NIGHTTIME VISIBILITY, COMPONENT OF ROAD SAFETY

[1]Alexandru Plaiasu, [2]Gheorghe Ciolan, [2]Ion Preda

[1] SC Autostart SA Braşov, Romania, [2] Transilvania University of Brasov, Romania

KEYWORDS – Road safety, Visibility, Luminance, Illumination, Accidents

ABSTRACT - An important component in present accident technology is the night car accident. Although the night traffic is reduced nocturnal accidents have very serious consequences. The paper presents the visibility conditions that lead to an accident at night, taking into account the darkness, street lighting and traffic light action. The analyzed situation in the paper shows the influence of a vehicle coming from opposite direction, through the background pedestrian contrast reducing due to background increasing.

INTRODUCTION

An important component in present accident technology is the night car accident. Although the night traffic is reduced nocturnal accidents have very serious consequences. Fatality rate of people resulting from accidents occurring at night is 38% higher than that of persons injured in fatal accidents during the day. In these circumstances it is necessary to find ways to reduce traffic hazards that occur, through elucidation night visibility conditions and improve traffic conditions at night. The paper presents the visibility conditions that lead to an accident at night, taking into account the darkness, street lighting and traffic light action.

THEORETICAL DATA AND EXPERIMENTAL RESULTS

An important role in the night visibility research it is the contrast luminance. The luminance contrast can be an objective contrast and a subjective contrast. Objective contrast is a physical quantity that can be measured and calculated. In practice are used several models, of which the simplest is the ratio of the illuminations of the two neighboring areas. In this case the threshold contrast matter, that shows how great the difference between light is and object environment for it to be noticed by human eyes. For object recognition, the contrast must be greater than the contrast threshold Ks. Since the light luminance density depends on the degree of luminance and reflection, illuminated objects by the headlights field can be grasped in different ways. The subjective contrast is a quantity determined by the sensation.

Most important for vision is the difference between environment illumination and object illumination. The human eye can only distinguish an object from above light threshold. This threshold depends on the environment light luminance and angle of the seen object. This threshold is determined in the laboratory and is presented as diagrams or spreadsheets. The primary criteria, to observe an obstacle is to have a K medium contrast (background):

$$K = \frac{L_{object} - L_{environment}}{L_{environment}}, \tag{1}$$

where: L_{object} is the object illumination and $L_{environment}$ is the environment illumination.

This contrast can be positive or negative (Fig. 1). The left image shows the positive contrast is a light colored person (illuminated from the front) on a dark background. In this case it can be shown seize and shape of the obstacle. If the person appears dark and is located in front of a light background, the contrast is negative, as shown on the right (illuminated from behind). If the middle graphic (Figure 1) when the contrast is very small ("stealth"), contrast ratio have a numeric values close to zero. At nocturnal accidents it is frequent this type of contrast. This contrast may appear small in a poor street illumination, improper disposal of light panels, or by provoking the so-called physiological blindness. For street lighting there are certain parameters, but there are deviations from normal: changing luminance parameters (dust, dirt, aging, wear), poor location, shielding by obstacles (buildings, trees, advertisements).

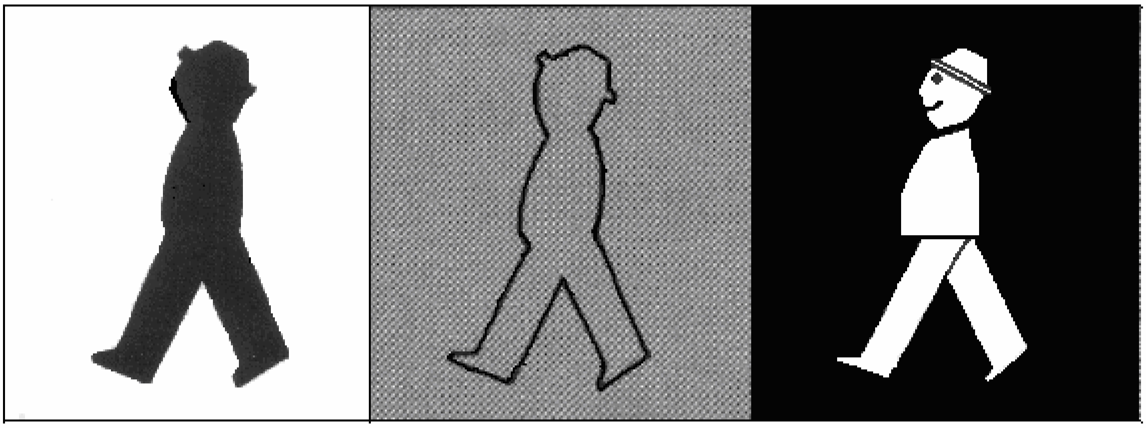

Figure 1. Contrast change regarding to the relative position to the light source

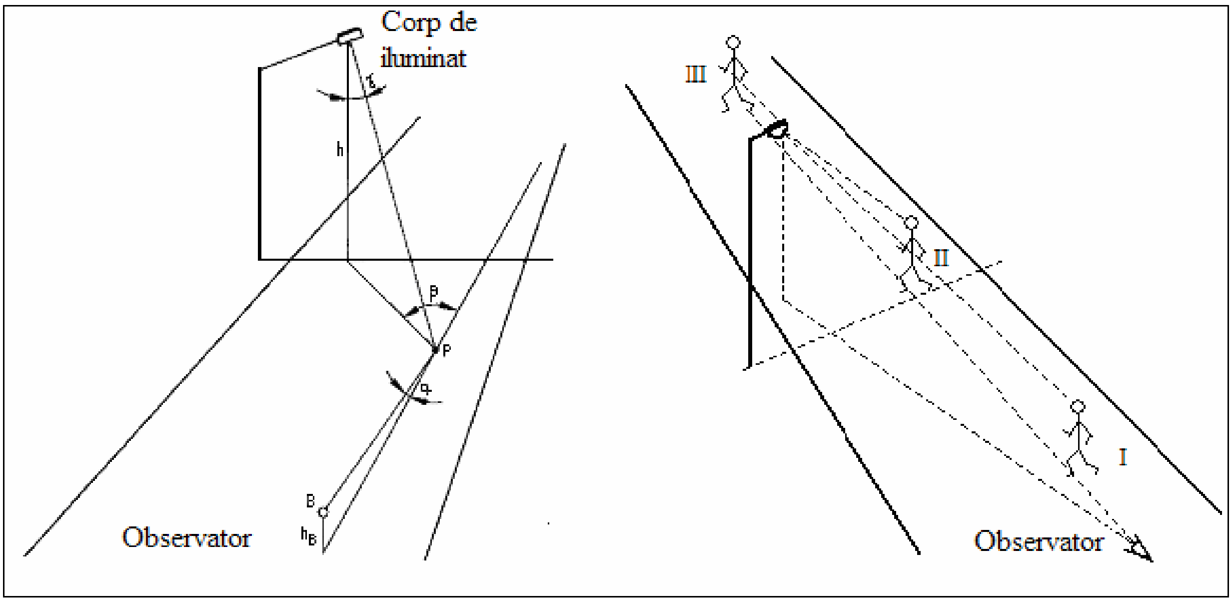

Figure 2. Illumination and observation geometry in street lighting

Most important for vision is the difference between environment illumination and object illumination. The human eye can only distinguish an object from the light above a certain threshold. This threshold depends on the light environment illumination and angle under which the object sees. This threshold is determined in the laboratory and is presented as diagrams or spreadsheets.

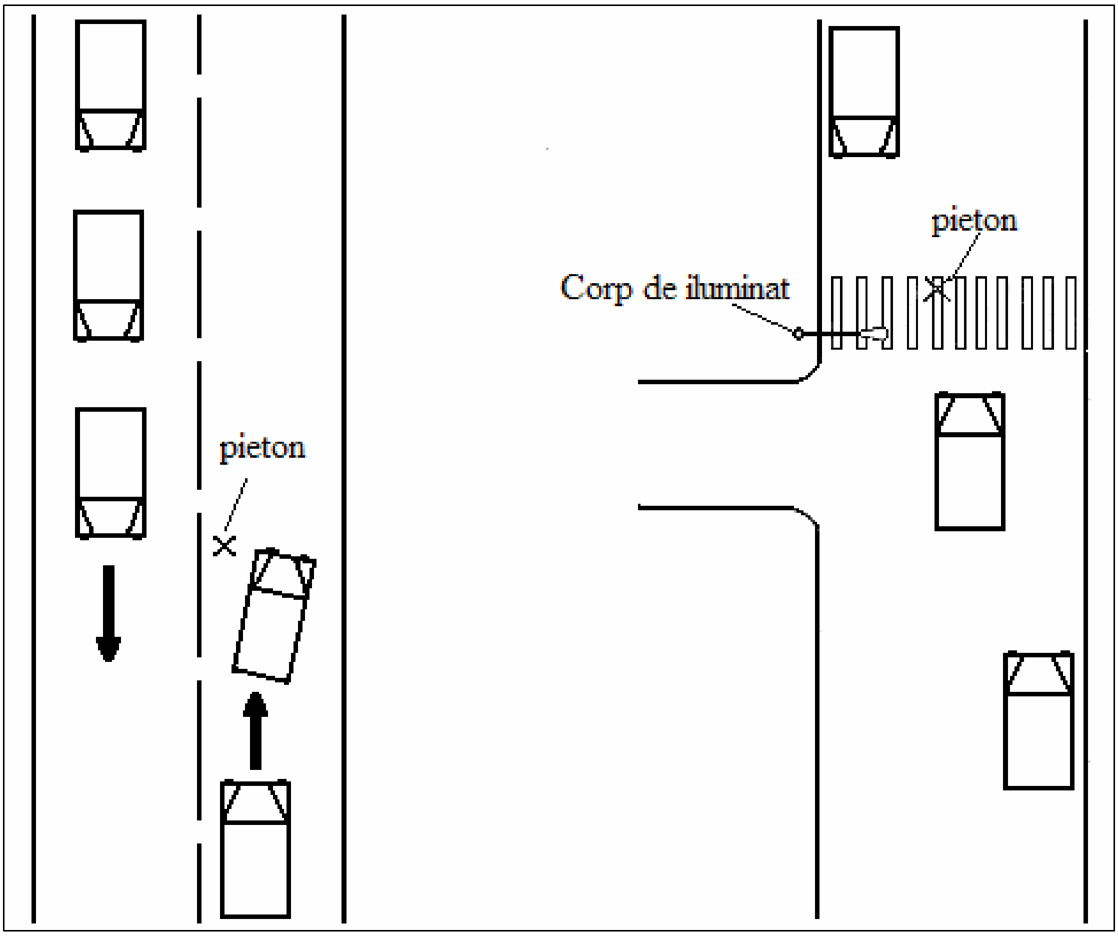

Figure 3. Accident source at the pedestrian crossing due to wrong placement of the lighting system

To resolve the situation described by the illumination model is necessary the model parameterization. Parameterization begins with establishing the field of illumination of the vehicle, the object brightness law of variation and the object contrast changing under perturbation (commercial lighting panel, drivers coming from opposite direction, etc.).Light intensity (I) for headlight assembly is determined by the formula:

$$I_m = \frac{Er^2}{\Omega_0 \cos\alpha} \tag{2}$$

Where: I_m - Average light intensity headlight assembly; E – Luminance measured in the characteristic points; α – angle between surface normal and the light beam falling; Ω_0 – unit solid angle (steradian sr).

The link between illumination (L) and luminance (E) is: $L = qE$ (3)

Where: q – light density. Light density is determined by the relation: $q = \frac{\rho}{\pi}$ (4)

Where: q is the reflectivity coefficient. If the case of diffuse reflection is bin applied the Lambert theory or cosine. It describes the dependence of light intensity, reflected by a segment of an ideal diffuse surface (Lambert surface) by the angle of observation (w).

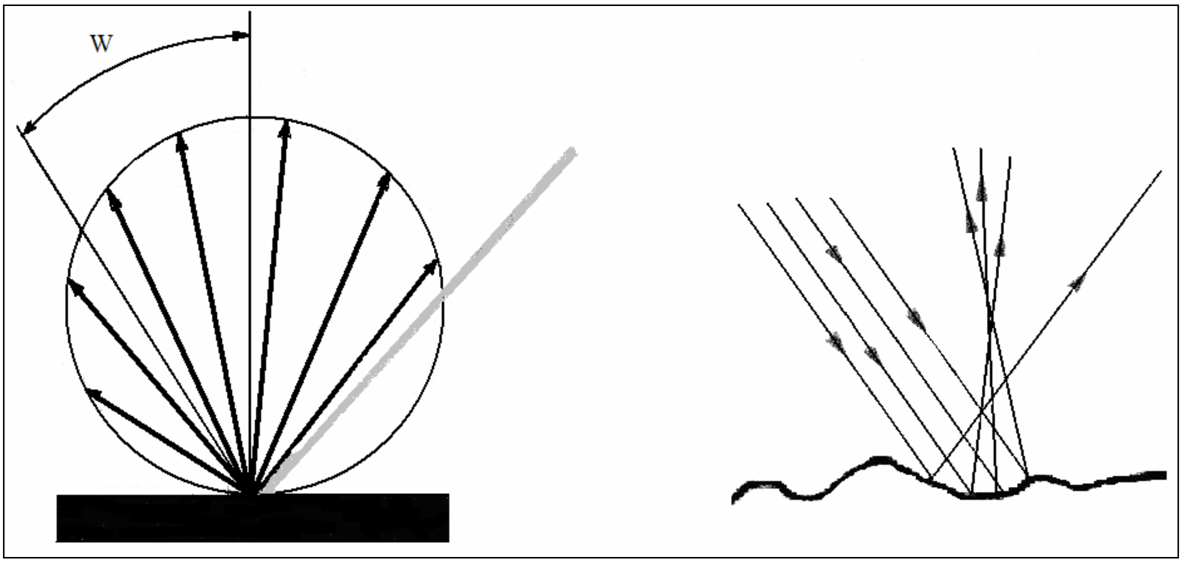

Figure 4. Diffusely reflected light from an ideal flat surface segment that aims Lambert theory (left). Rough surface as intuitive model for diffuse scattering that don't respect the Lambert theory (right).

Experimental data processing is made using the Adrian method. A and B are constants obtained from the Blackwell data (table) and characterize the illumination difference threshold ΔL_S in laboratory conditions according to the illumination of the environment L_U.

$$\Delta L_S = KC\left(\frac{A}{\alpha} + B\right)^2 \quad (5)$$

Where: C = 10 is a factor throw laboratory conditions are equivalent to experimental conditions. Vision distance can be determined if in the relation of illumination threshold is introduced the obstacle relative illumination, which is measured by electronic instruments, photo or video cameras especially for the measurement. The relation determines the angle that it sees the obstacle and determines the distance of visibility.

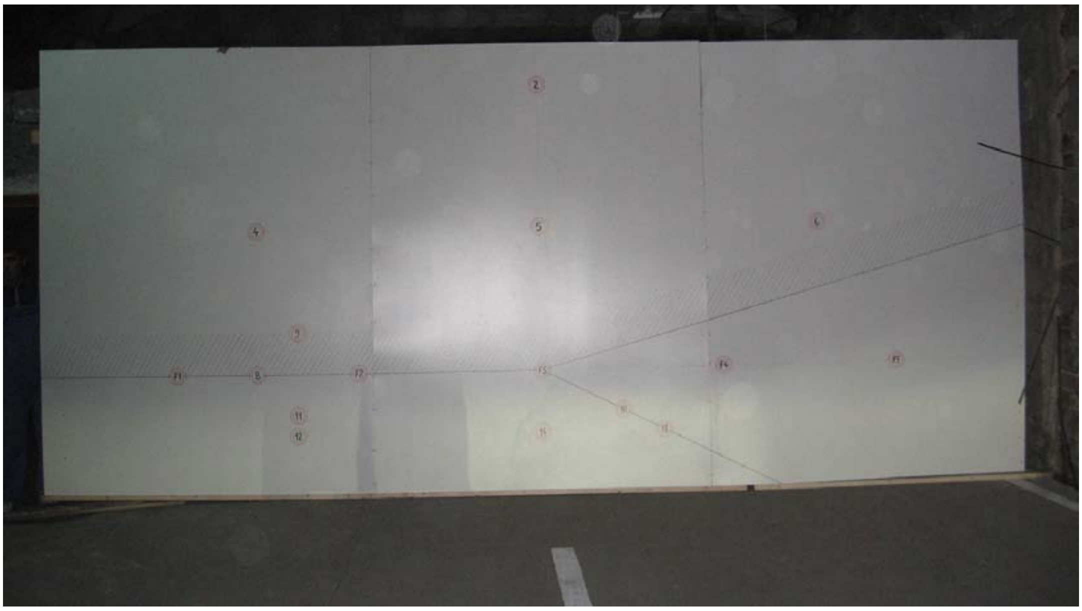

Figure 6. Panel measurement points

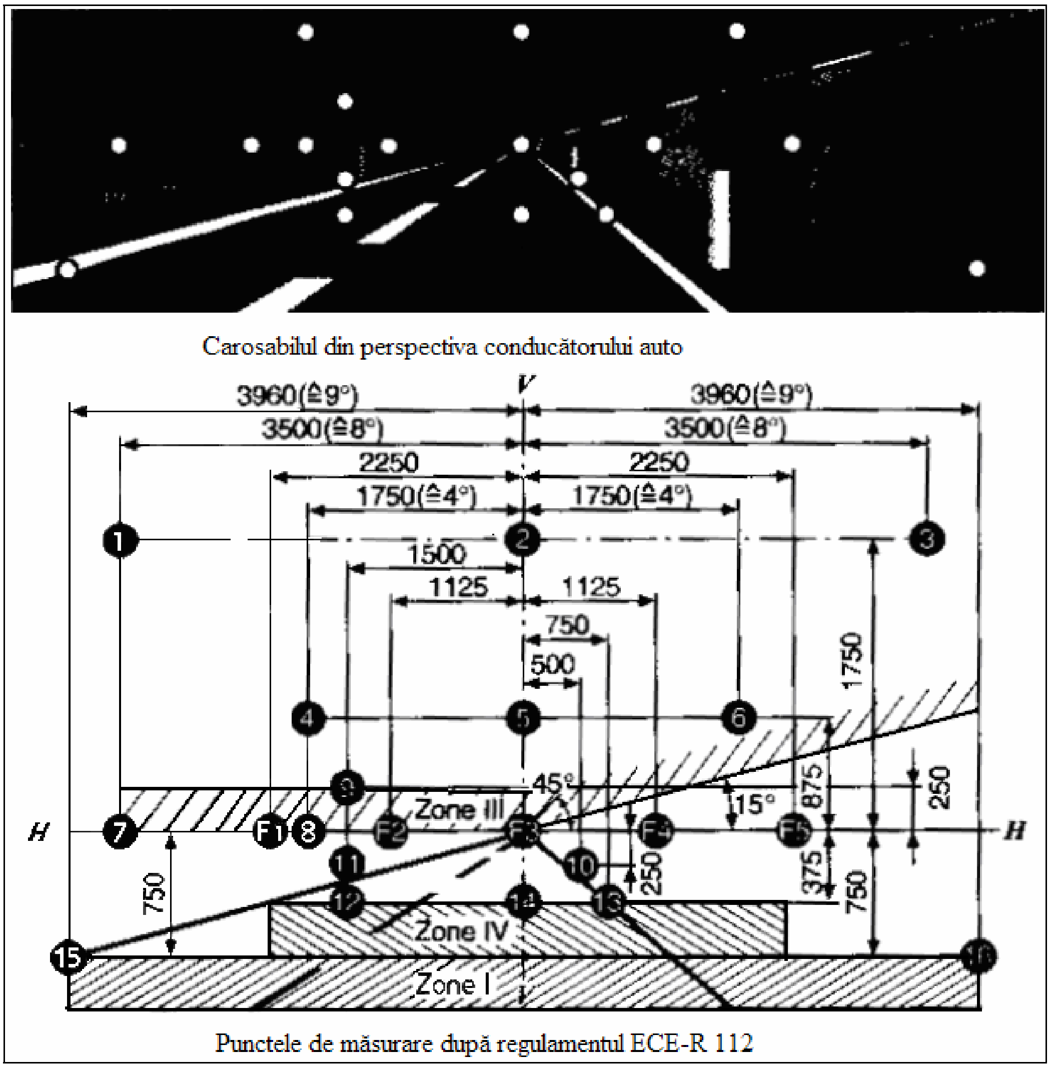

Figure 5. Roads in terms of driver (up). Measurement points after ECE-R 112 regulation

Table 1

MEASUREMENT POINTS	MEASURED LUMINANCE [LX]					
	DISTANCE FROM THE SCREEN [m]					
	10	15	20	25	30	35
F1	14.3	2.3	1.4	1.25	1.08	0.61
F2	8.1	3.3	1.7	1.4	1.23	1
F3	11.2	4.4	2.3	1.72	1.41	1.24
F4	100	9.3	2.6	2.3	1.8	1.59
F5	101	38.2	15	10.4	10.1	10.49
2	2.6	2.2	1.4	0.8	0.65	0.56
4	2.7	2	1.2	0.9	0.73	0.61
5	4.3	2.4	1.5	1	0.79	0.62
6	4.8	2.7	1.6	1	0.8	0.71
8	13.4	2.9	1.7	1.4	1.14	0.96
9	3.9	2.6	1.4	1.05	0.93	0.78
10	218	76.3	19	11	10.5	12.14
11	99	42.6	17	10	6.27	4
12	92.2	60.7	19.2	15	13.44	9.18
13	184	104.9	36.2	24	21	18.65
14	169.5	95.3	27.2	19.5	17.24	13.29
Luminance average E_m [x]	152.48	75,9	23,72	15,9	13,7	11,45
Average light intensity I_i [cd]	15248	17077	9488	9937	12330	14026

The average light intensity for points: I_m =13017 [cd].

Relations for partial illumination of the subject area are:

- Object luminance: $L_{ob} = \frac{\rho_{ob} E_m}{\pi}$ (6)

- Background luminance: $L_f = \frac{\rho_f E_m}{\pi}$ (7)

- Luminance perturbation (from the vehicle from the opposite direction):

$$L = \frac{10 E_{orb}}{\theta^2} = \frac{10 I_{orb}}{r_a^2 \theta^2} \qquad (8)$$

Contrast without disturbance (blindness) results from expression: $K = \frac{L_{ob} - L_f}{L_f + L_V}$ (9)

Making the replacements, results: $K = \dfrac{\dfrac{I_m(\rho_{ob} - \rho_f)}{r_0^2 \pi}}{\dfrac{\rho_f I_m}{r_a^2 \pi} + \dfrac{10 E_{orb}}{\theta^2}}$ (10)

Where: θ is the angle between the longitudinal axis of the disturbing vehicle and the line that join vehicle driver eye with the disturbing vehicle; ρ is distance between the longitudinal axis of the motor vehicles; r_o is distance from the vehicle to the object [m]; r_a is distance between vehicles [m]; E_{orb} - glare illumination measured at the driver eye level moving from the opposite direction.

Table 2

I_m [cd]	r_o [m]	r_a [m]	ρ_{ob}	ρ_f	$\theta = arctg\frac{b}{r_a}$	I_{orb}	K
13017	20	-	0,8	0,2	-	-	3
13017	20	100	0,8	0,2	2^0	6508	1,68
13017	20	50	0,8	0,2	4^0	6508	1,69
13017	20	25	0,8	0,2	8^0	6508	1,68
13017	20	100	0,8	0,2	2^0	13017	1,16
13017	20	50	0,8	0,2	4^0	13017	1,17
13017	20	25	0,8	0,2	8^0	13017	1,16

It can be seen the influence of a vehicle coming from opposite direction by reducing background contrast due to increased illumination. In the present case were considered two motor vehicles with the same luminous intensity and the and the luminance perturbation (from the vehicle from the opposite direction) is L_v = 3,25 [cd/m^2]. Reducing the light intensity of blindness in half (I_{orb} = 6508 [cd]) the contrast K = 1,68, correspondingly higher than the contrast threshold K_P = 1±0,17, and the object can be seen. In the case of blindness I_{orb} = 13017 [cd], the contrast value entering the contrast threshold, the object can not be noticed by the most drivers. The threshold contrast size range ΔKP = 0.17 depends mainly on the observation of subjects scattering curve.

In the representation of a function of time for K, is conceiving a model as in Figure 7, referring to a typical case encountered in nocturnal movements. For the general case, is made a replacement $r_a = D-S_1-S_2 = D-(V_1+V_2)*t$ in contrast (K) expression. To have a stable reference point where both cars are moving, we imprint to the model a reverse speed regarding to the reference vehicle. In this case the obstacle is approaching virtual reference vehicle. Results: $r_o = V_1*t$. In this case, the contrast function becomes:

$$K = \frac{\dfrac{I_m(\rho_{ob} - \rho_f)}{(V_1 t)^2 \pi}}{\dfrac{\rho_f I_m}{[D-(V_1+V_2)t]^2 \pi} + \dfrac{10E_{orb}}{\theta^2}} \tag{11}$$

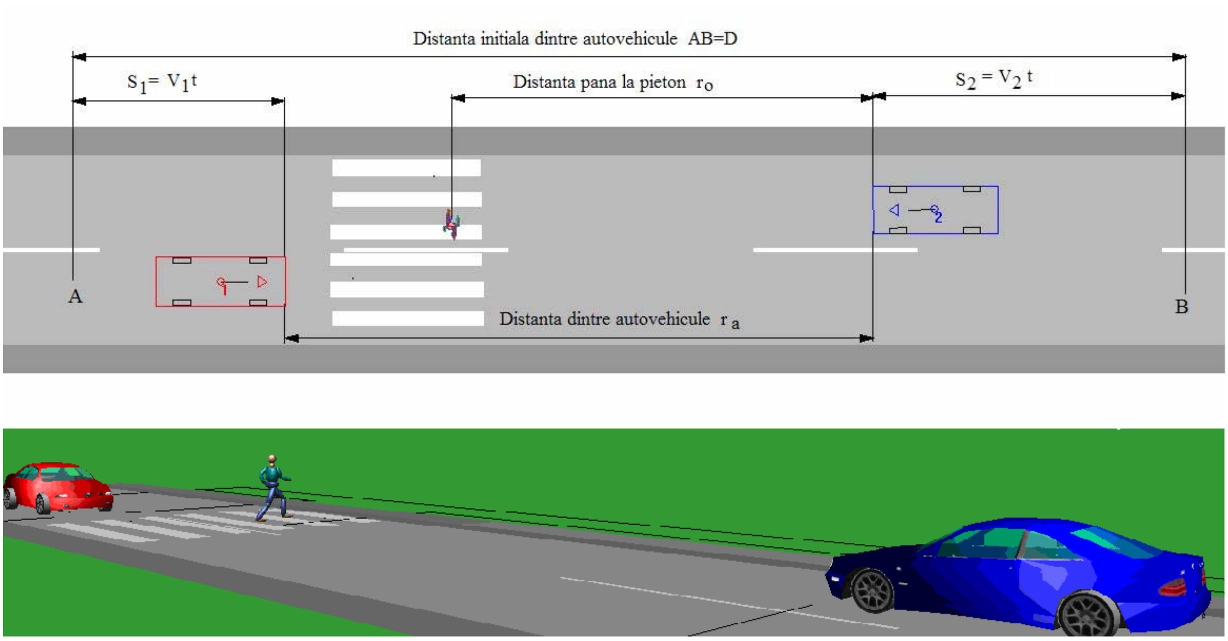

Figure 7. Model to a typical case encountered in nocturnal movements

CONCLUSION

In the practice of judicial expertise is necessary to analyze events occurring in road traffic conditions at night. Taking into account the characteristics of multiple dependencies lighting conditions is required systematization of dangerous situations. Much importance is the subjective nature of assessing these situations. For this reason the approach should be done within the limit of assessment objectives to which the judicial institution may relate to the situation in question. To achieve reference models it will be present a model for a particular situation. The first step is necessary to develop specific models that can be parameterized with both theoretical and experimental data. Decisive factor for the success of such models is the possibility of rapid luminance. The analyzed situation in the paper shows the influence of a vehicle coming from opposite direction, through the background pedestrian contrast reducing due to background increasing.

REFERENCES

1. Verkehrsunfall und Fahrzeugtechnik, nr.2, 2007
2. Martin, Eckert, Lichttechnik und optische Wahrnehmungssicherheit im Strasenverker, Munchen, Verlag Technik, 1993.
3. Peter McCarthy si col."Optical Interconections For Automotives Network Systems" AutoTechnology nr.4/2001; 4.DELPHI „Sicherheitskonzept für LKW" ATZ nr.9/2004;
5. BOSCH „AUTOELEKTRIK/AUTOELEKTRONIK" Vieweg Verlag, Braunschweig, 2002.