Technical Guide

Safety at level crossings

Case of proximity to a roundabout
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Technical Guide

Safety at level crossings
Case of proximity to a roundabout

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This document was written by Bénédicte Vignal and Sylvain Giausserand (Sétra) within the scope of the "level crossing and roundabouts" working group formed in the technical group associated with the central national policy coordination authority for the improvement of safety at level crossings.

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Reading convention

Terms followed by the symbol * are explained at the end of the publication in appendix 4.
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1 - Overview

1.1 – Context

In France, the stakes involved with intersection-related road accidents are high:
• 27% of accidents occur at intersections, causing 15% of deaths (i.e. 763 in 2004) and 20% of serious injuries (i.e. 3538 in 2003);
• 39% of deaths and 61% of serious injuries at intersections occur in urban areas.

The creation or conversion of existing intersections liable to generate accidents into roundabouts is often a suitable solution for decreasing the number and/or severity of intersection-related accidents.

In this way, with the development of roundabouts, design departments and road managers are increasingly faced with the problem of potential tailbacks of lines, in the event of proximity to a level crossing, on any of the branches. The term proximity refers to a distance such that the level crossing is highly likely to be located on the vehicle stacking area, at foreseeable and usual peak traffic times.

They may consist in new roundabout creation projects or projects to develop conventional junctions (with four or more branches) into roundabouts, or even existing roundabout projects.

The purpose of this document is to give recommendations and technical solutions for designers and managers, in their capacity as representatives of the local road authority, contracting agency or consultants to local authorities.

Note: this approach, although it covers the specific problems associated with roundabouts, may also serve as a point of reference for the application of a method of the same nature to other types of intersections located in the vicinity of a level crossing.

1.2 – Problem statement

The presence of a junction in the vicinity of a level crossing (P.N.) sets a safety problem associated with potential tailbacks on said level crossing.

In the case of a roundabout, this proximity may involve the following drawbacks:
• congestion of the level crossing, with the tailback of the line reaching the level crossing, accounting for the give way sign at the entrance to the roundabout and the behaviors observed (figure 1);
• blocking of the junction when the level crossing is closed (figure 2).

However, it also offers advantages such as:
• in one direction of the traffic, slowing vehicles down before they approach the level crossing;
• obtaining a significant gain in road safety, compared to other junction solutions in terms of route design.

In view of the above and according to the possible scenarios, a thorough study of the design choice is necessary:
• appropriateness of choice of roundabout;
• action on distance between level crossing and roundabout (new junction or significant change to intersection);
• action on geometry of project.
1.2.1 – Roundabout creation

In this case, it is always advised to ensure that the roundabout solution is fully justified in terms of safety. This solution offers potential gains in safety, if permitted by the design context, unlike any other solution: route design approach, accounting for vulnerable users, clearance of visibility and removal of obstacles following property purchases, for example. The selection criteria and professional standards given in urban and interurban junction design guides represent a good reference to assist with the road authority's decision.

In addition, the creation of a roundabout requires:
• the junction to be at a sufficient distance from the level crossing: as an indication, this distance (dPN) between the "Give Way" (CLP) line and the level crossing should not be less than 20 m, which prevents a heavy goods vehicle from occupying the level crossing due to its length;
• the operation of the roundabout/level crossing combination to be suggested and easily understood by all users, whether local or occasional, using police and direction traffic signs, according to conventional sequences;
• no cause, as soon as the junction is in operation, for the set-up of exceptional measurements (signing, lights, interconnected road and rail traffic warning or operating systems) such as those possibly envisaged for an existing roundabout (or the conversion of an existing junction into a roundabout); the risk analysis developed below makes it possible to detect unacceptable configurations.

1.2.2 – Development of existing junction into roundabout

If the existing junction is liable to accidents, a road safety diagnosis (detailed analysis or accidents and behaviors) is required.

The risks and behaviors associated with the operation of the junction are the same as those for roundabout creation (point I.2.1 above), leading to the same preliminary analysis precautions.

However, it is important to note that, if the branch on which the level crossing was previously located had priority, the existing stacking configuration is subject to adverse changes (change of priority, potential reduction in available stacking length due to radius of roundabout, etc.).

In the two scenarios above, it is necessary not to lose sight of the favorable effect that the development of a roundabout may have on the approach speed of vehicles in the vicinity of the level crossing for the direction in question (reduction in risk of collision with a train or of hitting railroad installations, particularly barriers).

1.2.3 – Existing roundabout

In this situation, the hazards and behaviors may be of the same nature as those for roundabout creation (point I.2.1 above); they may also ensue from a noticeable change in road or rail traffic (creation of new area of attraction, change to surrounding road network, etc.).
1.3 – Data inventory

The proposed analysis requires:
- knowledge of the distance of the new or existing junction with respect to the level crossing;
- knowledge of road accident research on the existing junction to be developed or the grounds for the new junction type;
- knowledge of accidents involving a train or near misses (impact of equipment, particularly breakage of barriers) associated with the level crossing;
- in-depth knowledge or forecasts of road traffic (by time slot, user type, traffic flow per peak 1/4 hour for each roundabout entrance according to type of travel depending on time and day);
- knowledge of rail traffic (number of trains, passing times, maximum speed, type, etc.);
- geometric characteristics for the roundabout (radius, ring width, number of branches, etc.).

1.4 – Proposed approach

In most of the cases inventoried and in view of the risk of a line tailback stopping on the level crossing, designers are frequently tempted to place traffic lights at the roundabout entrance on each branch, which is supposed to make it easier to clear the roundabout and the branch concerned by the level crossing.

This solution, which may prove to be useful or even necessary in some cases, should be recommended with proper judgment as it may prove to be liable to criticism in terms of effectiveness (in situations when a train is approaching and in situations when there is no train) and cost; particular attention should be paid to the possible behavior of unusual users of the area.

In order to prevent this drawback, a risk analysis and assessment-based approach is proposed in order to provide planners and managers with a suitable solution for the different situations.

In any case, from the preliminary design stage, it is advisable to organize consultation with all the partners concerned by the operation.
2 - Risk analysis

The assessment of the level of risk represents the first step in the design of the conversion of an existing junction into a roundabout or for the construction of a new junction in the vicinity of a level crossing. It is also included in the diagnosis when the roundabout already exists and when disruptions are observed or when a noticeable change in traffic is expected.

2.1 – Risks

There are two types of risks:
- the line from the roundabout may reach the level crossing;
- closure of the level crossing may create disruption in the operation of the roundabout.

In terms of safety, these two hypotheses do not have the same consequences or the same solutions.

2.1.1 – Risk of road accident

The line from the level crossing reaches the roundabout.

The closure of the level crossing, especially if it lasts for a long time due to a stoppage in a railway station in the vicinity, is liable to generate a line; as it gets longer, the line will block the exit of the roundabout, and then part of the ring and the previous entrances.

The entrances from the level crossing will never be blocked as the traffic is stopped beforehand; therefore, only three-quarters of the roundabout ring will be saturated; the effect depends on the time for which the level crossing is closed.

When the level crossing opens, the situation will clear in a time depending on the traffic and the distance between the level crossing and the roundabout.

Therefore, there is a risk of a delay in lines that may extend beyond the roundabout; this has no impact on safety except in the middle of the countryside if a line trails back into an area out of visibility.

Particular attention should be paid when the traffic is at the saturation limit at peak traffic times and when trains pass frequently during the same periods.

It should be noted that the risk of delays is not greater with a roundabout than with any other type of junction; in particular, removing the priority at the ring or controlling the junction with traffic lights would have a much more adverse effect, resulting in a complete blockage of the intersection (photo 1).

2.1.2 – Risk of accident on level crossing

The line from the roundabout reaches the level crossing.

Even though stopping in a line on a level crossing is strictly prohibited by traffic regulations [5], it cannot be excluded that it may occur, sometimes unintentionally.

If there is a risk of finding a vehicle stopped on the railroad track and of the vehicle not being cleared before the arrival of a train, this represents a significant safety problem.

In this way, according to the geometric and road and rail traffic data, a risk analysis is required.
Photo 1: P.N. 26 in Dax (source: CETE, South-West France)
It should be noted that this risk is not restricted only to roundabouts in the vicinity of a level crossing; other scenarios also exist: junction controlled by a stop or give way sign, priority road with saturated left-turning lane, even if the junction is controlled using light signaling (photo 2).

2.1.3 – Scenario in which a risk assessment is required

The question is formulated as follows: below which distance between the level crossing and the roundabout should the risk assessment be conducted?

The roundabout is less than 20 m from the level crossing.

This situation should be avoided; for the diagnosis of existing cases, or when it is not possible to accept any other solution, refer to section 4 "specific cases".

The distance is between 20 and 100 m.

In any case, following the risk assessment procedure proposed in section 2.2.

The distance is between 100 and 200 m.

Check the position of the traffic combination with respect to the curve in the graph below:

- below curve, the risk assessment study is not required;
- above curve, the risk assessment study is required.

see graph 1

The distance is greater than 200 m.

If problems are observed or likely with such a distance, the design of the junction is focused on first of all, checking that the choice of roundabout is suitable for the volumes and/or management of the traffic present (in this case, the solution is based on flow management in view of network capacity).
2.2 – Risk assessment

The approach consists in calculating the length of the maximum possible line at the entrance to the roundabout and comparing to the distance (dPN) between the roundabout and the level crossing.

2.2.1 – Data compilation

The data required for the study are:
• the geometric characteristics of the roundabout (required to calculate capacity), i.e. the radius, ring width, branch layout and widths of entrances, exits and dividing islands.
If the roundabout is at the design stage and its characteristics are not defined, standard values will be selected for the site and the type of road;
• the traffic on each branch obtained with automatic counts in quarter-hour intervals and in each direction for one week outside vacation periods.
For the creation of a roundabout, the following traffic forecasts will be taken:
• quarter-hour directional counts in the junction for peak times, defined using automatic counts (N.B.: data required to assess capacity [9]);
• assessment of pedestrian and cyclist traffic and corresponding routes;
• train passing times and the passing speed of each train in the vicinity of the level crossing and the closing times caused;
• any events that disrupt or generate traffic in the surrounding areas (other junctions, hypermarket, high school, etc.).

2.2.2 – Preparation procedure

• the quarter-hour traffic for each entrance will be used to draft a bar chart of the total traffic entering the roundabout, on which the train passing times will be recorded;
• to perform the directional counts, the time slots with the heaviest traffic during train passages (one-hour time slots overlapping with the train passing times) and the peak times in the mornings and evenings, if they are not included, will be selected;
• the directional counts for the quarter-hour during which the incoming-turning combination at the level crossing branch roundabout entrance is the greatest will be selected.

2.2.3 - Line calculation

• the selected quarter-hour matrix is multiplied by 4;
• a high peak coefficient of 1.5 is applied for roads in the tourist sector or in business areas or 1.25 for other roads;
• a capacity test [9] is performed (e.g. with Girabase);
• the max line for the entrance in question is selected and converted into lengths by adopting a length of 7.50 m per vehicle unit (lqmax).
In the case of a 2-lane entrance, it is necessary to estimate that one 25% of vehicles are stacked on the second lane.

2.2.4 - Risk assessment

The stacking reserve is calculated
\[
(R_{lq}) = \frac{dPN - lq_{max}}{dPN}
\]
• dPN is the distance of the roundabout entrance to the level crossing;
• lqmax is the maximum line length on the roundabout branch;
• the Rlq value ranges;
  – if Rlq > 50%
    Low risk - no problem
  – if 25% < Rlq < 50%
    Average risk - envisage, at least, one static solution
– or $0 < R_{Lq} < 25\%$
  High risk - also envisage a preventive (or corrective) dynamic solution
– if $R_{Lq} < 0$
  Unacceptable risk - change the roundabout capacity or review the project
3 - Solution proposal

In the event of a risk of finding vehicles stopped on the level crossing when a train is approaching, various solutions may be envisaged, either to dissuade or prevent drivers from entering the level crossing without being sure that they can leave it immediately, or to enable them to clear the railroad land before the train arrives.

Therefore, a distinction is made between preventive solutions and corrective solutions.

These solutions may be static, using signing or a diverging lane, or dynamic, with variable (light) signaling controlled on the detection of a line and the arrival of a train.

Each solution is not suitable for all site configurations, distances between the roundabout and the level crossing, roundabout size or traffic levels. Some solutions may complement each other.

<table>
<thead>
<tr>
<th></th>
<th>preventive</th>
<th>corrective</th>
</tr>
</thead>
<tbody>
<tr>
<td>static</td>
<td>P1 Increased signing</td>
<td>C1a Clearance area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C1b Direct right-turning lane</td>
</tr>
<tr>
<td>dynamic</td>
<td>P2 Variable message signing</td>
<td>C2 Traffic lights at previous entrance</td>
</tr>
<tr>
<td></td>
<td>P3 Traffic lights before level crossing</td>
<td>C3 Traffic lights on ring</td>
</tr>
</tbody>
</table>

3.1 – Preventive measures

3.1.1 – Increase in static signing (P1)

Above all, it is necessary to summarize the regulatory signs for a level crossing and a roundabout. They may interfere with each other depending on the distance between the roundabout and the level crossing.

<table>
<thead>
<tr>
<th>level crossing signing</th>
<th>roundabout signing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A7 warning sign</td>
<td>• D42b direction sign</td>
</tr>
<tr>
<td>• J10 markers</td>
<td>• AB25 priority sign</td>
</tr>
<tr>
<td>• G2 signal including R24 lights</td>
<td>• J5 island nose marker</td>
</tr>
<tr>
<td>• marking of a continuous axial line if required</td>
<td>• island nose marking</td>
</tr>
<tr>
<td></td>
<td>• AB3a priority signing and signal stop line</td>
</tr>
</tbody>
</table>
The solution consisting in increasing the static signing does not depend on the distance between the roundabout entrances and the level crossing.

From the range of other regulatory signals, only the following are suitable:
• B6d sign – "stopping and parking prohibited" completed by the M9z panel "on railroad tracks";
• KC1 sign indicating "stopping prohibited on railroad tracks";
• continuous yellow line following on from the edge marking from the R24 signal, up to the opposite R24.

At the present time, no specific measure is specified and the use of non-regulatory signals requires DSCR (Direction de la sécurité et de la circulation routières – Road traffic and safety directorate) approval [6]. Within this framework, the manager could, for example, envisage trying out an advisory sign and/or also using yellow box marking on the level crossing (a type of marking frequently used in other European countries).

However, railroad-related interventions must be authorized by the railroad operator.

3.1.2 – Addition of dynamic signing (P2)

The implementation of dynamic preventive signing (variable message sign if applicable) is associated with the following possibility:
the line from the roundabout entrance becomes dangerously close to the level crossing.

The line downstream from the level crossing reaches a distance of 15-20 m from the railroad platform. This solution assumes that the distance between the roundabout and the level crossing is at least 40 m. The procedure consists in detecting a stopped vehicle or a vehicle moving at a very slow speed.

This detection activates:
• either an AK30 signal indicating a line. On a road subject to heavy traffic, this solution may be researched for distances dPN of up to 100 m, (or 150m, if the risk is established). The signal is positioned 30 to 40 m before the level crossing;
• or a B6d sign if the distance dPN is lower. In this case, the signal is positioned just before the level crossing.

A trial is in progress on the use of the A7 sign on variable message signs within the scope of level crossing safety.

The AK30 signal may flash in alternation with an A7 signal which is activated when an approaching train is detected. In this case, the sign is deactivated if the line has been cleared and after level crossing is opened.
3.1.3 – Level crossing entry light management (P3)

It is necessary to prohibit entry to the level crossing as soon as the line from the roundabout entrance is too close to the railroad platform. This solution should be envisaged in the event of a high risk of the line overflowing upstream from the railroad (see 2.2.4).

As for solution 2, the line downstream from the level crossing reaches a distance of 15-20 m from the railroad platform. The procedure consists in detecting a stopped vehicle or a vehicle moving at a very slow speed to control the change of an R22v stream control signal (three-colored green yellow red signal) to red. The signal remains red until the line has moved forward.

This signal is positioned upstream from the R24 signal. It is not necessary to set up specific advanced signaling, as the A7 sign represents a preliminary warning sign.

This solution presupposes that the distance between the roundabout and the level crossing is at least 40 m. On a road subject to heavy traffic, this solution may be researched for distances dPN of up to 150 m, if the risk is established.

The light is continuously active; the idle setting is green; it is obligatorily set to red when a train is due along with the R24.

The light changes to yellow (3 seconds) and then to steady red if a line is detected or a train is due. This requires detection of the train 3 seconds earlier and, therefore, the movement from the origin in general.

The light changes back to green if there is no longer a line and no train due.

There is no minimum time for which the light is green in this particular context (see article 110.C.3 of the Interdepartmental instruction on road signing - part six - permanent traffic lights).

It is strongly advised not to deactivate idle lights, due to the reaction time required for the arrival of a train.
3.2 – Corrective measures

3.2.1 – Clearance area creation (C1a)

This solution consists in offering stopped vehicles on the railroad platform a possibility to clear the platform when the level crossing is due to close.

For this, a clearance area is provided on the right, at the exit of the level crossing, over a minimum length of 20 m (at least equivalent to double the length of the railroad crossing) and a width of 2 m to 2.50 m. It ends before the roundabout entrance. It is prohibited for traffic by zebra marking and for stopping and parking other than for its intended purpose, by a B6d sign completed by an M6f panel "PROHIBITED except for clearing level crossing" (figure 5).

For improved user information, it may also be signaled by a C50 sign with, for example, the message "emergency clearance area" (figure 5 - photo 7).

If the risk is higher, the addition of a dynamic sign, with a message such as "clear railroad track", activated by the arrival of a train, may increase the effectiveness of the system.

3.2.2 – Direct right-turning lane (C1b)

The construction of a direct right-turning lane at a roundabout entrance is exceptional, particularly in urban environments. It is justified by heavy right-turning traffic and can be used to limit the entrance to the single-lane roundabout to one lane. It may also be envisaged to facilitate the movement of exceptional traffic on dedicated routes.

When it exists, it can serve as a diverging lane, provided that it is accessible from the level crossing.

3.2.3 – Management of lights (R22j) at one or more roundabout entrances (C2)

The purpose of this solution is to clear the line from the roundabout before it reaches the railroad track. It consists in stopping the priority traffic on the roundabout with a light signal to enable the clearance, at the entrance, of the level crossing branch.

The light signal should generally be set up at the previous entrances. However, if the priority traffic includes a significant proportion of vehicles from another entrance, a light signal is also position on the other entrance.

The light signal is positioned 10 to 20 m upstream from the "give way" line. In the countryside, it is indicated by an A17 sign.

![Figure 5 - photo 7: P.N. on RD 746 at Luçon (85) (Source: CETE, Western France)](image)
Deactivated when idle, it is activated to flashing yellow when a line is detected in the vicinity of the level crossing. It then changes to red when a train is due (figure 6).

The time required to clear the platform depends on the size of the roundabout and the distance "dPN". Trains are detected at a sufficient distance for the line to move forward before the barriers start to come down, generally resulting in the movement of the origin of the train detection device.

Graph 2 gives the operating range as a function of the external radius of the roundabout (Rg) and the distance dPN, for 3 minimum time T values between the detection of a train and the start of lowering of the barriers (20, 25 and 30 seconds).

Irrespective of the level crossing closure time (e.g. stop in station when station is located between the origin of the detection device and the level crossing), the R22j light signal should not remain red for more than 30 seconds.

<table>
<thead>
<tr>
<th>Graph 2: operating limit of light at entrance</th>
</tr>
</thead>
<tbody>
<tr>
<td>rayon</td>
</tr>
<tr>
<td>radius</td>
</tr>
<tr>
<td>Un Rg &gt; à 30m devrait être exceptionnel</td>
</tr>
<tr>
<td>An Rg &gt; 30 m should be exceptional</td>
</tr>
<tr>
<td>largeur d’anneau</td>
</tr>
<tr>
<td>ring width</td>
</tr>
<tr>
<td>longueur de traverse du P.N.</td>
</tr>
<tr>
<td>level crossing length</td>
</tr>
</tbody>
</table>
3.2.4 – R22v slight signal management on roundabout ring (C3)

This solution consists in stopping the priority traffic upstream from the level crossing branch with a light signal located on the roundabout ring. The light signal is located on the dividing island and repeated on the central island. Deactivated when idle, it is set to green if a line is detected in the vicinity of the level crossing. It then changes to red when a train is due to arrive (figure 7).

The time required to clear the railroad platform depends only on the distance "dPN". As for the previous solution, trains are detected at a sufficient distance for the line to move forward before the barriers start to come down.

The graph below gives the operating limit distance as a function of the value of T. It is independent of the size of the roundabout and therefore suitable for larger roundabouts, particularly as it is difficult to install light signals for excessively small radii.

Irrespective of the level crossing closure time (e.g. stop in station when station is located between the origin of the detection device and the level crossing), the light signal should not remain red for more than 30 seconds, which is sufficient to enable the clearance of the level crossing while limiting the time that vehicles are blocked on the ring.

![Figure 7](image)

**Figure 7**

\[ T = \frac{dPN - 4.05}{2.78} \]

IPN = level crossing length  
T = minimum time between train detection and start of lowering of barriers

Comment: the value of T is that of the existing installation or incorporates necessary modifications (shift or set-up of new railroad detection)
4. Specific scenarios

4.1 – Roundabout very close to level crossing

The term very close refers to a distance between the give way line and the level crossing of between 0 and 20 m inclusive.

Preventive solution P1 (increased signing) using horizontal signing on the level crossing should be avoided due to the proximity to other markings: give way line, pedestrian crossing.

Preventive solution P3 (light signal management of level crossing entry) should be adapted using an R23 individual access control light signal (two-colored green-red signal) when the roundabout is very close to the level crossing. This makes it possible to allow vehicles to pass 1 by 1, when no-one else is waiting. It is only applicable when the traffic is moderate, less than 100 vh/hr.

The corrective solution with a diverging lane requiring space is unsuitable.

Dynamic corrective solutions can be used provided that the line detections between the level crossing and the roundabout entrance are replaced by a stopped vehicle detection device on the platform (detection method other than via loop - see appendix 2).

4.2 – Mini-roundabout

The term mini-roundabout refers to a roundabout with an external radius of less than 12 m which requires a low-kerbed central island. This situation is obligatorily urban.

Correct solution C3 (light signal management on ring) is impossible, failing a low-kerbed central island.

Corrective solution C1 (light signal management of level crossing entry) is generally unsuitable for dense urban environments, which justifies the construction of a mini-roundabout.

Corrective solution C2 (light signal management of roundabout entrance) may require light signals at all the entrances other than that of the level crossing.

4.3 – Level crossing inside roundabout

This situation should always be exceptional. It may be allowed if:

• the railroad track intersects the central island clearly;
• the size of the roundabout is sufficient to set up light signals and barriers on the ring;
• the closure time remains limited (not more than one minute);
• there is no risk of the left-turning traffic blocking each other when the barriers open;
• the entrances have a single lane.

Compared to a "conventional" level crossing, this situation generally requires the set-up of additional installations particularly on the central island (lights and barriers) with drawbacks associated with their maintenance (intervention of sufficient number of personnel, personnel safety, etc.).

Additional light signaling is to be used for one or several entrances very close to the railroad track (less than 10 m between give way sign and level crossing).
### 4.4 – Summary table of proposed solutions

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Scope</td>
<td>Low risk dPN 20 to 150 m</td>
<td>Low to moderate risk dPN 40 to 150 m</td>
<td>High risk dPN 40 to 150 m</td>
<td>Low to moderate risk dPN 20 to 100 m</td>
<td>High risk dPN 20 to 65 m</td>
<td>High risk dPN 20 to 120 m</td>
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<td>Preventive - Static</td>
<td>Preventive - Dynamic</td>
<td>Preventive - Dynamic</td>
<td>Corrective - static</td>
<td>Corrective - Dynamic</td>
<td>Corrective - Dynamic</td>
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<tr>
<td>Description</td>
<td>Addition of regulatory sign(s): B6d + M9z –KC1 …Continuous yellow edge line on level crossing</td>
<td>Use of variable message sign</td>
<td>Three-colored light signal</td>
<td>Extra width downstream from level crossing</td>
<td>Three-colored light signal at entrance before that from the level crossing</td>
<td>R22v three-colored light signal on ring</td>
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<tr>
<td>Operation</td>
<td>Activation in event of line</td>
<td>Activation of red light in event of line</td>
<td>Used to clear platform when a train arrives</td>
<td>Activation of red light in event of line and train arrival</td>
<td>Activation of red light in event of line and train arrival</td>
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<tr>
<td>Benefits</td>
<td>Lower cost</td>
<td>Comprehension</td>
<td></td>
<td>Independent of roundabout size</td>
<td></td>
<td></td>
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<tr>
<td>Drawbacks</td>
<td>Choice of regulatory signal</td>
<td>Positioning with respect to R24</td>
<td>Geometric constraint; parking risk</td>
<td>Max distance associated with roundabout size</td>
<td>Limited comprehension</td>
<td></td>
</tr>
<tr>
<td>Variants</td>
<td>Yellow box marking / level crossing; Experimental sign</td>
<td>Signal different if due to train arrival</td>
<td>R23 two-colored signal when roundabout is very close to level crossing</td>
<td>Additional variable message signs; Direct right-turning lane</td>
<td>Management of several entrances</td>
<td></td>
</tr>
<tr>
<td>Detection</td>
<td>no</td>
<td>Line or Train arrival</td>
<td>Line and Train arrival</td>
<td>Train arrival (in case of variable message sign)</td>
<td>Line and Train arrival</td>
<td>Line and Train arrival</td>
</tr>
<tr>
<td>Configuration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Train detection / clearance time</td>
<td>Train detection / clearance time</td>
</tr>
</tbody>
</table>
Appendices
Appendix 1 - Level crossing clearance time calculation [1]

a) In the case of a light signal positioned at the previous entrance, the time required to clear the level crossing following the detection of an approaching train is broken down into 4 parts:
• time at steady yellow;
• time required for the last vehicle to travel between the light signal and the crossing in front of the entrance corresponding to the level crossing;
• line start time up to the vehicle stopped on the railroad track;
• time required for last vehicle to cross the level crossing.

The time at steady yellow for an R22j light signal is 5 seconds.
The travel time is calculated on the basis of the average roundabout radius (middle of ring), at a speed of 36 km/h.
The line start time is 2 seconds for the first vehicle stopped at the give way line and 1.85 seconds for the following vehicles.
The number of stopped vehicles is calculated for the distance from the roundabout entrances and including the railroad land, counting 7.50 m per vehicle; the number is rounded up to the next highest unit.
The time required to cross the level crossing, for a last stopped vehicle is calculated at a speed of 10 km/h.

Note:
• the presence of HGVs in the line has no impact; one HGV is counted as 2 light vehicles; the clearance time, while it implies a slower start, is equivalent to that of 2 light vehicles due to the fact that all the vehicles are moving forward at the same time;
• in the case of priority traffic with a significant proportion of left-turning traffic from entrance N-2, it may also be necessary to set up a light signal at this entrance; in this case, the travel time on the ring is calculated from this entrance.

The most unfavorable calculation would consist in accounting for the case of a stopped HGV, with the booth under the barrier; a longer start time and the time required for its length to move forward would need to be taken into account.

b) In the case of a light signal positioned on the ring, the time required to clear the level crossing following the detection of an approaching train is no longer dependent on the size of the roundabout.

It is broken down into 3 parts:
• the time at steady yellow;
• line start time up to the vehicle stopped on the railroad track;
• time required for last vehicle to cross the level crossing.

After a green light, the time at steady yellow is 3 seconds. The calculation of the line start time and the time required to cross the level crossing include the same parameters as above.
Appendix 2 - Detections

Downstream line

The detection of a line downstream from the level crossing (between the level crossing and the roundabout entrance) activates:
• a dynamic preventive device as soon as a line liable to reach the level crossing is observed;
• a dynamic corrective device, when a line is observed and a train is approaching.

The principle consists in detecting a stopped vehicle or a vehicle moving at a very low speed at a distance of 15 to 20 m downstream from the level crossing. This implies an interval of at least 40 m between the level crossing and the roundabout entrance.

The use of dual detection when the distance to the level crossing is great enables the first level to activate a light system and the second (in the vicinity of the level crossing) to activate a light signal in dynamic solutions P3, C2 and C3.

Vehicle stopped on level crossing

The detection of a vehicle stopped on the level crossing or moving at an abnormally low speed activates, depending on the case:
• a dynamic preventive warning device, whether a train is approaching or not;
• a dynamic corrective device.

Loop detection should not be used. The other detection devices that can be envisaged should not interfere with the existing railroad installations, and vice versa. In addition, railroad interventions may only be authorized by the railroad operator.

Traffic upstream from level crossing

Counting of short traffic sequences upstream from the level crossing can be used to anticipate line formation and activate a preventive device.

Traffic upstream from the entrance N-1

Counting the priority traffic in short periods (generally from the previous entrance N-1) on the entrance N of the roundabout (from the level crossing) may be used to anticipate the formation of lines caused by continuous priority traffic. In this case, the action would be to artificially create gaps to facilitate the entrance N. This use is preferentially combined with line detection downstream from the level crossing.
Appendix 3 - Bibliographic references


**Appendix 4 - Glossary of terms**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.N.</td>
<td>Level crossing (Passage à niveau)</td>
</tr>
<tr>
<td>R.F.F.</td>
<td>Réseau Ferré de France (French Rail Network company)</td>
</tr>
<tr>
<td>P.M.V.</td>
<td>Variable Message Sign (Panneau à Message Variable)</td>
</tr>
<tr>
<td>Directional counts</td>
<td>Origin-Destination counts (Comptages Origine-Destination)</td>
</tr>
<tr>
<td>CLP line</td>
<td>&quot;Give way&quot; line (Ligne du « cédez le passage »)</td>
</tr>
<tr>
<td>T.A.G.</td>
<td>&quot;Left-turning&quot; movement or lane (Mouvement ou voie de « Tourne à gauche »)</td>
</tr>
<tr>
<td>T.A.D.</td>
<td>&quot;Right-turning&quot; movement or lane (Mouvement ou voie de « Tourne à droite »)</td>
</tr>
<tr>
<td>Girabase</td>
<td>Roundabout calculation software (Logiciel de calcul de capacité des giratoires)</td>
</tr>
<tr>
<td>R.P.N.</td>
<td>Road crossing railroad track (Route traversant la voie ferrée)</td>
</tr>
<tr>
<td>R.S.</td>
<td>Road intersecting with junction (Route sécante dans le carrefour)</td>
</tr>
<tr>
<td>I.P.N.</td>
<td>Level crossing length: distance measured from level crossing light signals to opposite barrier (Longueur de traversée du passage à niveau : distance mesurée du feu du P.N. à la barrière opposée)</td>
</tr>
<tr>
<td>Rg</td>
<td>Roundabout radius (Rayon du giratoire)</td>
</tr>
<tr>
<td>La</td>
<td>Ring width (Largeur de l’anneau)</td>
</tr>
<tr>
<td>dPN</td>
<td>Distance between give way line and level crossing (Distance entre la ligne de cedez le passage et la traversée à niveau)</td>
</tr>
</tbody>
</table>
The presence of a roundabout in the immediate vicinity of a level crossing is not recommended for safety reasons.

However, for existing facilities and scenarios where it is not possible to avoid placing a roundabout in the immediate vicinity of a level crossing, this guide offers the managers concerned some possible solutions.

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