Preventing plant-pedestrian collisions: Camera & screen systems and visibility from the driving position

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Highlights

- Detectability of a pedestrian by a driver using a camera-and-screen system.
- Pedestrian should always be shown on the screen with a minimum height of 10 mm.
- Detection zone should cover an area extending beyond the danger zone.
- Size of the screen does not have a significant influence on detection.

Abstract

The issue of collisions between plant or site vehicles and pedestrians concerns numerous sectors of activity. Lack of visibility for drivers over their direct environments is one of the main causes of such accidents, which are often serious. Visibility can be improved indirectly by using camera-and-screen systems. This article gives the findings of a study on the detectability of a pedestrian by a driver using such a system in various configurations. It is thus recommended that, under the most unfavourable conditions, any pedestrian entering the danger zone be shown on the screen with at least a minimum height of 10 mm. Since the risk of non-detection is higher at the edges of the screen than at the centre, it is also recommended that the detection zone of the system cover an area extending beyond the danger zone under surveillance. Finally, since the size of the screen does not have a significant influence on detection, the choice of the screen size should be governed more by criteria regarding the fitting out of and the ergonomics of the cab or of the driving position.

Relevance to industry

Preventing mobile plant-pedestrian collisions is a problem area that concerns many enterprises, in particular in activity sectors like building and civil engineering, handling, transport/logistics and waste collection. Using camera-and-screen systems allows improving the visibility of the driver. This study gives recommendations about choice of such systems, in order to ensure better detection of pedestrians.

Keywords

Prevention – Plant-pedestrian collisions – Visibility – Camera – Screen – Visual aid

1. Introduction

Preventing collisions between plant or site vehicles and pedestrians is an issue that concerns various sectors of activity whenever proximity or coactivity exists between pedestrians and machinery that can move. Examples of such sectors are building & civil engineering (earth-moving vehicles or plant), goods-handling (fork-lift trucks), waste collection (garbage trucks/dustbin lorries), or indeed logistics (trucks/lorries for goods haulage). In order to address this issue, INRS launched a multi-disciplinary research project focussed on systems for detecting people using laser, radio waves, ultrasound, digital vision, etc. (Gardeux, 2010; Klein, 2010; Tihay, 2012). Research was also begun on camera-and-screen systems bringing the driver visibility over masked zones (blind spots). Such visual aid or vision aid systems are in increasing use because of the boom in digital technology (with performance improving and costs decreasing). This article gives the findings of a study on the capacity of a driver to detect a pedestrian by using this type of system. The criterion of the height of the pedestrian on the screen is analysed in particular because it has a direct impact on the choice (size of the screen, angle of view of the camera) and the location (distance between the camera and the pedestrian) of the system.

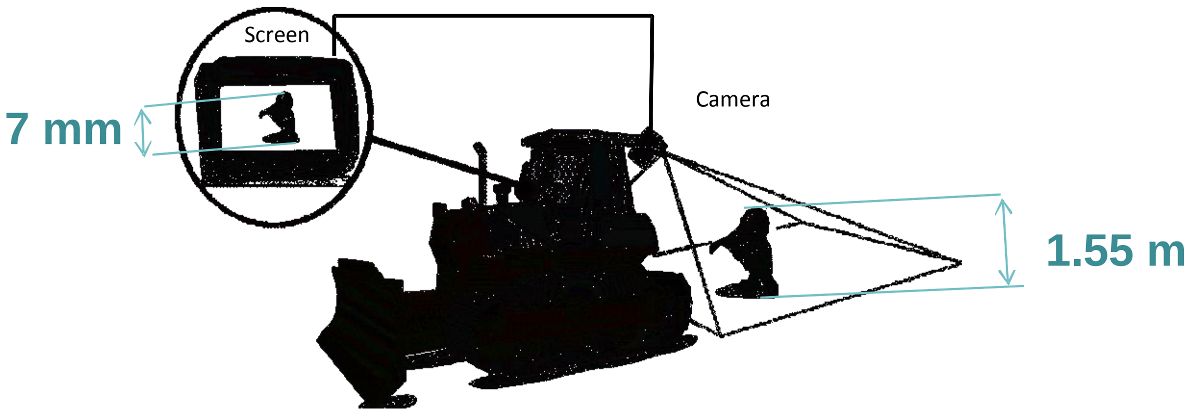
The visibility that a vehicle affords its driver is a decisive factor in preventing collisions between plant or site vehicles and pedestrians. When organisational measures do not make it possible to avoid coactivity situations, it is on the basis of the visual information taken from the surrounding environment that the driver decides on a driving strategy for avoiding the risks of collisions with people, or with other plant or vehicles, moving or standing in the same work space. Visibility is said to be direct or indirect depending on whether the driver observes the exterior elements directly through openings and glazed surfaces of the vehicle or plant, or via mirrors or any other visual aid system (e.g. a camera-and-screen system).

Many site accidents are related directly to insufficient visibility from the driving position (Marsot et al., 2009). In addition to affecting people moving and standing in the vicinity of the vehicle or plant, risk factors also affect the drivers themselves, who can then put themselves in dangerous situations due to masking of an obstacle, of a slope, etc. Insufficient visibility from the driving position is also a risk factor in back and low back pathologies due to uncomfortable postures taken up by drivers in order to obtain the visual information necessary for their activities (Godwin et al., 2007; Eklund et al., 1994; Hella et al., 1987; Vezeau et al., 2009).

As regards visibility, numerous regulatory or normative texts exist that are intended for plant manufacturers, defining evaluation methods and performance criteria. In this field a distinction should be made between road vehicles (Directive 70/156/EEC, 1970) and mobile machinery, i.e. machinery that can move or travel, in the sense of the “Machinery” Directive (Directive 2006/42/EC, 2006).

For road vehicles, and depending on the types of vehicle, Directives 2003/97/EC (2004) and 2007/38/EC (2007) set design specifications, installation instructions, and performance requirements for indirect vision systems (wing mirrors, rear-view mirrors, and camera-and-screen systems). For vehicles that are not designed to travel on the road (earth-moving plant, goods-handling trucks, etc.), that information can be found in the European standards that back up the “Machinery” Directive (NF ISO 5006, 2007; NF ISO 13564-1, 2012; NF EN 15830, 2012; NF ISO 14401-2, 2004; NF ISO 16001, 2008). Thus, in order to determine the range of a camera-and-screen system designed for earth-moving plant, Standard NF ISO 16001 (2008) sets at 7 mm the minimum height on the screen of the person to be detected (cf. Figure 1). This dimension of 7 mm was defined empirically in proportion to the size of the screens then most readily available on the market (with a maximum image’s height of 7 cm): “The effective operating range of the system is based upon on a minimum screen height of 7.0 mm. This is approximately 10% of the vertical screen height, which is normally considered acceptable for visual detection purposes” (excerpt from Standard NF ISO 16001).

Figure 1: Illustration of the height condition for determining the limits of detection of a camera-and-screen system (NF ISO 16001, 2008)



Analysis of the scientific literature on the use of camera-and-screen systems for combating the risk of plant-pedestrian collisions essentially shows work, in the early 2000s, on defining the hardware configurations necessary for covering the blind spots depending on vehicle type: haulage trucks/lorries, coaches and buses (Tait and Southall, 1998; Rau et al., 2003, 2005), and load-haul-dumpers (HSE, 2001; Godwin and Egert, 2009). Only one of those studies also addresses the concept of “visibility” of the pedestrian. Tait and Southall (1998) thus evaluated two types of camera-and-screen systems (one of which was cheap and the other top-of-the-range for the time). Twelve conditions were presented to three drivers: daytime and night-time, and with and without a test object/test body (A 1-m high, 75-mm diameter grey plastic pole, defined in Standard ISO TR 1255 (1994)) in the field of the camera. The images from the camera were shown for 0.5 seconds to each subject, who then had to indicate whether or not the target was present. On average, the target was not perceived in 14% of the cases under daylight conditions, and in 50% of the cases under night-time conditions. The authors explain these low performance levels by the distortions generated by the cameras that were used at the time.

Given the progress, in recent years, in the performance of camera-and-screen systems (going over from analogue to digital) and in the dimensions of the screens (8.9 cm (3.5 in) diagonal screens replaced by 12.7 cm (5 in), 17.8 cm (7 in), or 25.4 cm (10 in) screens), we launched a study to confirm or to invalidate the following hypotheses:

- **Hypothesis 1**: the smaller the pedestrian is on the screen, the higher the number of non-detections.
- **Hypothesis 2**: the smaller the screen, the higher the number of non-detections.
- **Hypothesis 3**: the larger the angle of view of the camera, the higher the number of non-detections due to distortions of the image.

Test these three hypotheses aims to establish the criteria for choosing a camera-monitor system, with focus on the detection of pedestrians in the vicinity of the vehicle to avoid a collision, as never done before. Moreover, camera’s angle, screen size and height of the pedestrian on the picture are three criteria that have previously not been taken into account simultaneously in previous studies.

2. Material and method

2.1. Material: camera-and-screen systems

A representative sample of the cameras and screens that were currently available for equipping mobile plant and site vehicles was selected for this experiment. Usually, manufacturers propose complete sets, with the cameras and screens being of the same make. In order to cover all of the characteristics considered, we intentionally selected the cameras (3 cameras) and the screens (3 screens) individually. The connectors were adapted so that each of the screens could be connected to all of the cameras.

The main selection criterion for the screens was their size: 12.8 cm, 17.8 cm and 25.9 cm diagonal. The main selection criterion for the cameras was their angle of view. Three families of angle of view are generally recommended, each being appropriate for a particular characteristic situation. All of the angles of view mentioned below correspond to horizontal angles (some manufacturers specify vertical or diagonal angles):

- wide angles (> 100°): the field of view is wide, and they make it possible to watch certain zones at the peripheries of the plant, e.g. by being positioned half-way up the back of the plant;
- intermediate angles (70°-100°): they are often used for straight-down views in order to watch the immediate vicinity of a vehicle or plant;
- narrow angles (< 70°): the field of view is deep but narrow. They are generally used to watch an environment of limited width, e.g. the side of a lorry (truck), etc.

Tables 1 and 2 below summarise the main optical characteristics of the selected equipment.

Table 1: Main characteristics of the screens used for the test

	Screen 1	**Screen 2**	**Screen 3**
Size (diagonal)	12.8 cm (5 in)	17.8 cm (7 in)	25.9 cm (10.2 in)
Resolution	337,000 pixels	384,000 pixels	384,000 pixels
Contrast	not disclosed	200:1	not disclosed
Brightness	300 cd/m^2	450 cd/m^2	400 cd/m^2

Table 2: Main characteristics of the cameras used for the test

	Camera 1	**Camera 2**	**Camera 3**
Angle of view (horizontal)	95°	131°	40°
Type of sensor	CCD ¼ Colour	CCD ¼ Colour	CCD ⅓ Colour
Resolution	270,000 pixels	317,612 pixels	315,544 pixels
Electronic correction of the variations in light intensity	Yes	Yes	Yes
Light sensitivity	0 lux (infrared LEDs)	0.5 lux	0.3 lux

2.2. Method

The methodology selected uses the same principle as that of the study conducted by Tait R. and Southall D. (1998) for evaluating the visibility of a pedestrian on a screen.

Thus, series of images (cf. Figure 2) pre-recorded with the selected cameras were shown to drivers on the three selected types of screen. The images were shown for 0.5 seconds. That length of time is representative of a “quick glance” that enables a person to analyse, understand, and memorise the essential information contained in an image (Sperling, 1960).

After being shown an image, the subject had to give two pieces of information: whether or not they had seen a pedestrian on the screen, and if they had, where on the screen (left, centre, or right). The latter piece of information made it possible to check that the subject had not confused a pedestrian with an element of the surrounding environment.

Figure 2: Examples of images recorded under different conditions

2.2.1. Test variables

Perception of a pedestrian on a monitoring screen can be degraded by various factors. In addition to the size of the pedestrian on the screen, other factors influence the quality of the image, and therefore the perception of a pedestrian by the driver: distortions of the image, reflections, insufficient contrast, etc.

A limited preliminary test made it possible to reduce the number of variables and some of their modes in order to keep only those that made it possible to be placed under the most unfavourable conditions. For example, it was initially intended that two modes would be tested for the posture of the pedestrian (stationary position and moving). Only the stationary posture was finally selected because the preliminary test showed that a moving pedestrian was detected systematically. Similarly, the conditions for the height of the pedestrian on the screen were reduced from five to four modes. The upper extreme mode (12 mm) was omitted since the data was without any statistical interest: 100% of the 12-mm pedestrians were detected during the limited test.

Table 3 shows the different types of variable selected for compiling the image base.

Table 3: Recapitulation of the variables selected for compiling the image base

VARIABLES RELATED TO THE CAMERAS	VARIABLES RELATED TO THE PEDESTRIAN	VARIABLES RELATED TO THE ENVIRONMENT	VARIABLE RELATED TO THE SCREEN
● 3 camera angles: 40° / 95° / 131° ● 3 camera positions: wide view / deep view / straight-down view	● 4 pedestrian heights: 2 mm / 5 mm / 7 mm / 10 mm ● 2 pedestrian outfits: with / without high-visibility vest	● Positions of the pedestrian: left / right / centre / no pedestrian ● 3 types of luminosity: Overexposed screen / Overexposed camera / Average ambient luminosity on the screen and on the camera	● 3 sizes of screen: 5 in (12.8 cm) diagonal / 7 in (17.8 cm) / 10.2 in (25.9 cm)

During the tests, screen type constituted an additional variable with 3 modes: 12.8 cm, 17.8 cm and 25.9 cm.

An additional test was conducted in order to test the "height of the pedestrian" on the screen under the most favourable conditions: absence of light pollution, pedestrian wearing a light-coloured outfit in the centre of the screen. This test was conducted on a limited image base (12 images), the main variable being the height of the pedestrian (2, 5, 7 and 10 mm). The object is to determine from what height a pedestrian becomes easy to see on the screen.

An experiment plan was then constructed in order to evaluate the influence of the other selected variables. Those selected variables were subdivided into variables of primary interest (camera angle, height of the pedestrian, and position of the pedestrian on the screen), and variables of secondary interest (size of the screen, outfit worn by the pedestrian, luminosity or brightness, position of the camera).
For each variable of secondary interest, the experiments were conducted using a full plan including all of the combinations of the variable in question with the three variables of primary interest. The other variables of secondary interest were then set at reference levels (screen size at 17.8 cm, without high-visibility vest, ambient luminosity and high camera position).
This plan made it possible to test the interactions between the variables of primary interest in all of these combinations and with the variables of secondary interest, but did not make it possible to test the interactions between variables of secondary interest. This experiment made it possible to reduce the number of images to be viewed by the subjects from 2,592 to 340. In order to avoid the phenomenon of learning by the subjects, the environment in which the images were taken was varied (with different obstacles) and the images were ordered randomly.

2.2.2. Image database

The fact that recorded images were used meant that there was a risk of biasing the experiment insofar as the recorded images might not reproduce the same quality on the screen as images filmed live. That is why the image of a target test card was observed in a live shooting situation and in a time-shifted situation in which the video recording was shown on the test screens. The rendering of the colours and of the dimensions of the target test card was compared visually in order to ensure that the image quality was equivalent under both conditions.

2.2.3. Statistical method

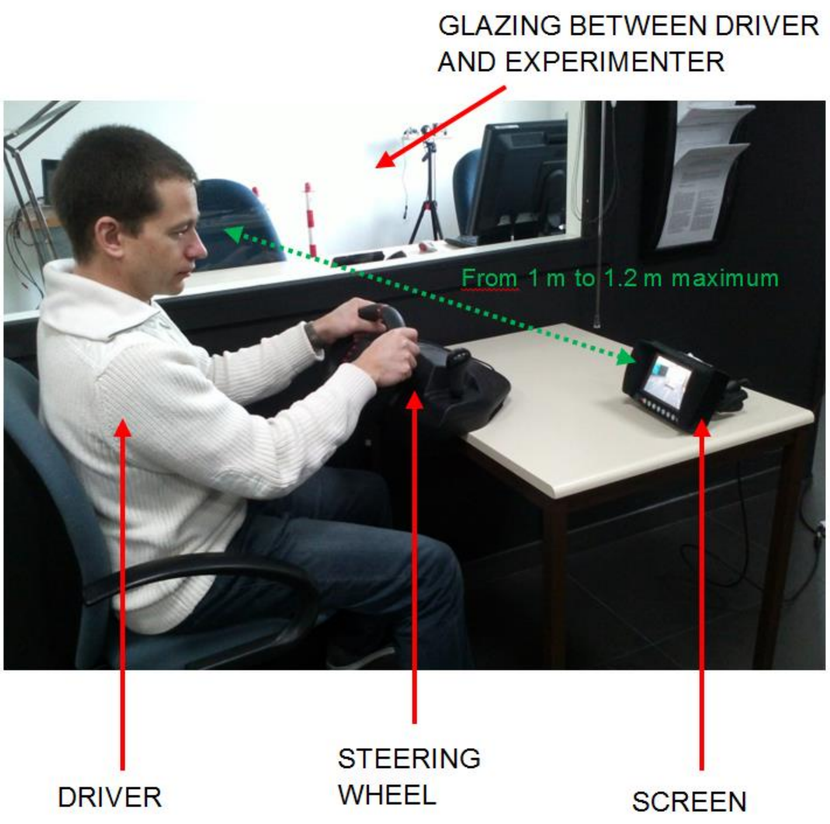
The statistical results of the experiment plan were analysed using the logistic regression model. The outcome of the experiment being binary (detection or not of the pedestrian on the screen), the standard statistical model is the multiple logistic regression, which models the probability of the outcome as a function of the different independent variables included in the experiment plan as well as their interactions, when possible (see above). The results of the different models are given as graphs of predicted probabilities averaged over the other factors not included in the graphs. The models were fitted using Stata 13 (Stata Inc, College Station, Tx).

2.3. Test protocol

The camera-and-screen systems were tested in the laboratory. The subject was seated at a table on which the monitoring screen was positioned (cf. Figure 3). The distance between the screen and the eyes of the subject was about 1 metre (Standard ISO 16001 (2008) recommends a distance less than 1.2 m). A steering wheel was also positioned on the edge of the table for the purpose of:

- marking a psychological boundary in order to avoid the subject moving closer to the monitor to detect a pedestrian;
- positioning the subject’s seat a fair distance away from the table while simulating the needs of driving and while having the hands on the steering wheel.

Figure 3: Conditions of the test (driving position)



The experimenter was in an adjacent room separated by glazing so as to check that the test was proceeding properly. The experimenter triggered showing the images on the monitoring screen at the request of the subject.

The experiment was subdivided into 6 sequences of from 10 to 15 minutes, with breaks between them so as to enable the subjects to have recovery times and thereby prevent visual fatigue and loss of concentration.
At the end of the tests, the subject accompanied by the experimenter answered a questionnaire in the form of a semi-structured interview in order to gather what the subject felt about the experiment, in particular about the manner in which he assessed his performance during the tests. The aim of the questions was to determine the level of confidence that the subjects had in the "camera-and-screen" systems.

2.4 Subjects taking part in the experiment

Fifteen plant drivers took part in this experiment (cf. Table 4). They were exclusively men aged from 20 to 53 and they all had one or more qualifications (Certificats d'Aptitude à la Conduite d'Engins en Sécurité (CACES), or "Certificates of Aptitude for Driving Plant Safely"). An eye test using the principle of the Monoyer scale (Monoyer, 1872) enabled their visual acuity to be checked.

Table 4: Description of the test population

Subject	Age	Type of plant driven	Visual Acuity
1	29 years	Backhoe Loader / Road Haulage Truck / Goods-Handling Truck / Site Truck / Auxiliary Crane	10
2	39 years	Road Haulage Truck / Auxiliary Crane	10
3	39 years	Excavator / Backhoe Loader / Loader / Mini-Plant	9
4	52 years	Road Haulage Truck / Goods-Handling Truck	10
5	44 years	Goods-Handling Truck	10
6	53 years	Goods-Handling Truck	10
7	30 years	Excavator / Goods-Handling Truck / Loader	10
8	25 years	Goods-Handling Truck	10
9	44 years	Roller-Compactor / Excavator / Goods-Handling Truck	10
10	23 years	Excavator / Dumper / Loader	10
11	20 years	Roller-Compactor / Backhoe Loader / Dumper / Excavator / Loader	10
12	50 years	Roller-Compactor / Excavator	10
13	23 years	Roller-Compactor / Backhoe Loader / Excavator / Dumper	10
14	31 years	Roller-Compactor / Backhoe Loader / Loader / Excavator / Dumper / Site Truck	10
15	26 years	Roller-Compactor / Backhoe Loader / Goods-Handling Truck / Excavator / Dumper / Site Truck	10

3. Results

3.1. Stastical analysis

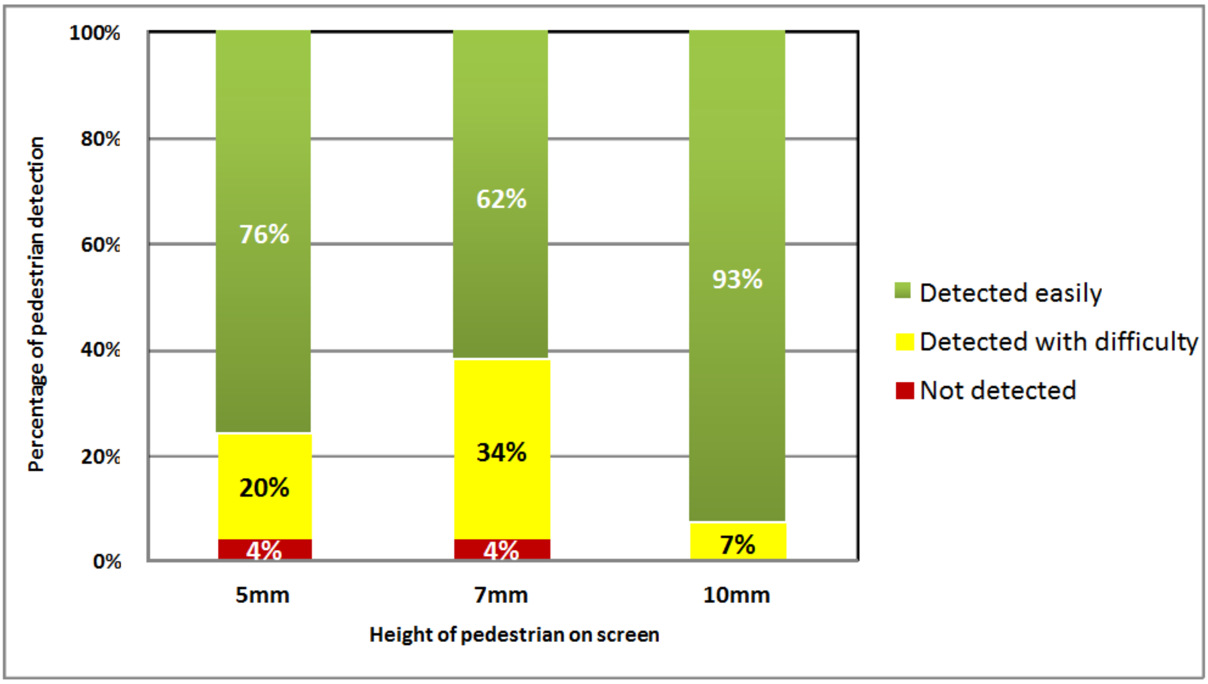
***3.1.1 Hypothesis 1**: the smaller the pedestrian is, the higher the risk of detection error.*

Firstly, we should note that the height of 2 mm was omitted from the statistical processing of the findings, because no pedestrian of that size was detected (100 % of the cases).

When the pedestrian is shown in a favourable situation (mean ambient luminosity, pedestrian wearing a light-coloured outfit, pedestrian in the centre of the screen), it can be observed that, as of a minimum height of 10 mm, a pedestrian located in the centre of the image is detected by all of the subjects. This detection is described as easy in 93% of cases (cf. Figure 4).
For heights of 7 mm and of 5 mm, although the rate of non-detection remains low (4%), detection is felt to be significantly more difficult: 20% and 34% respectively for the heights of 5 mm and 7 mm, as against 7% for a height of 10 mm.

Figure 4: Detection of pedestrians as a function of their height on the screen under favourable conditions

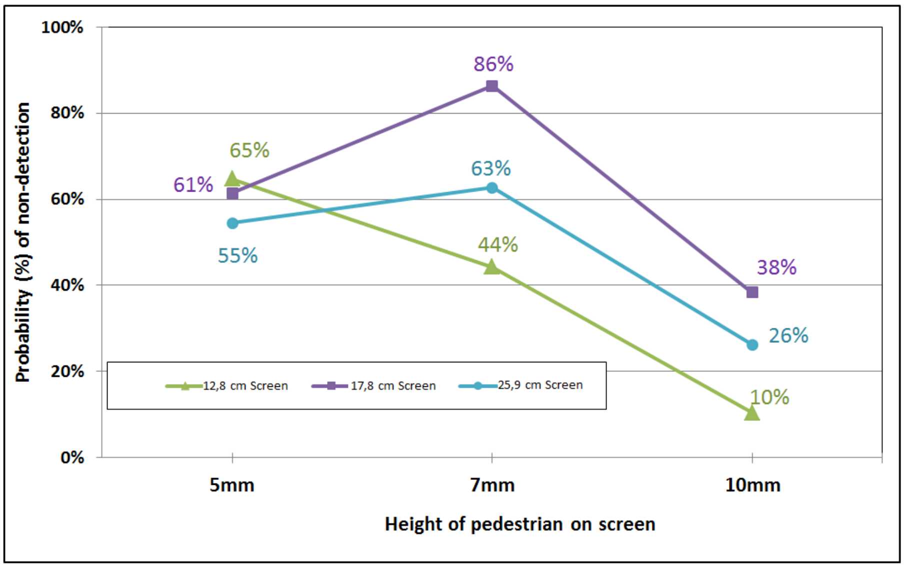
(Pedestrian wearing a light-coloured outfit, in the centre of the screen, & average ambient luminosity)



The statistical analysis of the findings over the entire experiment plan taking the other selected variables into account confirms this result. The risk of error for the height of 10 mm is 26.3% on average. It is respectively 50.3% and 60.3% for the heights of 5 mm and 7 mm. The difference between the heights of 5 mm and of 10 mm is statistically significant (coefficient = -1.25 with $p < 0.05$). Moreover, the statistical analysis shows that the difference between 10 mm and 7 mm is also significant.
However, it appears that the risk of error and the difficulty to detect a pedestrian are slightly higher with 7 mm size of pedestrian image in comparison to 5 mm. The reason for this variation cannot be explained, but the difference between 5 mm and 7 mm is not statistically significant (coefficient = -0.41 with $p = 0.681$).

3.1.2. Hypothesis 2*: the smaller the screen, the higher the number of non-detections of pedestrians.*

Figure 5: Probability of non-detection of pedestrians depending on screen size and on pedestrian height

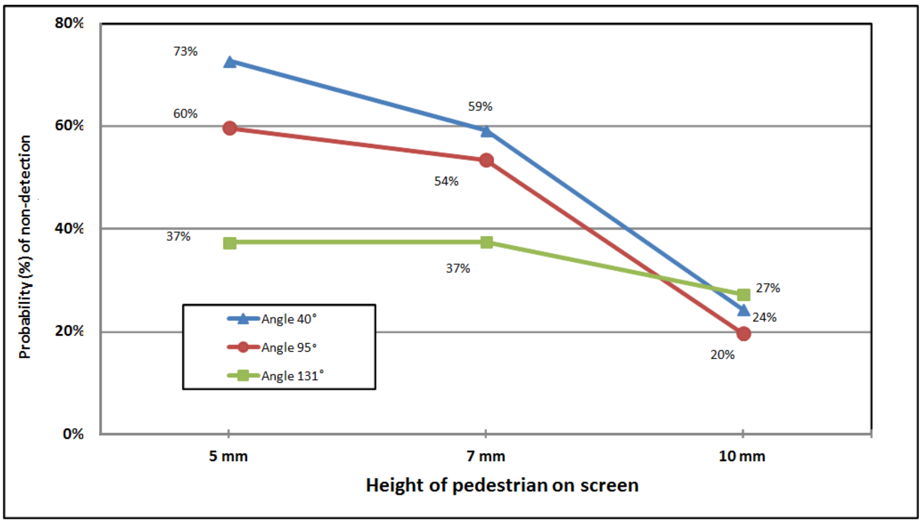


As shown in Figure 5, differences can be noted depending on screen size, in particular for the pedestrian heights of 7 mm and 10 mm, and with better results for the 12.8 cm screen.
However, these differences are not statistically significant (coefficient = 0.434 with p = 0.061 between the 17.8 cm and 12.8 cm screens, and coefficient = 0.673 with p = 0.0769 between the 17.8 cm and 25.9 cm screens). The findings do not show any significant difference between the three screen sizes tested (12.8 cm, 17.8 cm and 25.9 cm). Therefore we cannot conclude that highest number of non-detections correspond to the smaller screens, as we supposed: hypothesis 2 is thus invalidated, and even if statistical significance cannot be proven, the trend is to have better results with the small-sized screen (12.8 cm).

3.1.3. Hypothesis 3*: the larger the angle of view of the camera, the higher the number of non-detections due to distortions of the image.*

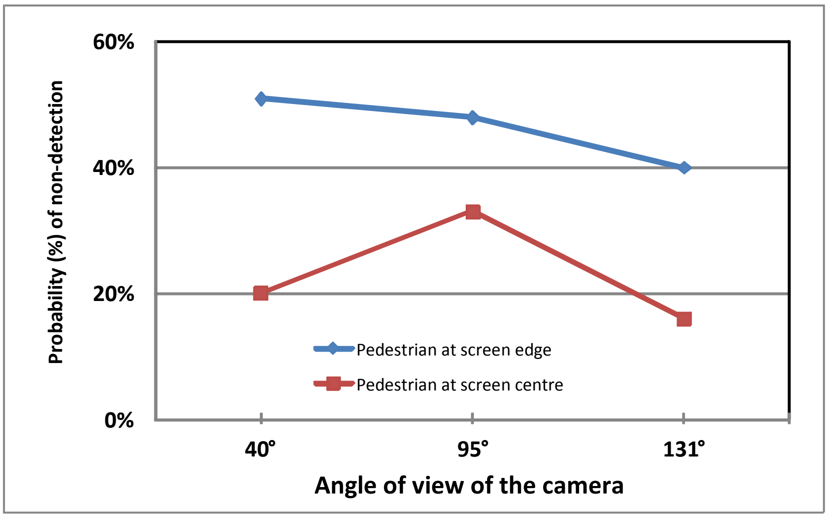
The results show a difference as a function of the angles of view of the cameras (cf. Figure 6).

Figure 6: Probability of non-detection of pedestrians depending on angle of view and on pedestrian height



The difference between the angles of 131° and 40° is statistically significant (coefficient = -0.415 with $p < 0.005$). The difference between the angles of 131° and 95° is also significant. The difference between the angles of 95° and 40° is not significant (coefficient = 0.137 with $p = 0.219$).
This result is also confirmed by the tests as a function of the position of the pedestrian in the image: in the centre or at the edge (cf. Figure 7). The same tests also show that the pedestrians positioned in the centre of the screen (probability of 14% error) are more visible than pedestrians positioned at the edge of the screen (probability of 62% error). This difference is statistically significant (coefficient = 1.375 with $p < 0.005$).

Figure 7: Probability of non-detection of pedestrians as a function of their positions on the screen and of the angle of the camera

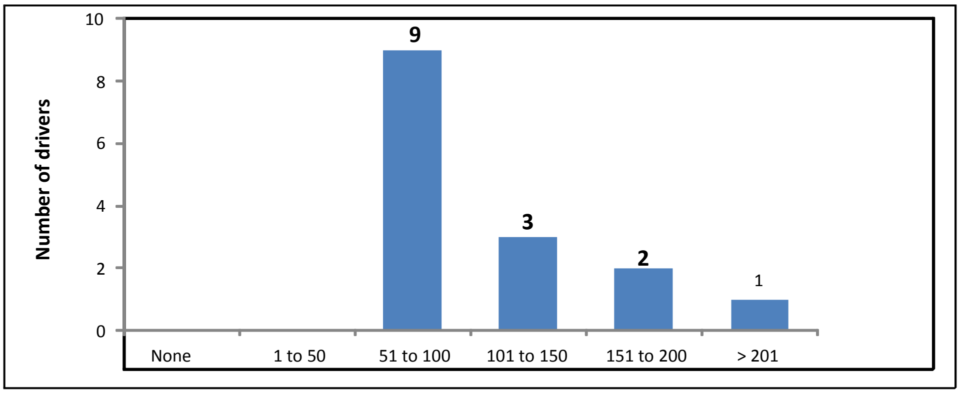


3.2. Qualitative analysis (questionnaire)

In reply to the question "What level of confidence (excellent, good, average, passable, poor) do you have in a camera-and-screen system for detecting a pedestrian?", over one half of the drivers (8 out of 15) had average confidence, 5 deemed it good, and 2 passable.

While the mean number of errors for the entire test (15 subjects x 340 images viewed) is 140, Figure 8 below illustrates the estimation made by the drivers on this subject.

Figure 8: Number of errors estimated by the subjects on the 340 images of the test



4. Discussion

This study on visibility by means of camera-and-screen systems was conducted in the context of preventing plant-pedestrian collisions. Its main objective was to determine the influence that apparent height of the pedestrian on the screen has on detection by the driver. This criterion has a direct impact on the choice (size of the screen, angle of view of the camera) and the location of the system (distance between the camera and the pedestrian).

In order to conduct this study, we put ourselves in the situation in which the plant driver uses the camera-and-screen system as a visual aid for watching over a masked zone (blind spot) occasionally, by glancing at it.

The test protocol was established on the basis of the following three hypotheses:

- **Hypothesis 1**: the smaller the pedestrian is on the screen, the higher the risk of detection error.
- **Hypothesis 2**: the smaller the screen, the higher the number of non-detections of pedestrians.
- **Hypothesis 3**: the larger the angle of view of the camera, the higher the number of non-detections due to distortions of the image.

The tests conducted confirm the first hypothesis. Under favourable conditions, detection is reliable at 100% as from a pedestrian height on the screen of 10 mm. Taking into account the other selected variables (position of and outfit worn by the pedestrian, light pollution, obstacles, etc.), a significant difference is also noted in favour of the height of 10 mm compared with 7 mm and 5 mm.

Therefore, we propose to set as a limit for defining the range of a camera-and-screen system a height on the screen of the person to be detected greater than 10 mm. This condition should be satisfied

under the most unfavourable conditions, namely: short pedestrian (5th percentile, i.e. having a height of 1.55 metres).
By way of example, the Table 5 below indicates the height on the screen of a pedestrian who is 1.55 m tall positioned 12 m away, this distance corresponding to the radius of the outer perimeter of the masking zones for earth-moving plant (Directive 2003/97/EC, 2004).

Table 5: Apparent height of a pedestrian (+/- 0.5 mm) positioned 12 m away from the camera

		Diagonal size of the screen		
		12.8 cm	**17.8 cm**	**25.9 cm**
Angle of view of the camera	40°	16 mm	18 mm	30 mm
	95°	10 mm	12 mm	18 mm
	131°	7 mm	8 mm	10 mm

As regards height on the screen (hypothesis 2), the findings do not show any significant difference between the three screen sizes tested (12.8 cm, 17.8 cm and 25.9 cm). Nevertheless, they are better with the small-sized screen (5-inch screen). This can be explained if we consider the very short time (0.5 seconds) given to the driver for viewing each of the images of the test: a small screen area is then quicker to scan for detecting any potential presence of a pedestrian in it.
Therefore, for the type of application studied, the choice of the size of screen is essentially dependent on constraints related to the work activity, to non-obstruction of the driver's direct field of view and to the space available at the driving position.

As regards angle of view, the choice cannot be made independently of the location of the camera on the plant. The first criterion for choice is dictated by the zone to be kept under surveillance. It should make it possible to cover an area that is broader than the surveillance zone so as to avoid the edges of that zone coinciding with the edges of the screen. The tests conducted show that a pedestrian is seen four times less well at the edge of the screen than at its centre.
Once this condition is satisfied, the second criterion consists in choosing an angle of view that is as large as possible. Of the three angles of view tested, it is the largest (131°) that offers the best results, even when the pedestrian is at the edge of the screen, where distortions are, *a priori*, greater.

5. Conclusion

In conclusion, although camera-and-screen systems are indeed a solution for bringing the driver visibility over masked zones (blind spots), choosing the systems should be based not only on the criteria of robustness and resistance to environmental conditions (vibration, impact, temperature, luminosity, etc.), but also on other criteria making it possible to minimise the risk of non-detection. The criterion of the apparent height of the pedestrian on the screen has, in particular, a direct impact on the choice (size of the screen, angle of view of the camera) and the location (distance between the camera and the pedestrian) of the system.
Although, for an apparent height of the pedestrian on the screen of 10 mm, no detection error was observed under optimum conditions, the rate of non-detection goes to more than 25% whenever other variables related to the environment are taken into account.
This risk of non-detection was well perceived by the subjects who took part in the test because over half of them had only average confidence in that type of equipment for detecting a pedestrian.

However, they overestimated their capacity because, out of the 340 images viewed, the majority of the subjects assessed their number of errors at in the range 51-100, whereas it was actually 140 on average.
It is important to remember that, beyond the technical limitations and beyond the detection errors, a driver concentrated on the task in hand is not always capable of spreading his attention simultaneously over several different sources of information (Godwin, 2007). Under such conditions, he might quite simply not pay attention to the monitoring screen. In order to alert the driver to a risk of potential collision, these “camera-and-screen” systems can then be supplemented advantageously with obstacle or person detection devices (NF ISO 16001, 2008; Lamy et al., 2012). Similarly, such camera-and-screen systems should under no circumstances be used to replace either the driver’s direct visibility or organisational measures that might also be put in place (separating traffic lanes, rules for pedestrians approaching vehicles, obligation to wear high-visibility vests, etc.).

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