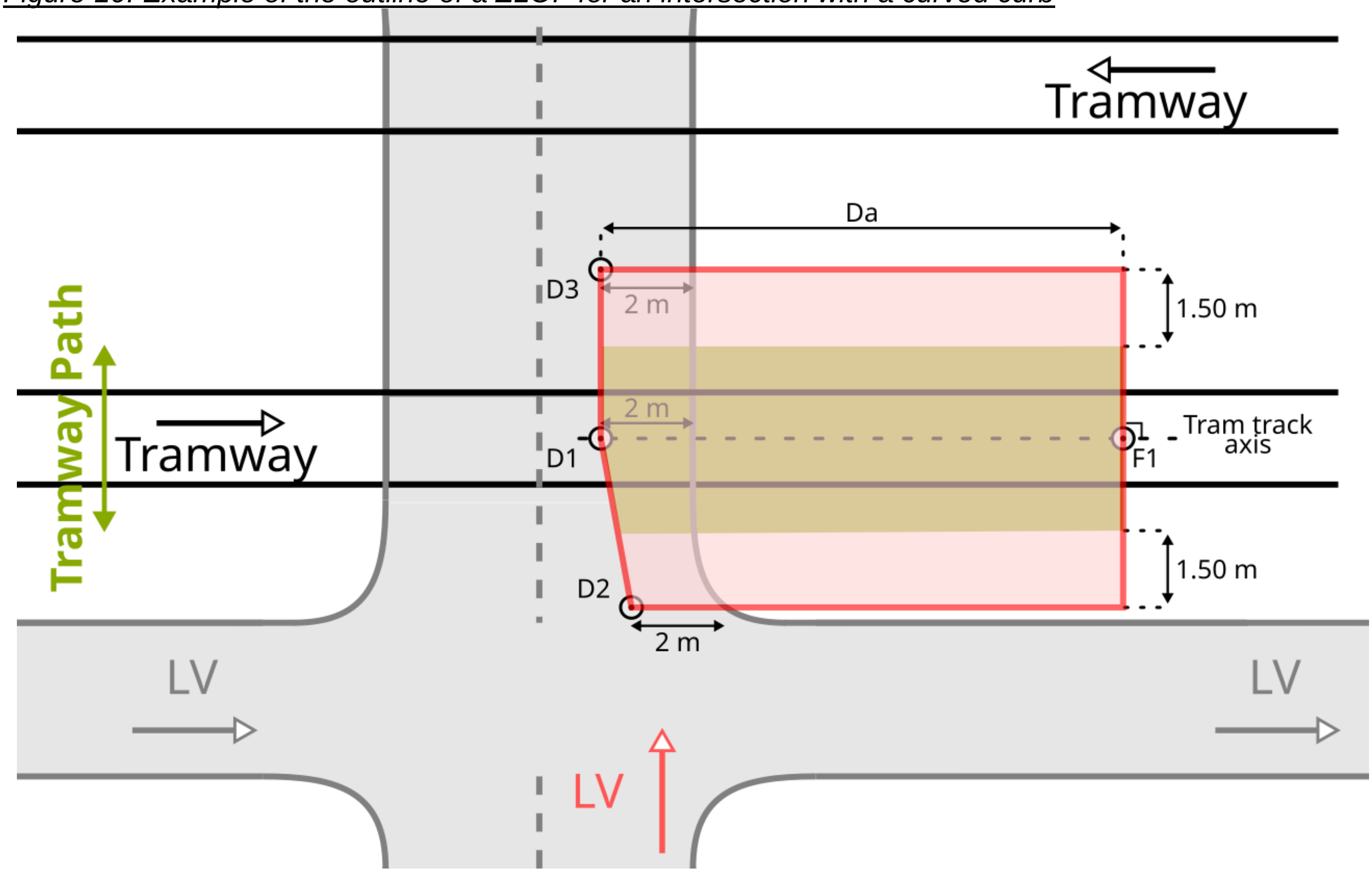
Tram speed v_0 (in km/h)	10	15	20	25	30	35	40
Zone length Da (in m)	3.7	6.6	10.2	14.5	19.5	25.1	31.5

11 See Glossary.

3.3 - Examples of ZLOF geometry

3.3.1 - Intersection with a curved curb

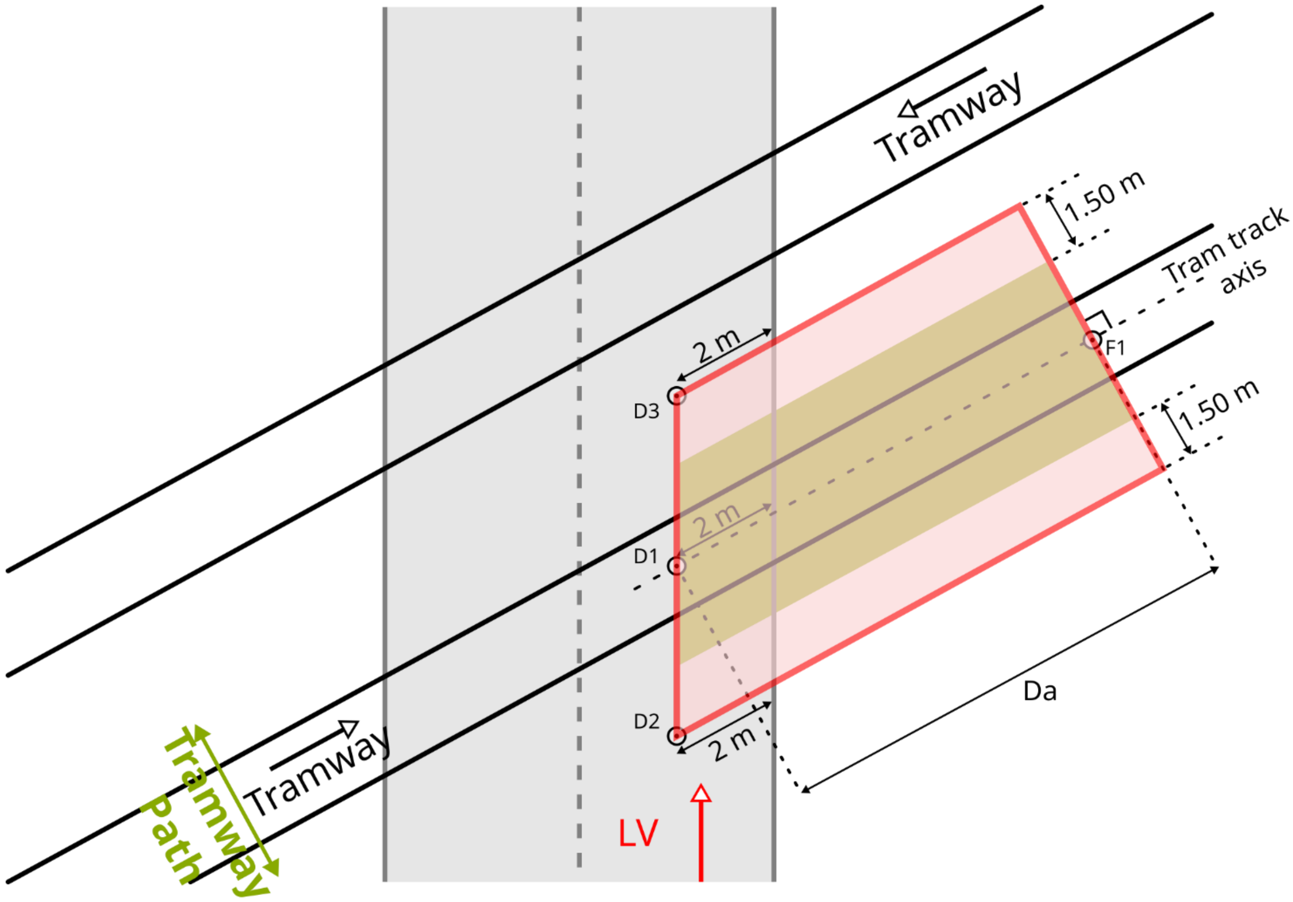
Figure 10: Example of the outline of a ZLOF for an intersection with a curved curb



Note: In order not to overload the diagram, only one ZLOF is shown here.

3.3.2 - Intersection with a straight curb not orthogonal to the tramway platform

Figure 11: Example of the outline of a ZLOF for an intersection with a straight curb not orthogonal to the tramway platform



Note: In order not to overload the diagram, only one ZLOF is shown here.

3.4 - Two-way tram track

In this specific case, the ZLOFs must be checked for each direction of tram travel. This includes, for example, a single tram track or a tram turn back zone, etc.

3.5 - Special case of an intersection with a central island

When there is a central island, the island and the objects on the island are to be considered as potential fixed objects. The island therefore generates two ZLOFs in addition to those mentioned in 3.1.1 Standard intersection, and these are defined later in the chapter.

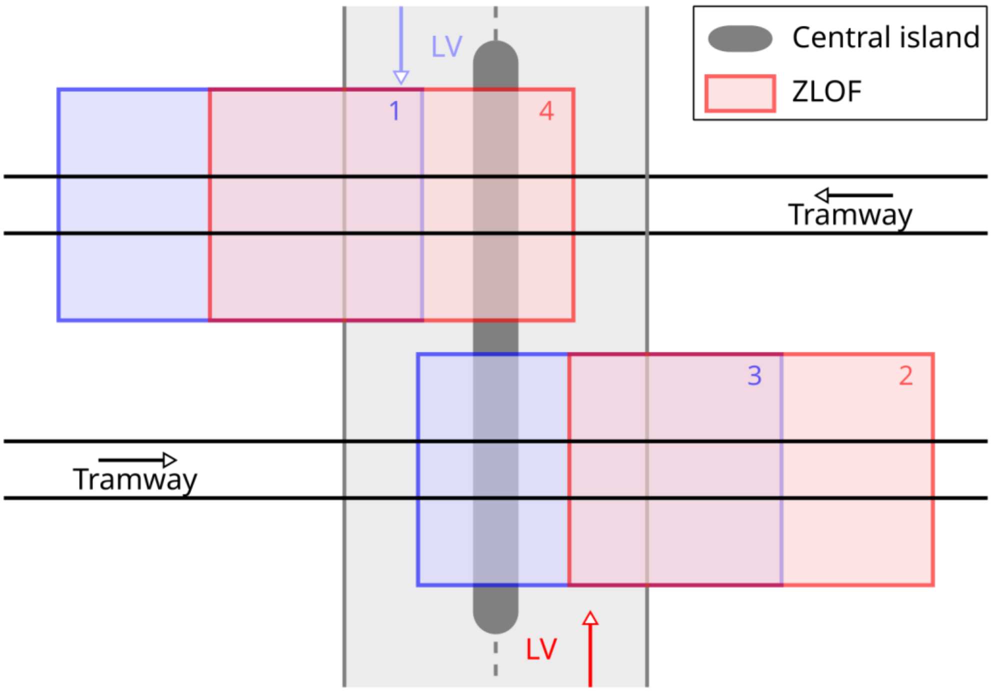
The intersection of the tramway platform with a 2x1 traffic lane intersection with an island thus creates four ZLOFs:

- Two ZLOFs numbered 1 and 3 for the blue LV traffic direction;
- Two ZLOFs numbered 2 and 4 for the red LV traffic direction;

These four ZLOFs are to be considered and outlined independently of each other, even if they overlap[12].

The association of the two roadways with an island is shown in Figure 12:

Figure 12: Principle for generating fixed object-free zones for an intersection with central island



Note: When there is no central island between the roadways, there is no need to create the ZLOFs produced by this island (here ZLOFs 3 and 4).

For example, Figure 13 is an example of a layout where it is necessary to take into account the four ZLOFs. The island has a height of less than 20 cm in relation to the running surface of light vehicles, and the traffic light pole on the central island is yielding.

12 In practice, it can be useful to make distinctions using color on a layout drawing.

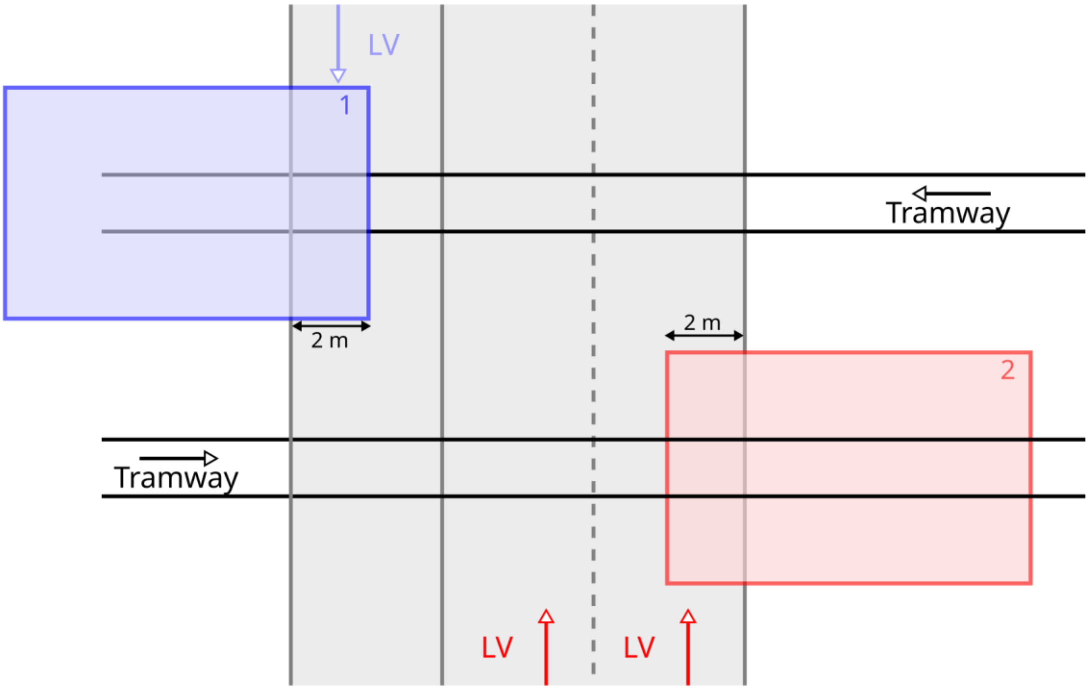
Figure 13: Example of an intersection with a central island between roadway lanes

3.6 - Case of several traffic lanes in each direction

When there are at least two traffic lanes in each direction, one ZLOF can be created per lane and per direction of tram travel. In general, there are no objects between these lanes, in which case only the ZLOF created by the traffic lane the most downstream from the direction of tram traffic needs be considered (see Figure 14).

Note: If there is an object between the two traffic lanes (e.g.: separation of directional flows with R14 signals), refer to Section 3.5 Specific case of an intersection with a central island.

Figure 14: Principle of generating fixed object-free zones for an intersection with 2+1 roadway lanes without a central island



3.7 - Geometry of ZLOF at a general traffic area entry

3.7.1 - General traffic area entry - ZLOF start and end

To construct the start of the ZLOF, the following three points must first be defined:

- First central point D1:
  - located on the axis of the tramway track,
  - 2 meters downstream from the first limit of the lane normally used by LV in the direction of tramway traffic,
- Second endpoint D2:
  - located 1.50 m from the SG,
  - at the intersection between the downstream limit[13] of the roadway lane normally used by LVs and the 1.5m over-width of the SG,
  - the limit of the roadway corresponds to the inner surface of the curb, and thus includes this limit in the ZLOF,
- Third endpoint D3:
  - located 1.50 m from the SG,
  - by convention, this point is taken orthogonally to the axis of the tramway track and passing through point D1.

The start of the ZLOF should then be constructed by connecting each of the endpoints D2 and D3 to point D1 with two segments.

Note:

- *Point D3 is taken by convention because it often cannot be placed;*
- *If the limit of the normally-used roadway is not shown on the diagram, this limit would need to be virtually extended in order to construct point D1 or D2.*
  - *In the case of a curved LV path, the virtual extension must be drawn so as to obtain a lane width of 3.3 m[14] (see 3.7.2),*
- *In the case where point D2 is located by construction downstream[13] of the perpendicular line passing through point F1, by convention it should be taken orthogonally to the axis of the tramway track and passing through point D1.*

The end of the ZLOF should be constructed as follows:

- Define the following exit point F1:
  - located on the axis of the tramway track,
  - at a distance Da from central point D1, measured along the axis of the tramway track,
- Draw a line perpendicular to the axis of the tramway track passing through point F1.

13 “*The downstream limit of the roadway normally used by LVs*” means according to the direction of tram travel

14 Width of the curved lane set for an LV with the goal of simplifying the drawing, from *Planning Guide Urban Roads and streets, Cerema, Reference Collection, 2016* (turning radii for a saloon car).

3.7.2 - Examples of ZLOF layouts at a general traffic area entry

Figure 15: Example of a ZLOF layout at a general traffic area entry with the tramway platform in straight alignment

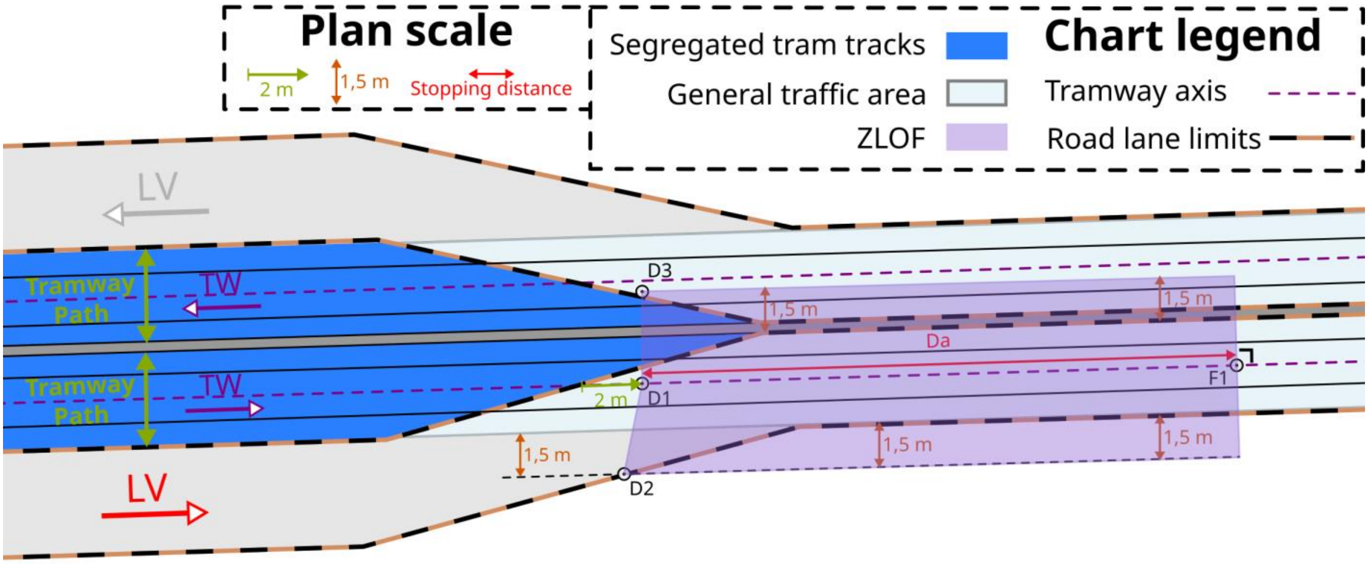


Figure 16: Example of a ZLOF layout at a general traffic area entry with a curved tramway platform

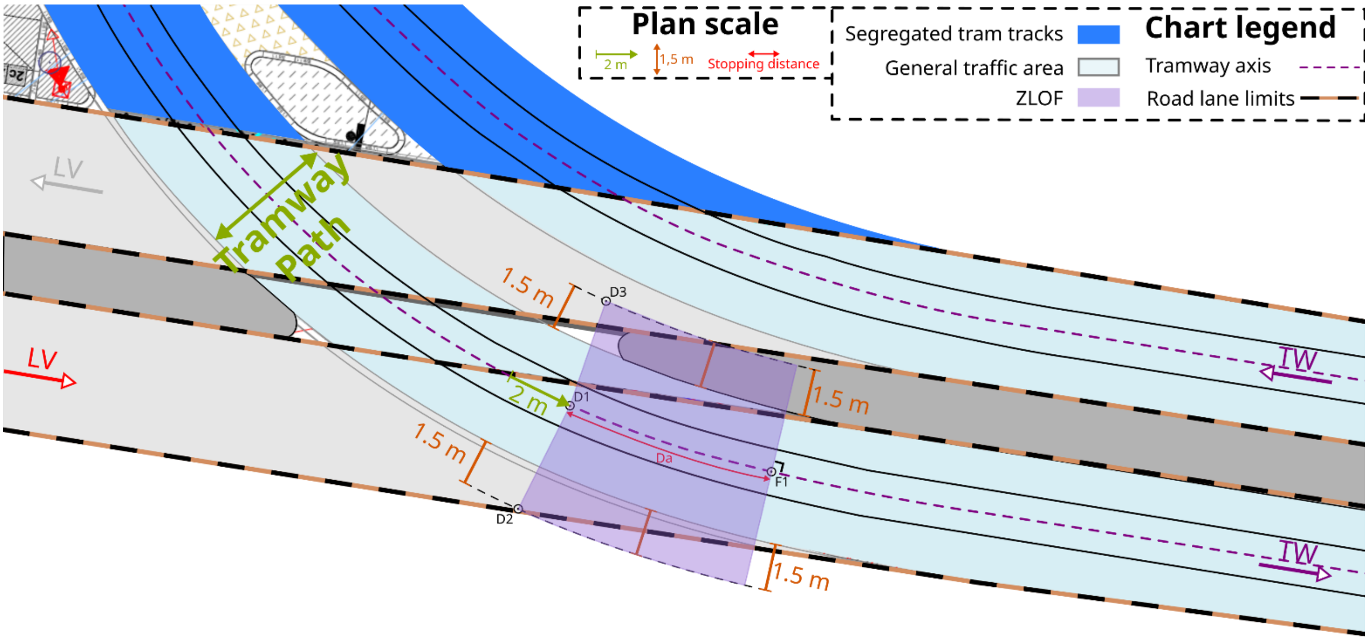


Figure 17: Example of a ZLOF layout at a general traffic area entry with the tramway platform in straight alignment

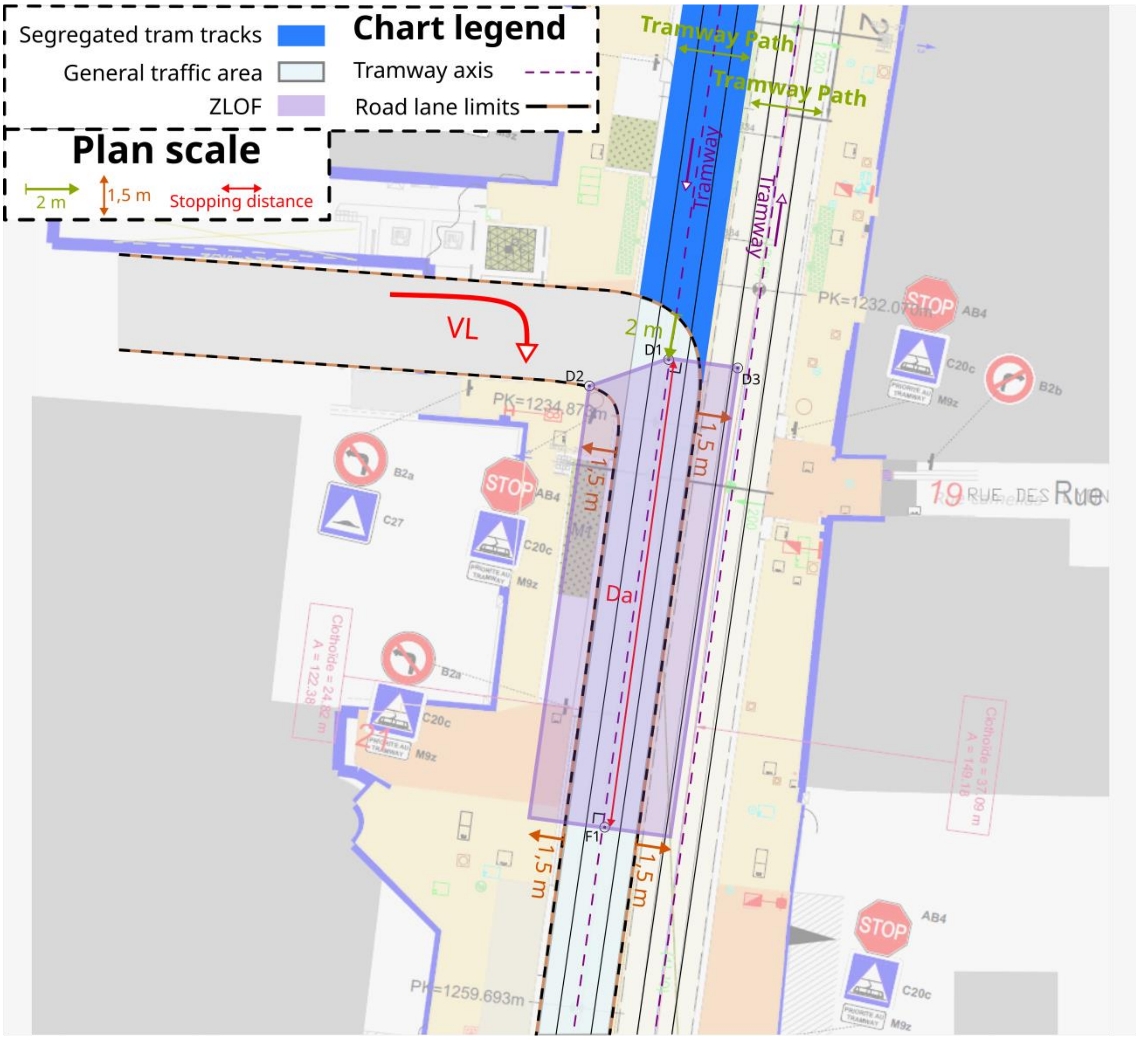
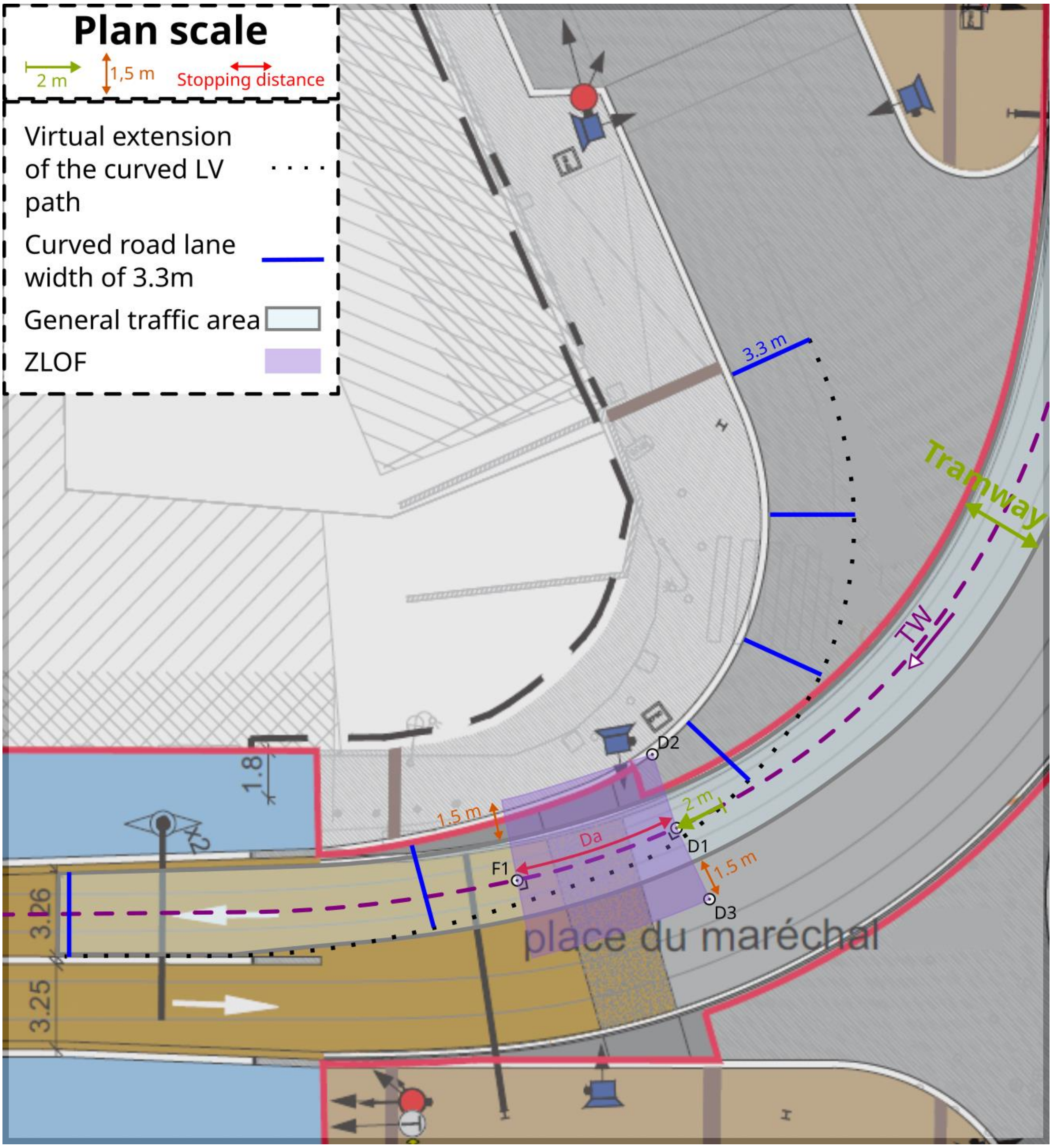


Figure 18: Example of a ZLOF layout at a general traffic area entry with a curved tramway platform and roadway



4 - Recommendation for the installation and maintenance of yielding objects

Yielding objects that are to be located in a ZLOF should be easily distinguished from similar non-yielding objects (for example using specific marking such as a label, engraving, etc.), (see APPENDIX C. Guide to preparing a Yielding Object Substantiation Report for Manufacturers).

The object must be installed in compliance with the installation constraints for the product specified in the manufacturer's documentation (burial depth, identification of yielding nature, etc.) to avoid unsuitable use.

In the event of replacement of a yielding object, it must either be replaced by another yielding object (identical or otherwise), in compliance with the installation criteria that ensure its yielding function. It would be good practice to prepare a document for the use of those in charge of the maintenance of yielding objects, listing the various types of yielding objects and their locations.

APPENDIX A. Figures

Figures

APPENDIX B. Fixed objects

Examples of fixed objects

Trees

Figure 19: Tree and posts located in the fixed object-free zone

Traffic light structures, public lighting

Figure 20: Traffic light pole located in the fixed object-free zone

Figure 21: Lampposts and trees located in the fixed object-free zone

Telecommunication poles, gantries, overhead contact line structures, electrical cabinets

Figure 22: Overhead contact line pole located in the fixed object-free zone

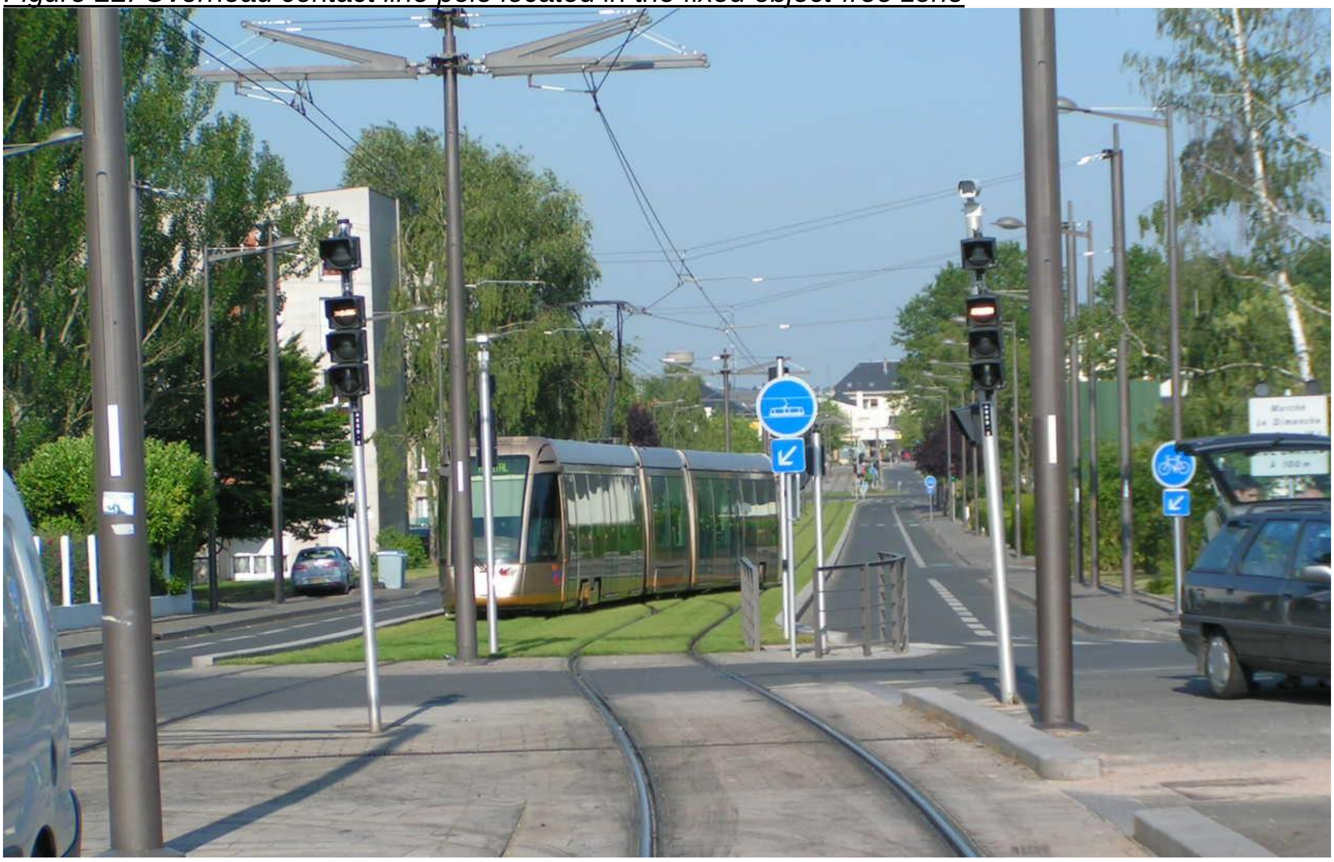


Figure 23: Electrical cabinet located in the fixed object-free zone

Street furniture (posts, barriers, stone/concrete bollards, etc.) and barrier gate housings

Figure 24: Urban furniture (posts, trash can) located in the fixed object-free zone

Masonry

Figure 25: Curbs located in the fixed object-free zone

Figure 26: Underpass walls located in the fixed object-free zone

Figure 27: Structural pillars located in the fixed object-free zone

Platform access area

Figure 28: Platform access area located in the fixed object-free zone

Examples of aggravated events

Overhead contact line pole

Location:	Neruta roundabout, Nantes
Fixed object involved:	Overhead contact line pole
Distance of the object from the SG:	0.2 m
Date:	May 2001
Note:	Tram derailed
Photo source:	SEMITAN

Figure 29: Collision between an LV and a tram, with aggravating factor of an overhead contact line pole acting as a fixed object

Location:	Voltaire / route de la Courneuve intersection, Saint-Denis
Fixed object involved:	Overhead contact line pole
Distance of the object from the SG:	0.2 m
Date:	January 2006
Photo source:	RATP

Figure 30: Collision between an LV and a tram, with aggravating factor of an overhead contact line pole acting as a fixed object

Location:	Parilly roundabout, Lyon
Fixed object involved:	Overhead contact line pole
Distance of the object from the SG:	0.9 m
Date:	July 2006
Photo source:	KEOLIS Lyon

Figure 31: Collision between an LV and a tram, with aggravating factor of an overhead contact line pole acting as a fixed object

Location:	Sasselange intersection, Tourcoing
Fixed object involved:	Overhead contact line pole
Distance of the object from the SG:	Less than 1.5 m
Date:	May 2019
Photo source:	TRANSPOLE

Figure 32: Collision between an LV and a tram, with aggravating factor of an overhead contact line pole acting as a fixed object

Masonry

Location:	Avenue Ambroise Croizat / Rue Eugène Charbonnier intersection, Fontaine
Fixed object involved:	Curb in the ZLOF
Height of fixed obstacle with respect to LV running surface	0.30 m
Distance of the object from the SG:	Less than 1.5 m
Date:	May 2017
Photo source:	SEMITAG

Figure 33: Collision between an LV and a tram, with aggravating factor of a curb acting as a fixed object

APPENDIX C. Guide to preparing a Yielding Object Substantiation Report for Manufacturers

This appendix suggests a set of elements to be supplied with the goal of substantiating the yielding function of a component.

1 - The value of yieldability

1.1 - General

The manufacturer must design the component taking into account weather loads and urban environment loads but without oversizing, in order to protect third parties in a light vehicle against crushing risks in the event of a collision with a tram.

Non-oversizing is ensured by the value of 570 daN.m with respect to the LV running surface as specified in the STRMTG guide (see 2.1 Definition of fixed object). This value is from a CEREMA (formerly SETRA) technical guide entitled "*Traitement des obstacles latéraux sur les routes principales hors agglomération*" (Managing lateral objects on main roads outside agglomerations) (2002 edition) and is also used in the French National Technical Instruction for Road Signals[15].

This value characterizes the maximum allowable moment for the component with respect to the LV running surface leading to its complete yielding. Any remaining emerging parts must not be more than 0.2 m above the level of the LV roadway. Consequently, the structure may be weakened up to this height (see definition above).

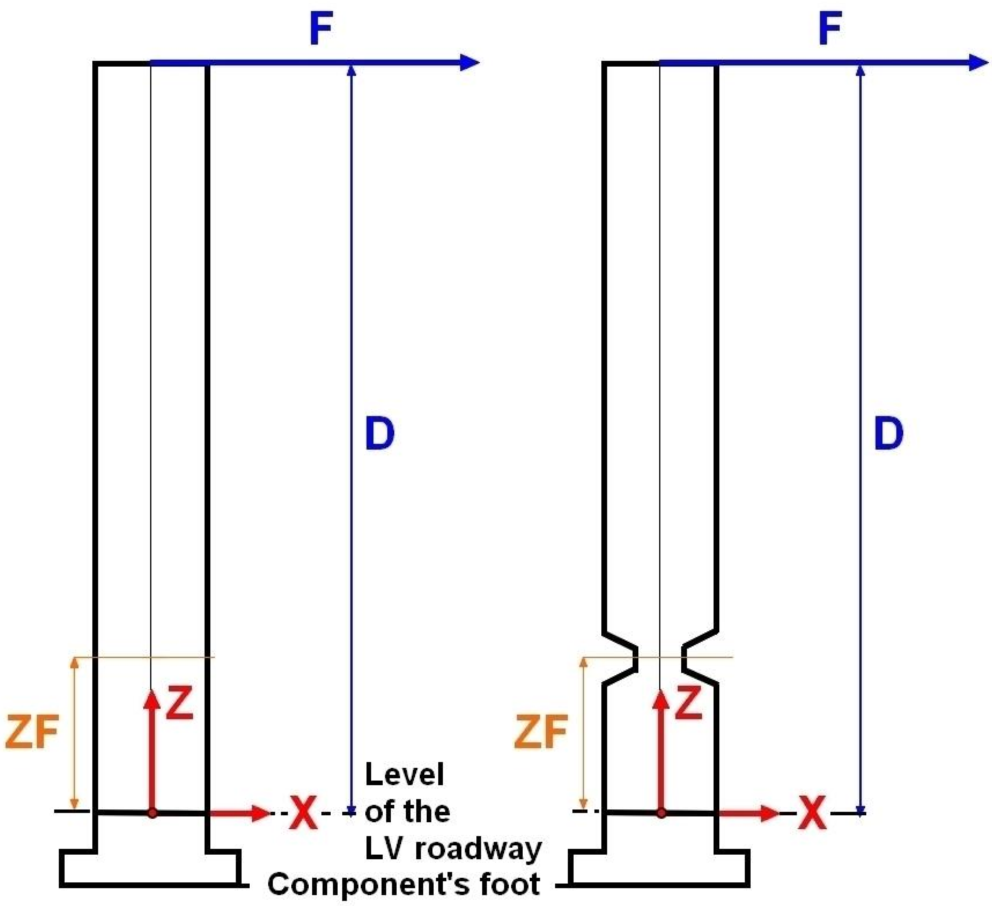
1.2 - Definitions of different parameters

- F: Variable force to be applied to the component (in N);
- D: Height of application of force F with respect to the LV running surface (in m)
- ZF: Height of the weakened area (in m). This height can vary from 0 to 0.2 m.

Note: the weakened area is not necessarily visible, for example in the case of an object in a composite material where the weakening may be obtained by specific layering of the fibers.

15 IISR, Part I, Article. 6.

Figure 34: Illustration of different parameters



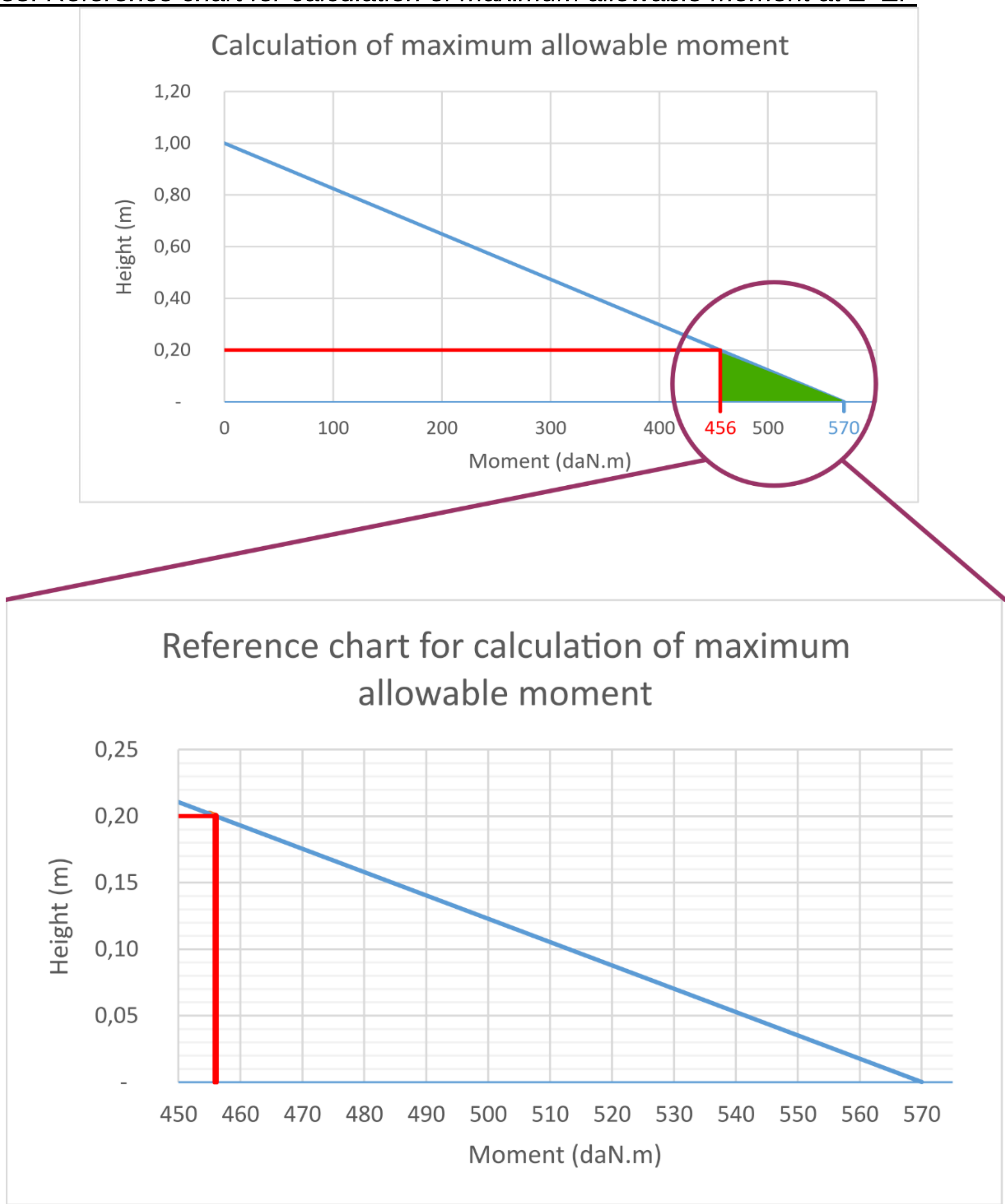
1.3 - Value of the reference bending moment in the weakened area

Non-oversizing is ensured by the value of 570 daN.m corresponding to a force of 570 daN applied at 1 m with respect to the LV running surface.

Consequently the reference equation for the calculation of the maximum allowable moment as a function of the weakened area is as follows:

$$M(ZF) \leq 570 \cdot (1 - ZF)$$

Figure 35: Reference chart for calculation of maximum allowable moment at Z=ZF



$$Example: M(0.2) \leq 570 \cdot (1-0.2) \text{ i.e. } M(0.2) \leq 456 \ daN.m$$

1.4 - Maximum force to be applied for yielding

In order to validate the yielding test at the level of ZF, the yielding should occur by applying a maximum force F (in daN) at Z=D (in m with D>ZF), calculated such that:

$$FMax(D; ZF) \leqslant \frac{570 \cdot (1-ZF)}{(D-ZF)}$$

$$Example: FMax(1.5; 0.2) \leqslant \frac{570 \cdot (1-0.2)}{(1.5-0.2)} \text{ i.e. } FMax(1.5; 0.2) \leq 351 \ daN$$

If there is no weakened area, ZF = 0 should be used.

2 - Experimental substantiation of yielding via testing

2.1 - Testing must meet the following requirements

2.1.1 - General

a) The tested components should be finished products ready for sale;
b) The component shall be tested. Testing and approval of the tests must be overseen by a second independent body outside the component manufacturer (competent recognized independent body or manufacturer entity recognized as independent of the design);
c) Computer simulations are not acceptable;
d) The component tested must be fitted with all equipment providing maximum rigidity (inspection hatch, etc.);
e) The force must be applied at a height D > ZF;
f) The direction of the force must be orthogonal to the plane of greatest inertia of the component. If there is doubt as to the plane of greatest inertia, several directions of force must be tested (several load cases);
g) Force F shall be applied to the component locally in such a way that it can retain its integrity. No local deformation should be observed at the application surface of force F[16];
h) The complete yielding of the component, at an applied moment less than or equal to the moment defined in Section 1.3 Value of the reference bending moment in the weakened area, must be ensured (in particular in the case of structures with complex geometry such as an urban furniture barrier);
i) Variable force F must be gradually increased, in compliance with one-minute force application steps, until the component yields completely.
j) During each test, a maximum duration of one minute is tolerated between applying the maximum force and the component yielding completely.
k) For each test, a proof table must be provided, detailing the trajectory of the point of application of force on the structure (vertical and horizontal position) as a function of the force applied up to Fmax.

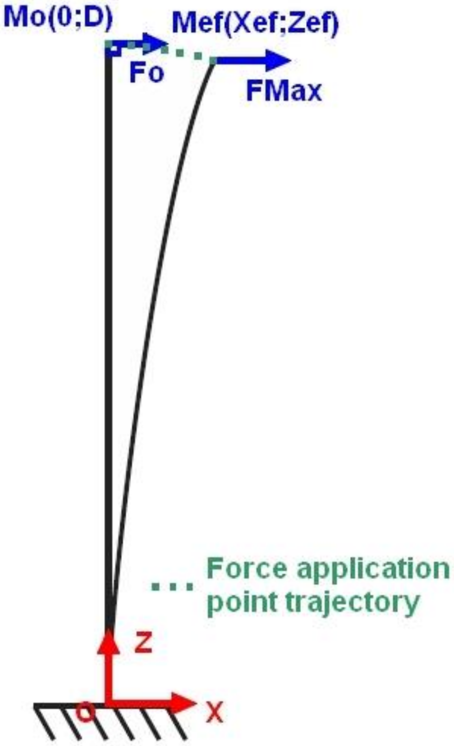
2.1.2 - Case of small displacement structures

This part covers the case of small displacement structures such as metal poles and posts.

a) These tests are quasi-static tests;
b) The test set-up must be able to apply force over the entire range of the component's deformation up to its complete yielding. The direction of force must remain horizontal with respect to the ground throughout its application up to complete yielding.

16 For example, the force must not be applied on the inspection hatch.

Figure 36: Principle for applying force horizontally with respect to the ground for structures with small displacements



2.1.3 - Case of large displacement structures

In the case of large displacement structures such as an elastic swivel joint at the base of the component or a flexible structure (e.g. shape-memory post), a specific test must be proposed.

2.2 – Test validation conditions

A test shall be valid if:

a) Under the effect of a variable force F, at most equal to Fmax and under the conditions previously specified in Section 2.1 , the tests meet the following requirements: the component completely yields at a height of ZF ≤ 0.2 m with respect to the LV running surface (where this level corresponds to the normal installation of the product as specified by the manufacturer);
b) For each load case, a minimum of 3 tests must be performed. The “Fmax” criteria must be complied with for each of the 3 tests.

Example:
Component A – Load Case 1 with D = 1.5 m and ZF = 0.2 m.
According to Section 1.4, Fmax(1.5; 0.2) is 351 daN.

Component A – Load Case 1	Fmax measured during the test
Test 1	338 daN (< 351 daN so OK)
Test 2	310 daN (< 351 daN so OK)
Test 3	321 daN (< 351 daN so OK)

3 - The Yielding Object Substantiation Report

The Yielding Object Substantiation Report is the documentation that will be examined for any STRMTG general opinion requested by a component manufacturer.

The expected content of the Yielding Object Substantiation Report is as follows:

3.1 - Description of the standard component

a) Manufacturer's part number and/or brand name of the component:
b) Suitably marked component overall drawing;
c) Suitably marked detailed drawing of the component;
d) Description of the yielding principle (for example: weakening by stress concentration, spring-based shape-memory yielding, etc.);
e) Details regarding the materials that contribute to yielding (for example: supply of materials certificates for short runs substantiating maximum resistance, classification by materials specifications for large runs substantiating maximum resistance, etc.).
f) Identification of the installation constraints:
   - In order to minimize unsuitable installations by installers (burial of the weakened area, etc.), the product's installation constraints must enable a permanent identifier on the component whose location is marked on the component overall drawing,
g) Identification of the yielding nature:
   - So that it can be easily identified as a yielding component by maintenance services, the component must have specific, permanent marking (label, engraving, etc.) whose location on the component is marked on the component overall drawing.

3.2 - Standard component testing

Experimental substantiation of yielding:

a) Description of the body overseeing test performance and validation (independent second opinion): identification of the body, references (certificates, accreditations, etc.);
b) Test protocol:
   - Detailed description of the test set-up:
     - Diagram of test set-up for applying the force (height D, etc.),
     - Positions of the various instruments (dial gauges, force gauges, etc.),
   - Description of the measurement instruments (characteristics: accuracy, valid calibration certificates, etc.),
   - Description of the various load cases to be tested,
   - Validation criteria for the various load cases.

3.3 - Test report for the standard component

The results of the standard component tests shall be drawn up into a report by the body that performed the tests.

In the event that this body and the independent second opinion are two different entities, the independent second opinion shall approve this test report.

A conclusion attesting to the compliance of the tested component with the requirements of the current STRMTG guide must be clearly written.

3.4 - Reproducibility of the manufacture of series components

A description must be given of the quality control procedure to ensure reproducibility of the manufacture of series components. It shall also cover later identical production runs.

Without being exhaustive it must:

- Show that series production produces components identical to the standard component (substantiation of lack of deviations, etc.);
- Or, where necessary, experimental substantiation of yielding via testing on a sample of components from the newly manufactured components. These tests may be performed by the manufacturer.

APPENDIX D. Preparation of the guide

In compliance with French Decree 2010-1580 of 17 December 2010, pertaining to the creation of a Technical Service in Charge of Safety for Ropeways and Guided Transport (STRMTG), responsible for drawing up guides and reference documents.

This document has been drawn up based on:

- discussions and proposals:
  - from the STRMTG inspection offices;
  - from the industry (CEREMA, CERTIFER, EGIS RAIL, ERA, GHM, ÎLE-DE-FRANCE MOBILITÉS, KEOLIS, RATP, RLA, RTM, SCE, SEMITAN, SETEC ITS, SYSTRA, SYTRAL, TISSEO, TRANSAMO, VALMONT Industries Inc., UTP);
- the technical guide for the installation of fixed objects near tramway/road intersections (second edition dated 26/01/2012).

The following contributed to proof-reading the guide:

Stéphane CONTARDO	STRMTG – Mechanical Group
Mathieu WEISS	STRMTG – Mechanical Group