LRT urban insertion and safety: European experiences

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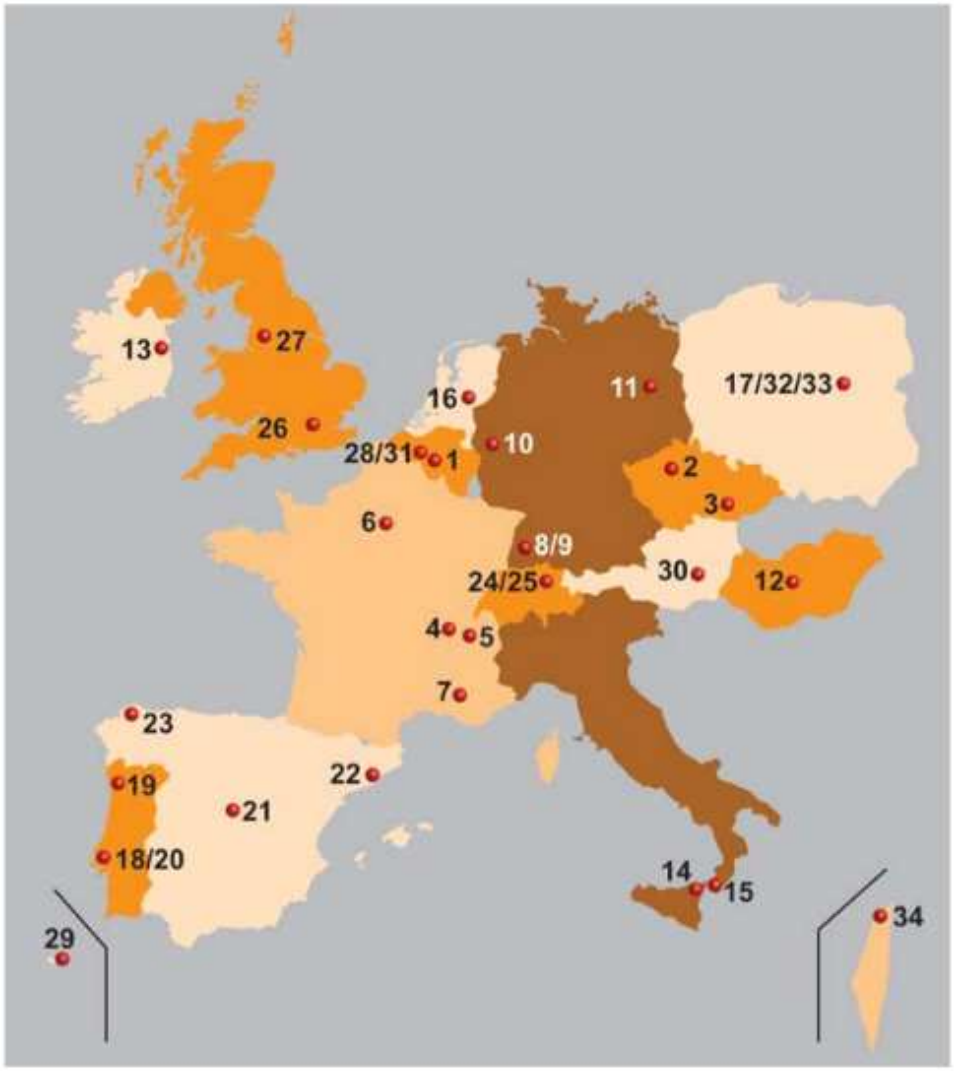


Operation and safety of tramways in interaction with public space

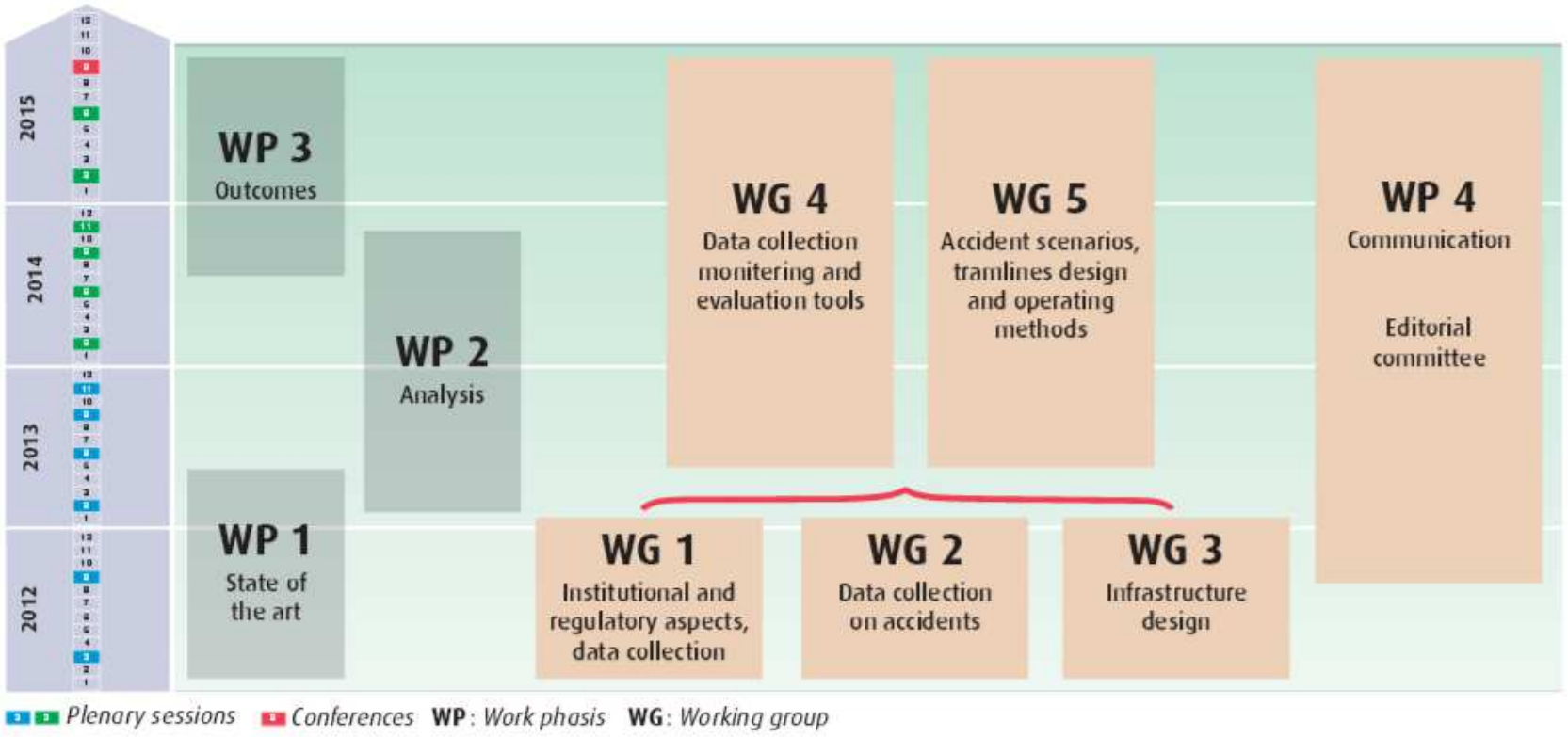
34 entities from 15 countries

+ UITP (International Association of Public Transport)

http://www.tram-urban-safety.eu/

COST ACTION TU 1103

Operation and safety of tramways in interaction with public space



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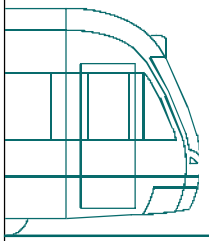


INTERACTION POINTS

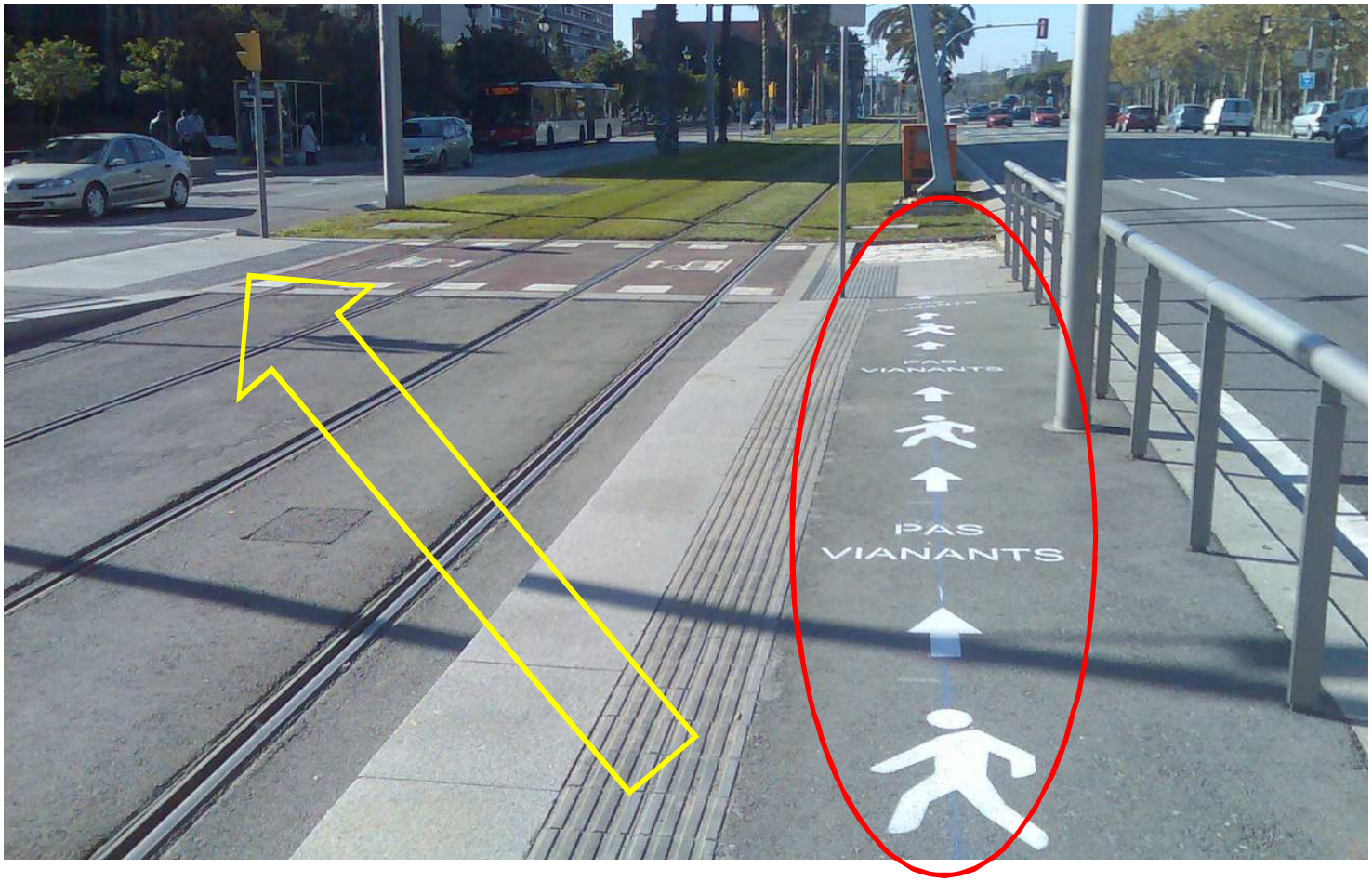
- Stations/Stops
  - Pedestrian pathways at stations
  - Platform design
- Between stations
  - Pavement treatment of LRT channel
  - LRT separators on segregated channels
  - Intersections
    - Left-turn intersections
    - Roundabouts
    - Pedestrian and cyclist crossings
    - Other innovative solutions at intersections
  - LRT channel differentiation and protection by means of pavement, marks, fences and barriers
  - OCS (overhead contact system) poles locations

PEDESTRIAN PATHWAYS AT STATIONS/STOPS

Porto signalization of appropriate zones for crossing at stops

PEDESTRIAN PATHWAYS AT STATIONS/STOPS

Barcelona signage to guide pedestrians



PEDESTRIAN PATHWAYS AT STATIONS/STOPS

Montpellier light barriers in staggered platforms zone

PLATFORM DESIGN

Width of the platform should be enough for the users and a barrier should be provided if there is a road lane in the back of the platform

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PLATFORM DESIGN

Vehicle-platform gap as small as possible

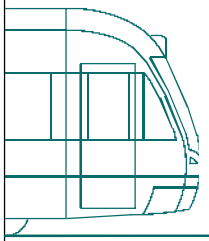
PAVEMENT TREATMENT

Pavement treatment in shared space

PAVEMENT TREATMENT

Pavement treatment on segregated channels

- Pavement treatment on segregated channels important from the safety point of view:
  - The type of pavement can encourage or discourage the use of the LRT tracks by other users (road vehicles, pedestrians, cyclists)
  - The type of pavement can reduce or increase the damages caused when an accident happens



LRT SEPARATORS ON SEGREGATED CHANNELS

- Separator selection:
  - The more impassable the separator is, the better the safety for LRT and other street users.
  - Separator selection is closely related to the street section and width: an impassable separator can lead to traffic flow problems where there is only a narrow lane for general traffic.
  - The use of passable separators makes it easier for the LRT channel not being respected by drivers

LRT SEPARATORS ON SEGREGATED CHANNELS

Parking should be forbidden along the separator

LRT SEPARATORS ON SEGREGATED CHANNELS

Green separators

- Dissuasive effect on pedestrians and, specially, on car and bicycle drivers, to cross the tracks.
- Positive impacts due to the increase in the amount of green zones in the city.
- Disadvantages:
  - Need for maintenance of the green area
  - Visibility problems in case that the green species grow too tall: Irish Railway Safety Commission establishes a maximum height of shrubs and any container of 600 mm

LRT SEPARATORS ON SEGREGATED CHANNELS

Too narrow sidewalk-alike separator

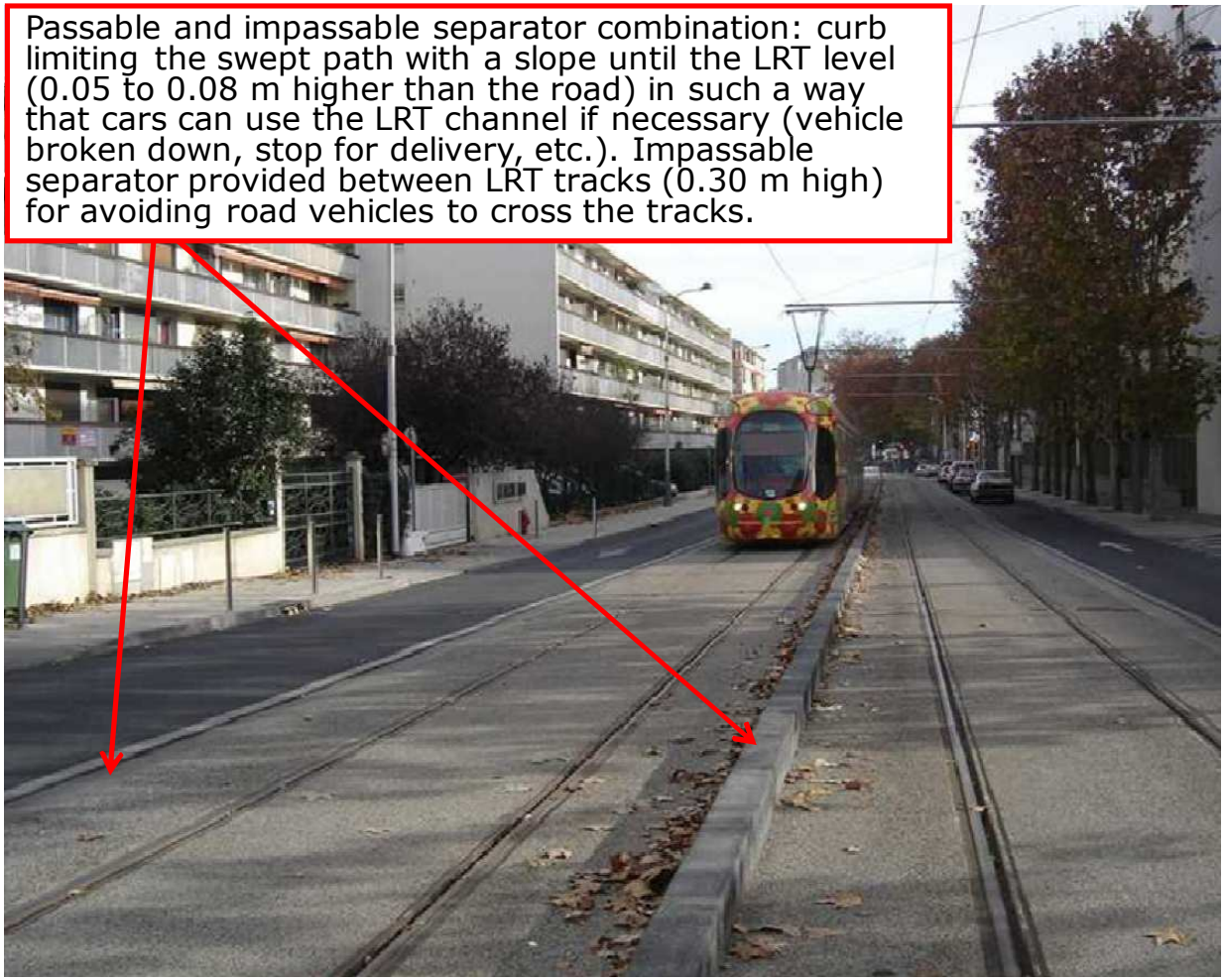
LRT SEPARATORS ON SEGREGATED CHANNELS

Good design of LRT – cycle lane separator

LRT SEPARATORS ON SEGREGATED CHANNELS

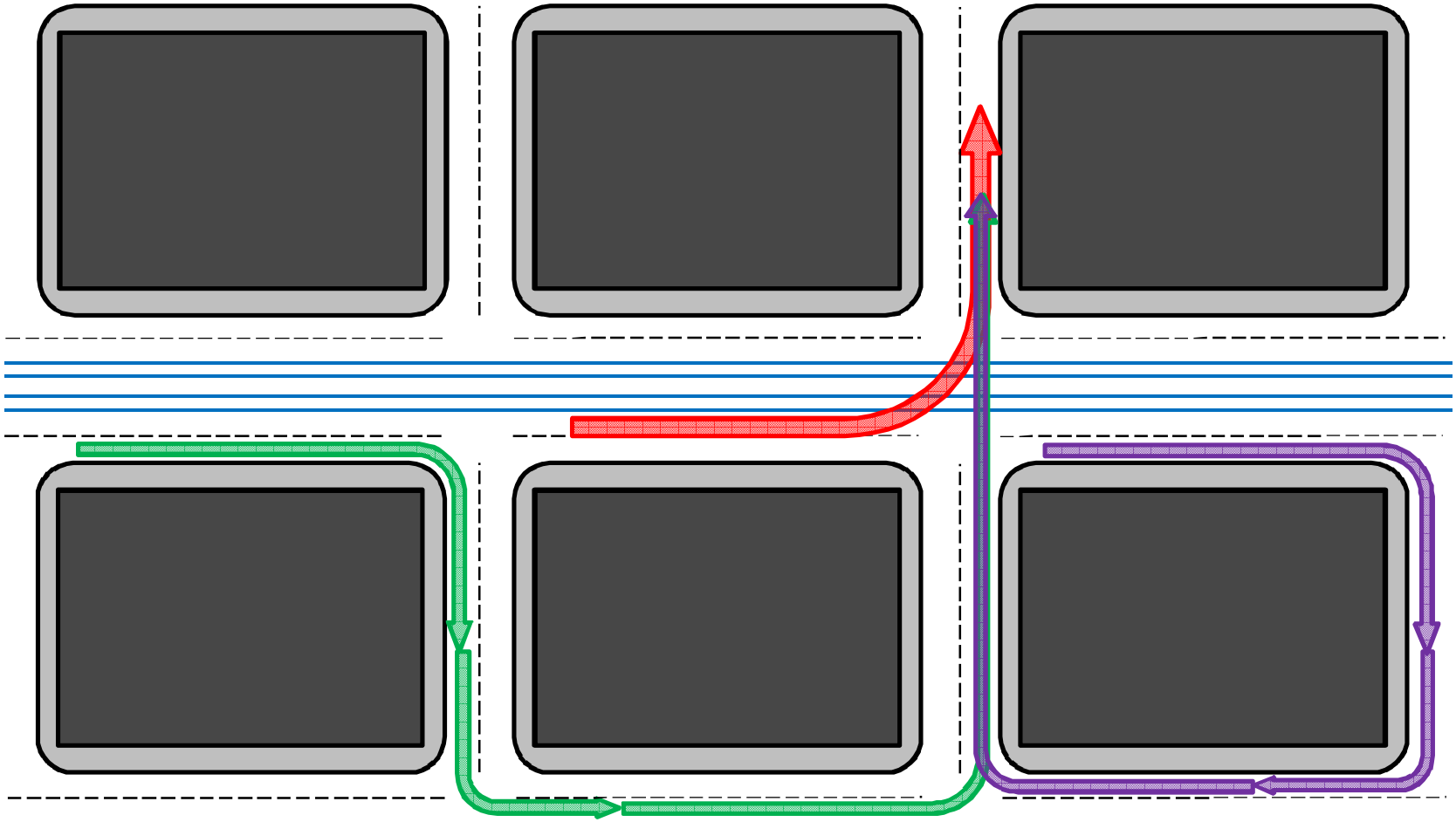
Passable and impassable separators combination

Passable and impassable separator combination: curb limiting the swept path with a slope until the LRT level (0.05 to 0.08 m higher than the road) in such a way that cars can use the LRT channel if necessary (vehicle broken down, stop for delivery, etc.). Impassable separator provided between LRT tracks (0.30 m high) for avoiding road vehicles to cross the tracks.



LEFT-TURN INTERSECTIONS

Transforming left-turns in other kind of movement



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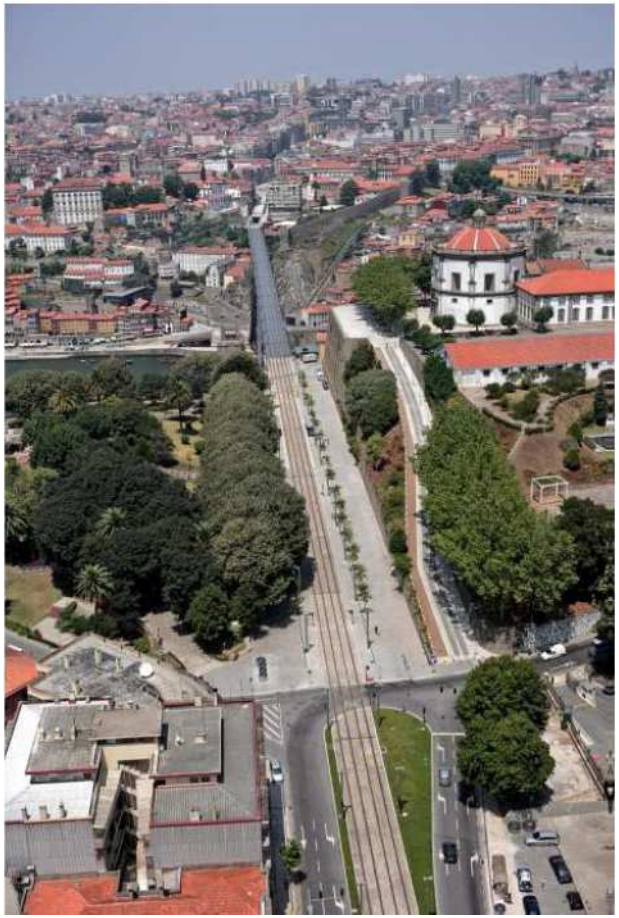
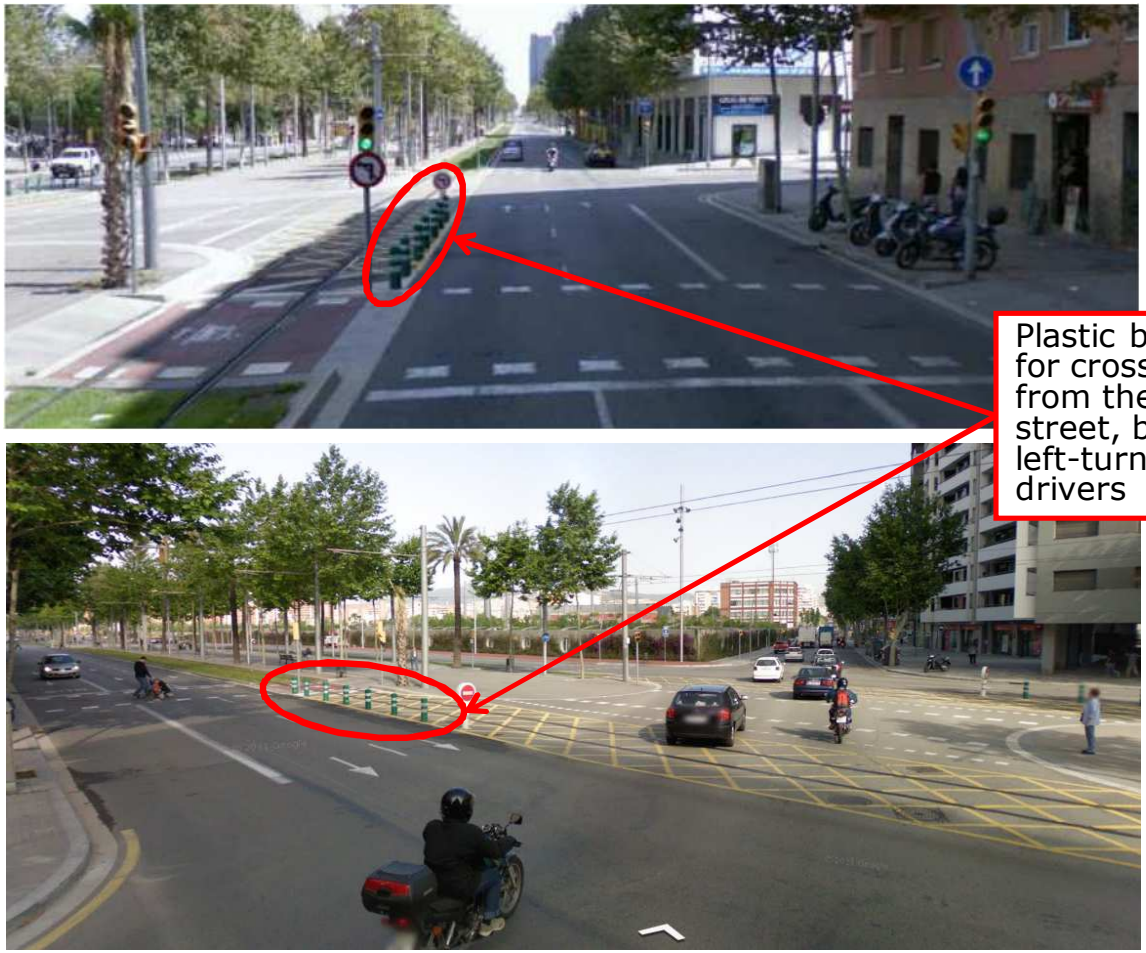


LEFT-TURN INTERSECTIONS

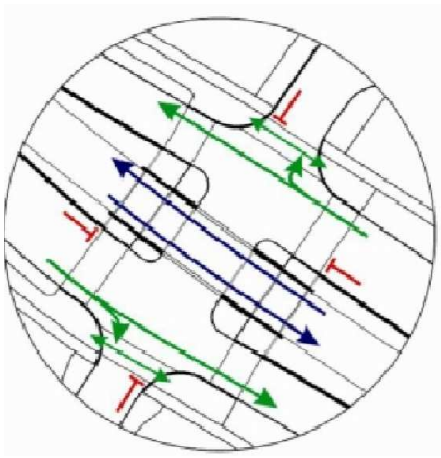
Avoiding forbidden left-turns



Plastic bollards leaving space for crossing vehicles coming from the perpendicular street, but complicating the left-turn to offender car-drivers

LEFT-TURN INTERSECTIONS

Avoiding misreading of turning and straight on traffic lights



ROUNDABOUTS

- Very common solution for junctions in Europe. Main advantages:
  - Road vehicle drivers need to reduce their speed when approaching the roundabout, leading to an increase in safety at the junction
  - Management of a junction by means of a roundabout avoids the need for traffic lights, reducing the operational and maintenance costs
  - Junction capacity increases due to the almost continuous traffic flow and the elimination of dead-times produced by traffic-lights
- Usually, the roundabout operation changes when a light rail system is added to the roundabout
  - The roundabout works as a conventional one when the LRV is not present
  - But traffic lights are provided to give priority to an approaching LRV
- Key safety issues:
  - Need to avoid the misreading of the roundabout and the traffic lights by car-drivers, which can easily lead to an accident or incident
  - Car-drivers should encounter the tramway as near to the perpendicular direction as it is possible, in order to improve the visibility and awareness of the LRT presence

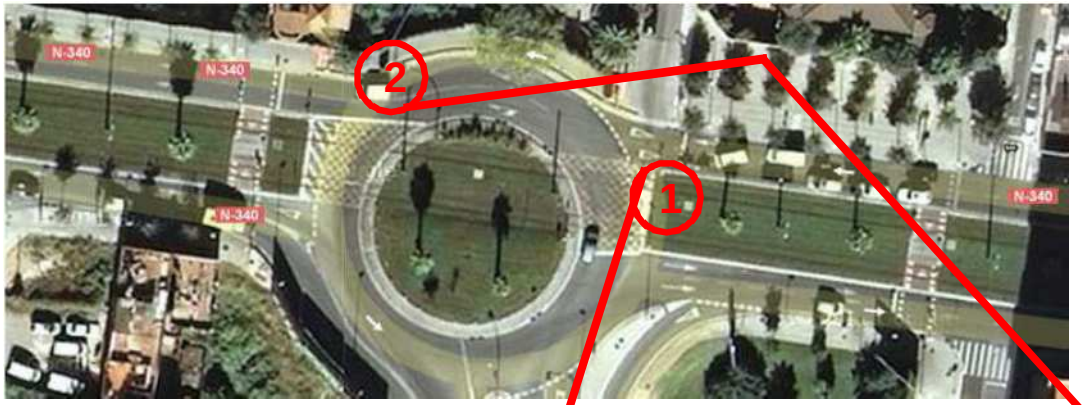
ROUNDABOUTS

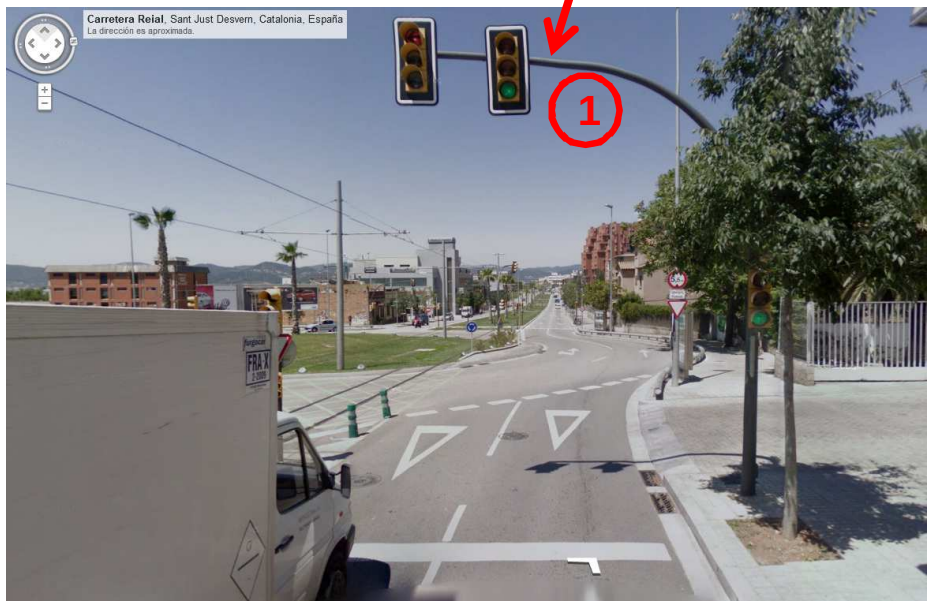
Improving awareness by means of additional double small traffic lights

Double small traffic lights are provided in the lower part of traffic light, to reinforce the awareness of road vehicle drivers arriving to the junction

ROUNDABOUTS

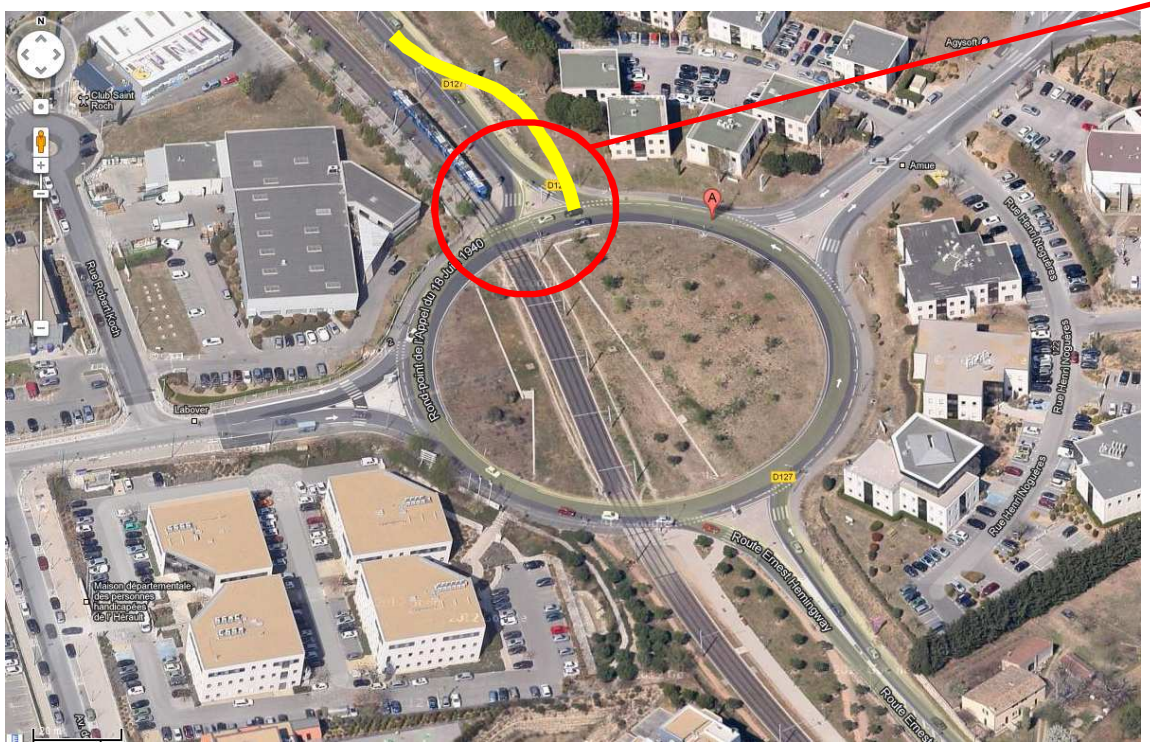
Avoiding confusion about traffic lights message





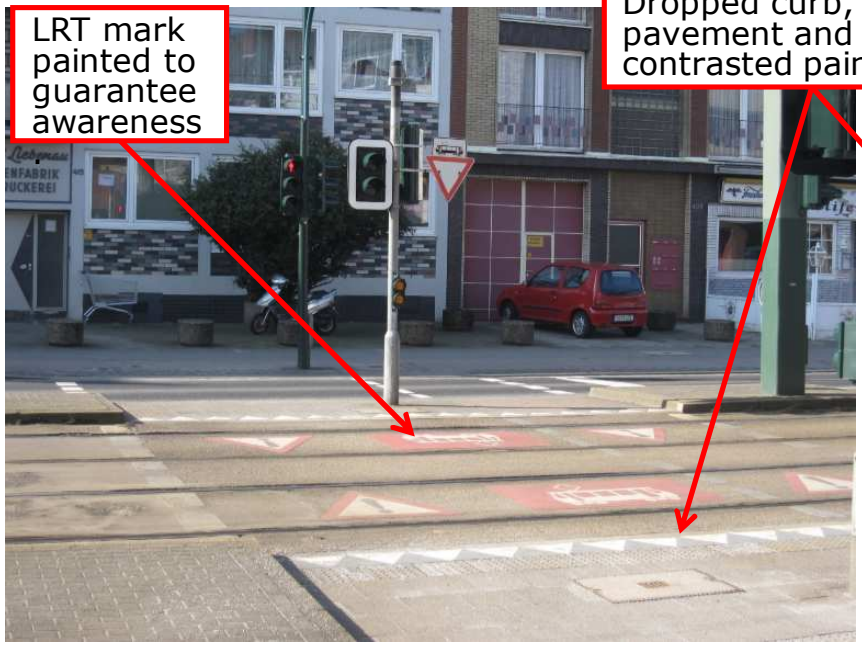
ROUNDABOUTS

Problematic road-LRT interference due to alignment



PEDESTRIAN AND CYCLIST CROSSINGS

- In many European countries LRT has priority over the rest of the traffic when running on the streets.
- Hence, it is common to avoid marking the LRT channel with zebra crossings, which give priority to pedestrians.
- In any case, the designated zones for crossing are usually marked in any other way, to guarantee a clear identification of allowed zones for crossing.
- Special attention should be made to visually and mobility impaired people

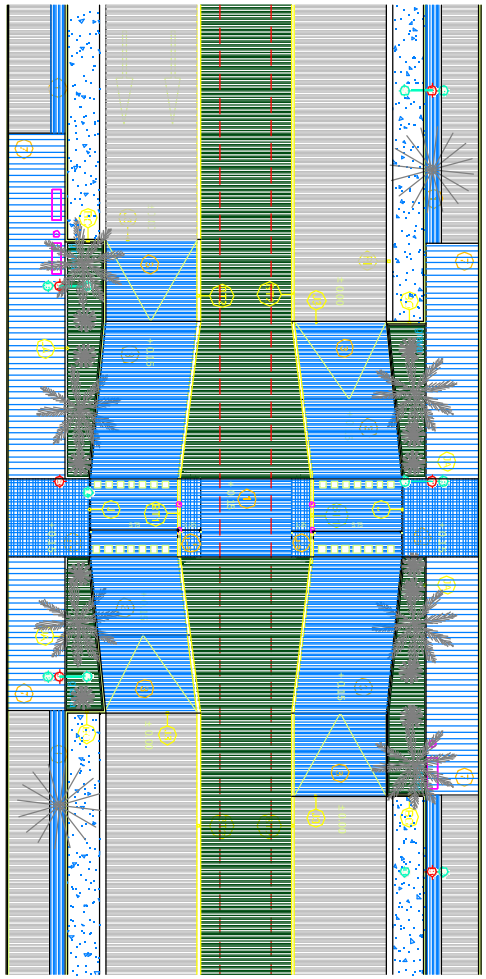


PEDESTRIAN AND CYCLIST CROSSINGS

Well-designed pedestrian crossing

Well-designed pedestrian crossing in a wide straight avenue:

- Pedestrian refuges between the general traffic lanes and the LRT tracks to allow pedestrians to cross the street in several stages
- These refuges imply a change in the direction of general traffic trajectory, and they are elevated in relation to road surface to match the sidewalk height → More convenient for pedestrians and oblige to reduce the speed to road vehicle drivers
- Bollards installed in the interface between road lanes and LRT tracks, to eliminate the possibility that car-drivers use this pedestrian crossing for running on the tracks and change their direction

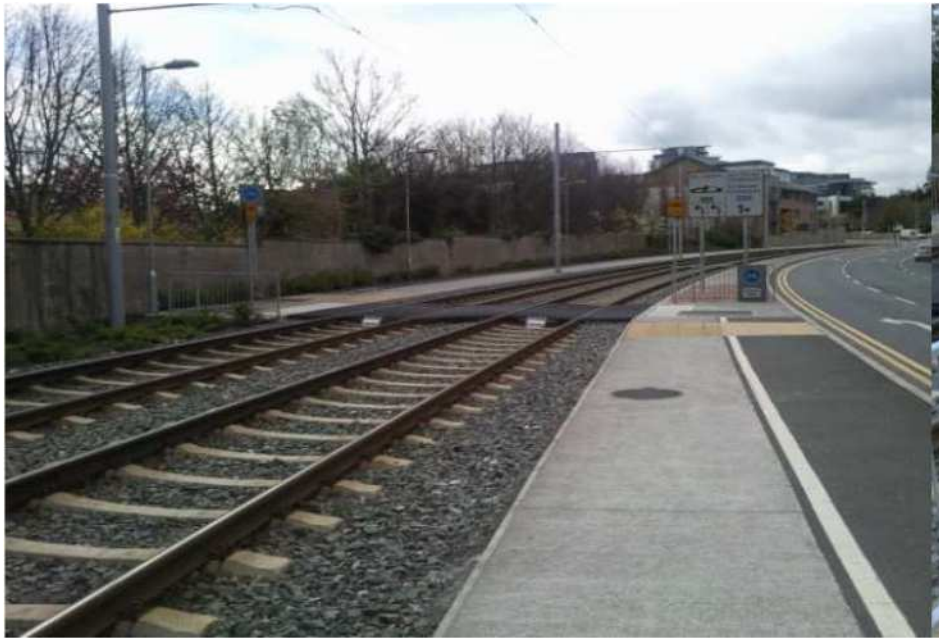


PEDESTRIAN AND CYCLIST CROSSINGS

Z pedestrian crossing

PEDESTRIAN AND CYCLIST CROSSINGS

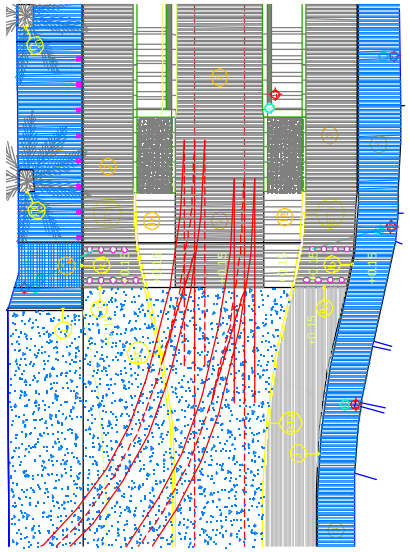
Barriers in a pedestrian+cyclist crossing to avoid dangerous direct movements of cyclists



PEDESTRIAN AND CYCLIST CROSSINGS

Pedestrian crossing with switches presence

Not an advisable solution (it may cause an accident if a pedestrian enters foot or any body part into the switch and it changes position in that moment).
Possible solution: elongated switches in order to have the moving parts away from the pedestrian crossing. In this case the adjacent stop complicates this option.



PEDESTRIAN AND CYCLIST CROSSINGS

Pedestrian crossing too close to a hump

Pedestrian crossing located near a hump, which can result in pedestrians not being able to see approaching LRVs (40 km/h speed in this zone).
Possible solutions:
- decrease in speed limit for LRVs (pedestrians have more time to see the vehicle coming and reciprocally);
- installation of an active signaling system (lights flashing when the LRV is coming);
- and, the obvious one, to change the pedestrian crossing location if that is possible.

OTHER INNOVATIVE SOLUTIONS AT INTERSECTIONS

LED lights in pedestrian crossing for improving awareness

The LEDs adjacent to the sidewalk repeat the pedestrian signaling (red/green), while the LEDs adjacent to the LRT channel are orange and flash when the LRV is approaching. The main disadvantage of this solution is its cost: it is an expensive and difficult solution to implement, as it implies civil work.

OTHER INNOVATIVE SOLUTIONS AT INTERSECTIONS

Flashing red road studs (to display in conjunction with red traffic signal)

OTHER INNOVATIVE SOLUTIONS AT INTERSECTIONS

Red light camera for photo enforcement

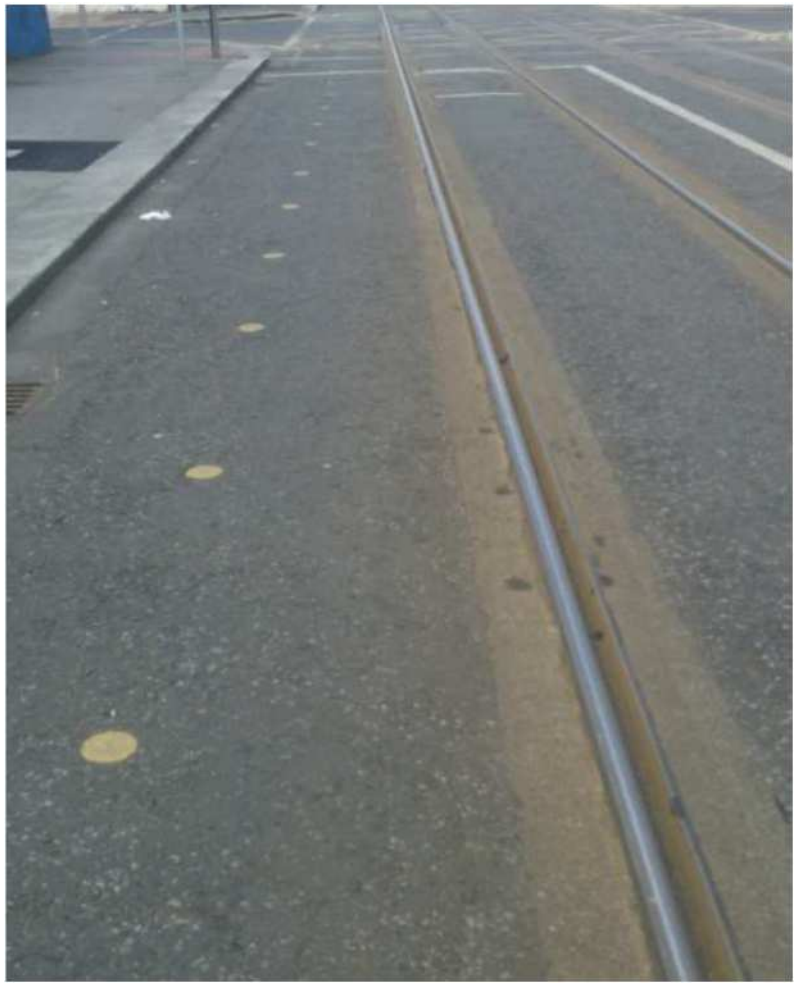
LRT CHANNEL DIFFERENTIATION AND PROTECTION

Intersection treatment to discourage road vehicles entrance

The entrance to this section is marked with warning signs and the surface at the entrance is covered with a deterrent paving of red cobbles set into the surface.
If road vehicles enter the segregated area, driving over the deterrent paving will make the driver aware that he/she has left the road surface. Nevertheless, the warning signs and deterrent pavement do not prevent road vehicles entering the segregated section on purpose.

LRT CHANNEL DIFFERENTIATION AND PROTECTION

Demarcation of swept path in a shared channel



LRT CHANNEL DIFFERENTIATION AND PROTECTION

Barriers for protecting the LRT channel

LRT CHANNEL DIFFERENTIATION AND PROTECTION

Fences for avoiding crossing in a dangerous place (lack of visibility)

Provision of a fence between the columns under a flyover to avoid pedestrian crossing the tracks in this zone: if a person is about to cross the tracks and stands in between two columns, the LRT driver will not see this person, and an accident can happen if this person continues crossing without being aware of the LRV presence.

MINIMUM DISTANCE BETWEEN JUNCTIONS AND OBSTACLES

- It is advisable that OCS poles and other obstacles are always away from junctions in the usual direction of LRV running
- When a crash between a car and a LRV occurs, the LRV may drag the car along certain distance. If a pole is placed near the junction then the car may be squashed between the LRV and the pole.
- If the pole is located at least at the LRV stop distance from the junction this situation is avoided

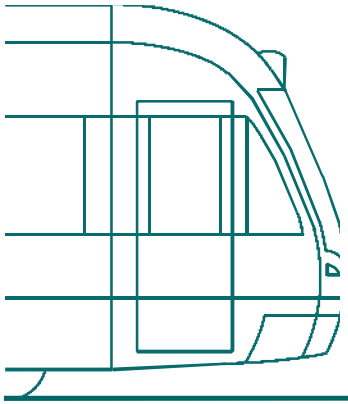
$$d = \frac{v_0^2}{(2a)} + v_0 \cdot t_r$$

d: LRV stop distance (length of the zone without fixed obstacles)

a: LRV deceleration (2.8 m/s^2 or the one given by the manufacturer)

v_0: LRV speed when passing through the intersection

t_r: equivalent response time (0.85 s)



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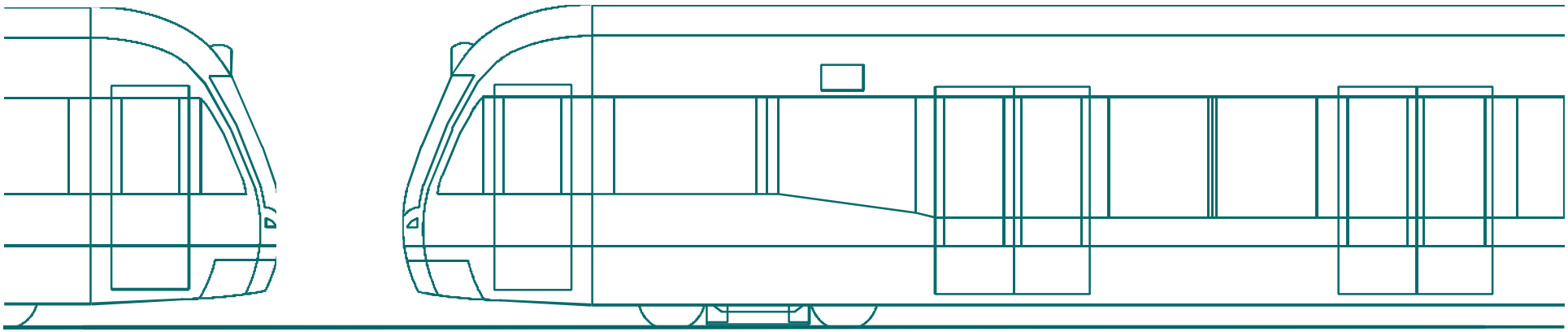

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