

# Light Barrier for Level Crossings in the CZ – Experience after One Year of Operation

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**ABSTRACT:** In European countries, measures to increase warnings at level crossings are currently getting support. One of them is the so-called light barrier. Most of its applications are in the process of testing, in practice it is only used in Austria to some extent. In the Czech Republic, a light barrier was installed at a level crossing in Nová Včelnice under the R&D project SVEZA - TA01031404 “Research on the applicability and effectiveness of the so-called light barrier at level crossings in the CZ” (the project is being carried out with the financial support of the Technology Agency of the CZ). After one year of operation we can say that the device is effective. At the previously problematic level crossing (one accident every year on average and recurring risk situations) there has been no accident since the installation. In addition, a questionnaire survey among users showed mostly positive attitudes; respondents pointed to the enhanced comprehensiveness of the crossing, good light intensity, and the eligibility of the light barrier at this type of crossing. The testing of its operation and maintenance are still in progress, and camera monitoring of the behaviour of users is being prepared.

**KEY WORDS:** Level crossings, light barrier, safety.

## 1 INTRODUCTION, DEFINITION OF A LIGHT BARRIER

At present, the testing of a pilot installation of the so-called light barrier is taking place in Nová Včelnice at a level crossing on a narrow-gauge railway operated by JHMD (Figure 1). This is the first installation of a device of this kind in the Czech Republic and we do not find many examples of its implementation even in Europe, although in recent years reports suggest upcoming pilot projects. More widely, a light barrier is only used in Austria (Figure 2), where dozens of applications have been implemented, and more are being prepared. The device is also defined in Austrian legislation in the level crossing ordinance EKVO (Eisenbahnkreuzungsverordnung).

A light barrier is a device consisting of a set of red traffic light studs placed on the lane before a level crossing, perpendicular to the axis of the road. These studs will light up with flashing red lights simultaneously with the basic warning lights, creating an optical barrier in front of an approaching vehicle, which reminds the vehicle of the obligation to stop. In principle, it is another form of the so-called additional warning, similar to an audible alarm or mechanical barrier in addition to a crossing signalling device.

The colour of the light barrier is strictly red. Any colour variations are excluded. Only the colour red evokes unambiguous behaviour in road users (the signal for “Stop”). According to psychologists, interpretation of different colours could be perceived ambiguously and lead to serious problems in practice. All signalling devices used on roads always use red signalling colour to give the signal “Stop!” (whether it is an ordinary signalling device or warning lights).

A light barrier is activated by a non-potential or, in other words, free contact of the crossing signalling device relay, which passes information to the electronic control unit of the light barrier that warning lights at the level crossing were initiated. The circuit of the light barrier is safely separated from the crossing signalling device so that in the case of any failure (e.g. short circuit) of the light barrier, the basic warning light signal of the crossing signalling device would not be affected.

The basic idea of a light barrier is based on the assumption that the probability of the perception of the basic light warning can be effectively increased by in-road signalling devices. The purpose of a light barrier is to produce a strong light, enhancing the status of warning on a level crossing, thus “doubling” vital information. This reduces the risk of overlooking a warning, e.g. in bright sun (which can cause a sun-phantom effect) and it is in these situations where a light barrier can save lives. “A light barrier significantly increases attention or, more precisely, the potency of road users' perception” (Müller, 2010).

The efficiency of light barriers as perceived by drivers can be scientifically documented e.g. on the basis of the research project “Analyses of drivers' views at level crossings”, implemented by the Institute for Holistic Accident and Safety Research under E. Pflieger (2009). Analysis of driver's views using a unique technology Viewpointsystem, conducted at 31 level crossings, found deficits in driver's visual perception and helped formulate recommendations to optimize the arrangement of level crossings. As stated by Pflieger (2009): “drivers usually concentrate visually on vertical markings on the right side of the road and the area before the crossing”. Another finding is that a driver who is under psychological pressure and does not concentrate fully on driving (e.g. quarrel with driver's wife, naughty children, ringing phone, etc.) tends to look down”, that is rather on the road than up to the warning lights. Pflieger (2009) also states: “In a stress situation, the probability of perception of a warning produced by a light barrier is very high”. These are convincing arguments for the implementation of light barriers.

In Austria, a light barrier is a part of the strategy “let's help drivers” adopted by ÖBB. The strategy is based on the assumption that accidents on level crossings are caused by a failure of drivers who must therefore be assisted with complying with the principles of safe conduct, and that therefore the crossings must be improved and made more driver-friendly. This principle is based on a partnership approach rather than repressions. In this connection, reference can be made to a study of 87 fatal accidents from years 1988 – 1998 (Sochon & Davies, 1998). Over 80% of them occurred during daylight and in nice weather, and the main cause of 42% of them was found to be an “accidental mistake of road user”. According to the study it is likely that “it is difficult for the driver to understand in time the road signs and signals at the crossing, estimate the speed of a train and the position of the intersection”.

New safety features are also supported from a state level. The manufacturer of light barriers (EBE-Solutions, GmbH, ensuring delivery of light barriers for ÖBB) was rewarded a state prize for their project in a technological competition Staatspreis Verkehr 2009.

Installations from other countries are not known, with the exception of Slovakia, where there is only one experimental level crossing in Bratislava-Jarovce. Slovakia however does not count with further applications, mainly due to administrative reasons.



**Figure 1: Light barrier in Nová Včelnice.**



**Figure 2: Light barriers in Austria.**

## 2 ARRANGEMENT OF A LIGHT BARRIER WITH REGARD TO ROAD AND CONNECTION TO CROSSING SIGNALLING DEVICE, ECONOMIC ASPECTS

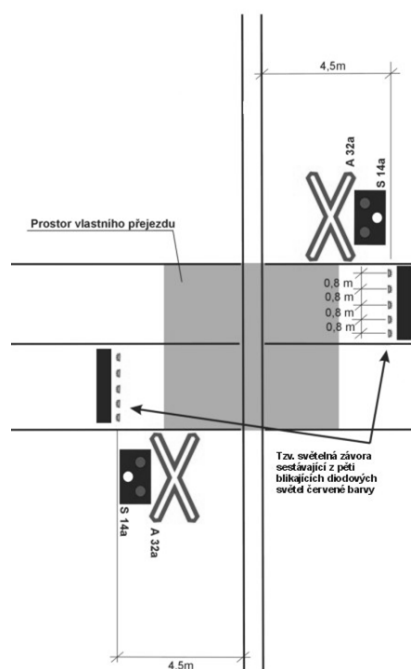
A light barrier usually consists of five traffic light studs; on narrow roads with no dividing line we can also find light barriers consisting of four studs. Studs are usually mounted 20 cm before a single solid transverse line (traffic sign No. V 5).

In principle, a light barrier is mounted on the approach lane before a crossing. It is not mounted over the whole width of the road. In addition to higher prices and more complicated maintenance, such an arrangement would also imply a more complicated installation – the need of complete road closure, and there would be no safety benefits (e.g. no case of driving around a light barrier has yet been recorded).

Connecting to the crossing signalling device is very simple in principle. The only element to be provided by the level crossing administrator is the non-potential, or free contact, of the activation relay of the crossing signalling device. This contact gives information to the control unit of the light barrier that the warning state of the level crossing has been initiated (in principle, similar to the consecutive light signalling device of the neighbouring intersection).

The electronic control unit of the light barrier is normally located in a crossing house (Austrian practice). In the pilot light barrier project in the CZ (site Nová Včelnice, see below) the control unit is placed in a separate distribution board next to the crossing house (for administrative reasons – the light barrier can also have a different administrator).

Light barriers are powered from the network (an electric connection is always available at crossings with a crossing signalling device). Actual power consumption of traffic light studs with LEDs, however, is very low (supply current for two light barriers at a level crossing is only about 20 mA).



**Figure 3: Scheme of light barrier.**

A light barrier is very reliable in practice, mainly due to the absence of mechanical elements. Since 2008, when the first light barrier was installed in Wieselburg an der Erlauf, only sporadic problems have been reported. There were several cases when the current protection of the light barrier circuit was activated during a storm. In one case one traffic light stud was torn away by a snow plough (due to an installation fault). LEDs are extremely reliable, only in a few places has their glass cover been damaged, especially where fine gravel is used for winter gritting (the LED lights up but the light loses its intensity, it is therefore advisable to check the condition of glass covers once a year). The light barrier at the pilot Czech level crossing has been in operation for over a year without a single failure. Compared, e.g. with mechanical barriers, this device is less vulnerable and damageable, and the probability of failure is smaller (this does not suggest that light barriers should completely replace mechanical ones, as it is a device for a different purpose and criteria of usage).

The installation costs of a light barrier (meant in both travel directions) for a standard level crossing in Austria are approximately EUR 15 000 (i.e. the equivalent of about

CZK 380 000). In the Czech Republic, the cost of a light barrier can even be more favourable due to the generally lower price levels (about CZK 250 000 and less).

### 3 USE OF A LIGHT BARRIER

A light barrier can be very effective at level crossings having the following features:

- The crossing is less conspicuous in the terrain (e.g. a track in a slope, complex urban environment with many stimuli, etc.) and there is the risk of overlooking the basic warning lights;
- Direct road line, high speeds, wide open view through a level crossing;
- Risk of overlooking the basic warning lights due to low sun (risk of being dazzled at sunrise or sunset, or possibly mistaking the warning state for a sun-phantom effect), especially when the road intersects the track in an east-west direction;
- Great importance of road transport and low importance of railway transport evoke in drivers the psychological feeling of having the right of way, which may decrease the vigilance of drivers towards rail traffic (which in fact has the right of way).

Although light barriers were originally used as a cheaper option to additional mechanical barriers at level crossings secured by a crossing signalling device without barriers, in the Czech Republic a research team under the SVEZA research project has formulated the hypothesis that light barriers could also be effectively used on level crossings protected by a crossing signalling device with mechanical barriers. The main advantage could be in particular their immediate commencement to work, decreasing the probability of a driver entering the crossing when the warning bell is ringing beforehand and the mechanical barriers have not yet been lowered (which is interpreted by many drivers as “I still have time” or “the train is coming, but in a long time”). According to CDV surveys, 1-2% of drivers and more than 15% of pedestrians behave in this way, and these could possibly be stopped by an additional light barrier (Skládaná & Skládání, 2012). Ellinghaus and Steinbrecher (2006) also point at the risk associated with ringing the bell beforehand: “Switching on the red lights beforehand leads to the confusion of road users and undermines the authority of the light warning”.

However the idea of having a combination of a light barrier with mechanical additional barriers slightly controverts the original philosophy of a light barrier as a low cost alternative to conventional barriers. Such a solution will therefore be tenable in practice only in exceptional, substantiated cases.

### 4 LEGISLATIVE SITUATION ON LIGHT BARRIER

Legislation of the Czech Republic does not regulate light barriers as a whole, and laws and regulations relating to the railway and road traffic do not recognise the term light barrier. However, the light barrier as an element (traffic stud and traffic light stud) is defined as a traffic device by Decree No. 30/2001 of the Ministry of Transport and Communications, which implements road traffic rules and the arrangement and management of traffic on roads. The optical part of the light barrier is mentioned only in technical regulation TP 217 Highlighting optical elements on roads – Highlight posts, curb reflectors, guiding permanent light studs and highlight studs – principles of use, mentioning basic conditions related to their arrangement and parameters. From the perception of a road user, a light barrier is an unambiguously and intuitively understandable – in their subconscious, a red light

is strongly associated with the signal “Stop” (i.e. a light barrier is in compliance with the principle of a so-called self-explanatory road).

In Austria, the light barrier was incorporated in 2011 into the amendment to implementing Decree to the Law on Railways EKVO – Eisenbahnkreuzungsverordnung, which factually means its formal legislative recognition. It is regulated in § 13 of EKVO, where it is given the status of a device for additional warning (literally “other additional equipment”), i.e. in principle, it is regarded similarly to e.g. an additional mechanical barrier or an acoustic warning device.

## 5 PILOT SOLUTION OF A LIGHT BARRIER IN THE CZECH REPUBLIC

In accordance with the plan of activities of the research project SVEZA, a pilot installation of a light barrier on a level crossing in the Czech Republic was implemented. It was carried out on a level crossing in Nová Včelnice (a district of Jindřichův Hradec) on the track Jindřichův Hradec-Obrataň, at point km 12.189 (owner Jindřichohradecké místní dráhy, a.s.). It is intersected by a regional through road III/12826.

The manner of selecting the crossing in Nová Včelnice was complicated and lasted several months. The solution team considered and discussed a number of potential sites, and also consulted this matter with the Railway Infrastructure Administration, on whose network the first installation was initially expected. The main aim was to choose a crossing in which a light barrier would operate efficiently (have a favourable effect on drivers) and clearly demonstrate its features and benefits (referred to in the chapter Usage of a Light Barrier).

The level crossing in Nová Včelnice was finally found to be the optimal solution for the following reasons:

- The crossing used to be a black spot;
- It is inconspicuous in the terrain and visually disappears in the field, which is a very important typological aspect helping to emphasize the light barrier;
- Concerns about the so-called psychological right of way, because the road is straight, very comfortable (about 10 m wide) and inspires drivers to high speeds;
- The track gives the impression of being very subtle (760 mm narrow gauge track, apparently insignificant) and the danger of a collision with train may be underestimated by drivers (objectively the railway traffic is quite intense – more than 20 trains per day);
- Technical feasibility, mainly the good condition of the road before the crossing, allowing the traffic light studs to be embedded in it (any road defect would affect installation quality or lifetime);
- A smaller railway company with a clear structure, responsiveness of JHMD management to technical innovations and experimental solutions, simpler process of negotiating;
- It was financially and time efficient to combine the implementation of the light barrier with the construction of a crossing signalling device, initiated at the beginning of June 2011 (the crossing was originally secured only by a level crossing sign and sign “Stop, give right of way”).

After the pilot level crossing had been selected the phase of obtaining opinions and statements of the authorities concerned followed, which included the Ministry of Transport. It can be appreciated that the concerned parties showed a very positive attitude towards

the test installation of a light barrier, including the railway company (Jindřichohradecké místní dráhy, a.s.) that, without any difficulties, agreed to connect the light barrier with the crossing signalling device and provide the power. It is also necessary to appreciate the understanding and professionalism of the road administration, who officially specified the light barrier in terms of roads. Accordingly the project researchers obtained positive opinions in a relatively short time, and the light barrier installation was performed as early as June 8<sup>th</sup>, 2011 (installation of traffic light studs in the road) during the planned closure of both the railway and the road. The light barrier was factually put into operation in mid-July, 2012 together with the regeneration of the crossing signalling device.

The light barrier in Nová Včelnice has now been successfully in operation for over a year and the experience and reactions to its operation are practically only positive. The device works excellently, is one hundred percent reliable; no single failure of an electrical or mechanical character has occurred. The overall visual impression of the light warning emitted from the road is very positive, effective and comprehensible (Figure 4). As indicated by the survey results presented below, the distinctive impression of the transverse red line motivates drivers to stop. The positive acceptance by users is reflected in the local press: “Though a light barrier is a device having a psychological effect, in contrast to traditional mechanical barriers that form a physical obstacle, it is far more reliable, and of course cheaper. The psychological effect of the red line lit before a driver across the road is really strong. First experiences are excellent and the device seems to fully meet expectations: On the mentioned site, drivers pay much more attention than before” (Šatava, 2011).



**Figure 4: Light barrier in Nová Včelnice, day and night.**

During the pilot testing the following quality criteria and parameters are expected to be verified:

- The state of public opinion (using a questionnaire survey of users),
- The impact on the behaviour of road users (by analysing camera recordings),
- Evaluation of visibility under different lighting conditions and when snowing,
- Measurement of luminance and other light-technical parameters, temporal stability,
- Reliability in terms of electricity (possible existence of error messages and their form),
- Mechanical reliability – resistance to heavy traffic and winter maintenance,
- Traffic accident rate (evaluation is expected after 3 years of operation).

Out of these activities, the survey on the opinions of users on the installed light barrier at the crossing has been currently completed, which is mentioned below.

## 6 USERS' SATISFACTION WITH LIGHT BARRIER AT THE LEVEL CROSSING IN NOVÁ VČELNICE – QUESTIONNAIRE SURVEY AFTER ONE YEAR OF OPERATION

### 6.1 Objective of survey and the method

In June 2012, a questionnaire survey on users' satisfaction with the light barrier was carried out around the level crossing in Nová Včelnice. After one year of operation, users could express their views on the application of this device in a given location both in terms of their own comfort and the effect on the behaviour of other drivers, cyclists and pedestrians, and assess the advantages and disadvantages of the device compared to conventional level crossing protection. The objective of this survey was only a description of the users' opinions, not a description of the real impact of the light barrier on their behaviour; the real impact has been the subject of a long term observation.

Interviewers addressed passing motorists, cyclists and pedestrians (Figure 5). Drivers were stopped by a Czech Police patrol during their normal activities. Due to the nature of the questions, only those respondents who had had a personal experience with the device were interviewed. Interviews were therefore conducted only with respondents who live nearby or pass through the place on a regular basis, and are already familiar with the device. Drivers passing over this level crossing for the first time were not interviewed. With regard to traffic and the form of questioning, interviews were mostly brief; the questionnaire form contained three elaborated questions as follows:

- Are you satisfied with the present design of the railway crossing? Please choose the answer that suits you most. (Possible answers: Yes, a crossing signalling device with a light barrier in the road is a good solution; Yes, but I think that a crossing signalling device with no supplements would be sufficient, a light barrier is unnecessary; Yes, but extra mechanical barriers would be better; No, a mechanical barrier instead of the light barrier would be better; It is quite unnecessary, the previous solution, a level crossing sign and "Stop sign" was sufficient; Other);
- What do you think are the advantages and disadvantages of a level crossing equipped with a light barrier compared to a level crossing equipped with other forms of protection? (A light barrier is clearly visible, even if sun lights – agree/disagree/no opinion; Even to a distracted person, a light barrier gives a clear signal to stop – agree/disagree/no opinion; Unlike with mechanical barriers, no risk of getting trapped on a crossing - agree/disagree/no opinion; A light barrier does not prevent crossing on a red light as reliably as mechanical barrier - agree/disagree/no opinion; A light barrier saves time, it turns off faster than a mechanical one rises - agree/disagree/no opinion; A light barrier attracts too much attention, one may overlook something important - agree/disagree/no opinion; Other);
- Do you think that the light barrier at this level crossing helps– at least to a certain extent – to prevent users from crossing on a red light? Please choose the answer that suits you most (Possible answers: Yes, definitely; Yes, partially; Yes, but rather only on drivers; Yes, but rather only on pedestrians; No).





**Figure 5: Inquiry in Nová Včelnice.**

## 6.2 Survey results

### *The sample set*

In total, 125 valid interviews were gathered (91 drivers, 29 pedestrians, and 5 cyclists). In the sample group, as well as between the users of the crossing, motorists prevail. They are also usually more receptive to new level crossing arrangements than most pedestrians.

### *Satisfaction with the device*

Generally, it can be said that users are satisfied with the light barrier (see Table 1). The vast majority of respondents are satisfied with supplementing the crossing signalling device at this level crossing with a light barrier, especially in comparison with the previous situation (a stop sign and a level crossing sign) and they do not wish any changes. Some respondents generally consider a crossing signalling device with a mechanical barrier more reliable, but they regard such a solution at this crossing unnecessarily expensive. Among the respondents, only four of them would prefer a crossing signalling device with mechanical barriers, and five of them a crossing signalling device with both the mechanical and light barrier. Two respondents would welcome supplementing the warning lights with white positive signal. Two female respondents (one pedestrian and one driver) did not realize that, for already one year, there had neither been the level crossing sign nor the traffic sign No. P6 “Stop and give way” but instead the new device, even though they often travel there.

**Table 1: Satisfaction of respondents with the light barrier.**

Yes, a crossing signalling device with a light barrier in the road is a good solution	111	90.2%
Yes, but I think that a crossing signalling device with no supplements would be sufficient, a light barrier is unnecessary	0	0.0%
Yes, but extra mechanical barriers would be better	5	4.1%
No, a mechanical barrier instead of the light barrier would be better	4	3.3%
It is quite unnecessary, the previous solution, a level crossing sign and “Stop sign”, was sufficient	0	0.0%
Other	3	2.4%
Total	123	100%

(Two respondents did not answer.)

Regarding satisfaction with the light barrier, there were no fundamental differences between the categories of users.

### 6.3 Advantages and disadvantages of the device

In comparison with other types of protection (crossing signalling device without supplements, or those with mechanical barriers) users especially appreciated the good visibility of a crossing signalling device with a light barrier in any weather, at dusk and in full sun, its conspicuousness and efficiency in warning even a distracted person to stop. They often also mentioned time savings, as compared both to a crossing signalling device with mechanical barriers (light barrier turns off immediately after a train passes, no lost time) and the previous situation (a crossed level crossing sign and “Stop sign”) – no need now to stop and take a long look. If the device is not in operation, they can slowly continue the journey. In this connection, some respondents expressed their desire to have a positive white light here, enabling them to pass through more quickly. Other advantages or drawbacks were mentioned only marginally. The results are summarized in Table 2.

**Table 2: Perception of advantages and disadvantages of light barriers by respondents.**

	Agree	Disagree	No opinion	Total
A light barrier is clearly visible, even when the sun shines	86 (68.8%)	2 (1.6%)	37 (29.6%)	125
Even to a distracted person, a light barrier gives a clear signal to stop	89 (71.2%)	1 (0.8%)	35 (28.0%)	125
Unlike with mechanical barriers, no risk of getting trapped on a crossing	49 (39.2%)	0 (0.0%)	76 (60.8%)	125
A light barrier does not prevent crossing on a red light as reliably as mechanical barrier	34 (27.2%)	15 (12.0%)	76 (60.8%)	125
A light barrier saves time, it turns off faster than a mechanical one rises	63 (50.4%)	2 (1.6%)	60 (48.0%)	125
A light barrier attracts too much attention, one may overlook something important	3 (2.4%)	25 (20.0%)	97 (77.6%)	125

In assessing the advantages and disadvantages, respondents from the group of drivers were more active. Though pedestrians commented on individual items to a lesser extent, their opinions were not different.

### 6.4 Effects on user behaviour

The majority of respondents positively assessed the effectiveness of the light barrier on user behaviour. Among the respondents, 63% of pedestrians and 56% of drivers reported that the device definitely helped deter users from crossing on a red light, while 11% of pedestrians and 18% of drivers viewed that this was only true to some extent. Among the respondents, 22% of pedestrians and 21% of drivers felt that a light barrier affects drivers rather than pedestrians. The results are summarized in Table 3.

**Table 3: Respondents' estimation of the effect of the light barrier on user behaviour.**

Yes, definitely	69	57.5%
Yes, partially	20	16.7%
Yes, but especially only on drivers	24	20.0%
Yes, but especially only on pedestrians	1	0.8%
No	6	5.0%
Total	120	100%

(Five respondents did not answer.)

## 6.5 Other remarks and experiences

Respondents also noticed some other details. Several mentioned that the light emitted by the barrier is stronger than that of the warning lights. Others pointed to the uniqueness of that device – many users stop just because they are curious, and moreover, the light barrier is a local attraction. The combination with a psychological brake is something which they also liked.

On the other hand, respondents pointed to the fact that the force of habit of local people often makes them behave the same as when the crossing had been fitted only with a crossing sign and a “Stop and give way” sign – in all cases, they stop and look around. Two female respondents did not even realize that the crossing had changed a year ago, although they travelled there regularly. Not all are certain to understand how to behave on such a protected level crossing when the device is not warning. For any further installations, relevant information e.g. in the local press would therefore be useful.

## 7 CONCLUSION AND PERSPECTIVES

Although not all activities that are part of the testing of the device within the framework of the research project have been finalised, we can now say that the installation of the light barrier on the level crossing in Nová Včelnice was the right step towards increasing the safety of level crossings. At this crossing, which had previously been problematic, no accident or failure was recorded during the testing, and the assessment of users, though non-professional, confirms the hypothesis that the device makes the level crossing distinctive, strongly reminds users of an alert state of the crossing and improves its visibility. Satisfaction of road users and thus their demand is a strong argument for the broader use of light barriers in practice.

Within the research project SVEZA it is assumed that a light barrier will be installed at three level crossings (technical installation may vary slightly in the interests of comparison) and evaluated.

After completing and evaluating the research project SVEZA (in 2014), light barriers should be technically and legislatively prepared (let us say “handled” in terms of technology and especially legislation) for its possible “serial implementation”. One can imagine a situation where a light barrier would be part of a new construction or reconstruction of a crossing signalling device without mechanical barriers, where a level crossing is typologically suitable for the light barrier, e.g. the horizontal curve of the intersecting road has sufficient radius to enable a good view of the light barrier, etc.).

If developments in the Czech Republic proceeded similarly as in Austria, we can expect several dozens of installations in the near future (even hundreds if infrastructure managers take a positive attitude). Taken purely typologically, a light barrier can be justified at many level crossings secured with a crossing signalling device without mechanical barriers

(and exceptionally even with mechanical barriers). The decisive factor is the need to highlight an inconspicuous crossing in the field or the risk of overlooking a light warning, e.g. due to low level sun. An additional light warning emitted from a light barrier installed on the road is virtually impossible to fail to notice.

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