Application of TASolver software package in the study of circumstances of traffic collisions that occurred in conditions of limited visibility

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Prior to the implementation of computer equipment and software engineering into an expert practice, the relative position of participants of traffic collision in the road-accident analysis was determined by creating a graph-analytical model. The modern foreign software package makes it possible to simulate the mechanism of traffic collision development at its various stages but they are complex and licensed which means they are quite expensive.

This article considers examples of the study of traffic collisions that occurred in conditions of limited visibility using TASolver software package developed at National Scientific Center «Hon. Prof. M. S. Bokarius Forensic Science Institute». Using the graphic-analytical method, this software package determines the distance at which the vehicle was located from the place of collision at the moment of danger for further movement. The use of TASolver software package is possible to determine the relative position of both a vehicle and a pedestrian in the event of a collision, as well as several vehicles at the moment of their collision. TASolver software package allows to quickly and easily simulate the situation of traffic collision that occurred due to an object that limited visibility.

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The article purpose is to improve the quality of examinations and expert studies, reduce export's labor costs, as well as increase the probative value of an expert's opinion which will be facilitated by the use of TASolver software package for the study of traffic collisions that occurred in conditions of limited visibility.

Keywords: *road accident analysis; traffic collision; study; limited visibility; vehicle; software package; collision; graphic-analytical method.*

Research Problem Formulation

One of the main issues facing road-accident analysis during the investigation of traffic collisions (hereinafter referred to as *TC*) is the issue of whether a driver has technical ability to prevent a collision. The solution of this issue involves establishing the distance at which the vehicle was (hereinafter referred to as *Vehicle*) from the place of collision at the time of danger for further movement. Determining the distance during the investigation of TC that occurred in conditions of limited visibility is a complex process and differs from similar situations in conditions of unlimited visibility as it involves investigative actions at the scene of TC with every second movement of Vehicles and pedestrians or several Vehicles from the place of the collision taking into account their speeds. This method involves the use of calculations to determine the distances covered by Vehicles and pedestrians or several Vehicles over a period of time. In the future, the participants of TC are moved from the position in which they were at the time of the collision to the position in which they had been at the time when the driver saw a pedestrian or other Vehicle because of the object that restricts visibility. The distance can also be determined by creating a graphic-analytical model based on the initial data set by the investigator.

Analysis of Essential Researches and Publications

The application of the graphic-analytical method of determining the distance in the process of conducting road-accident analysis in their works is considered by V. O. Ilarionov, V. A. Kirielev, I. B. Sirodzha, V. I. Briantsev, V. I. Ruban, A. P. Khomiakov, A. M. Turenko, V. I. Klymenko, O. V. Saraiev, C. V. Danets [1], A. V. Lubentsov [2],

1 Судебная автотехническая экспертиза. Часть 2. Теоретические основы и методики экспертного исследования при производстве автотехнической экспертизы: пособие для экспертов-автотехников, следователей и судей ; под ред. В. А. Илларионова. Москва, 1980. 163 с. ; Киреев В. А., Сироджа И. Б. Графоаналитические методы исследования механизма дорожно-транспортного происшествия. Киев, 1976. 47 с. ; Брянцев В. И., Рубан В. И., Сироджа И. Б., Хомяков А. П. Методика математического моделирования при исследовании механизма дорожно-транспортного происшествия. Киев, 1972. 40 с. ; Туренко А. М., Клименко В. І., Сараєв О. В., Данець С. В. Автотехнічна експертиза. Дослідження обставин ДТП. Харків, 2013. 319 с.

2 Лубенцов А. В., Варлахов В. О. Технічний аналіз дій водіїв транспортних засобів на нерегульованих перехрестях під час виконання лівого повороту. *Теорія та практика судової експертизи і криміналістики :* зб. наук. пр. 2020. Вип. 21. С. 411—421. DOI: 10.32353/khrife.1.2020_28 (date accessed: 25.11.2021).

M. S. Korchan, V. M. Kovkin, Yu. M. Malko, A. Yu. Krishtop, V. P. Yakovliev, V. O. Labintsev, O. O. Sviderskyi, V. O. Varlakhov, V. S. Olkhov, V. O. Stepko [3], A. D. Koshkarov [4], R. Li, F. C. Pereira, M. E. Ben-Akiva [5], S. Amini, E. Papapanagiotou, F. Busch [6], M. Fellendorf [7], B. Anbaroglu, B. Heydecker, T. Cheng [8] and others.

The Article Purpose

To improve the quality of examinations and expert research, reduce the labor costs of the expert for conducting expert research, as well as increase the probative value of the expert's opinion.

Main Content Presentation

The graphic-analytical method of studies is universal and has a number of advantages as it allows to establish the relative position of the Vehicle and pedestrian or several Vehicles at different moments of time and provides visibility of results (in particular, intermediate). The main initial data for this method of TC investigation in the event of collision with a pedestrian: location of the collision place with the pedestrian and coordinates of this place relative to the boundaries of the carriageway, breaking marks, the place of the pedestrian's exit on the carriageway; brand of Vehicle and speed of its movement; pedestrian speed; the distance over which the Vehicle was moving that collided relative to the boundaries of the carriageway; coordinates of the driver's location of the Vehicle that crashed; the distance from the rear or front of the Vehicle, which limited visibility, to the pedestrian at the time of his exit to the carriageway; the distance from the boundaries of the carriageway to the Vehicle, which limited visibility, or the lateral interval between several Vehicles.

Prior to implementation of computer equipment and software engineering into an expert practice, the relative position of Vehicles and pedestrians at certain intervals was determined by experts using creating graphic-analytical construction (most often — graphical construction on a scale diagram). Today there are many software packages that allow modeling a mechanism of TC development at different stages (*V-SIM*, *PC-crash*, *CARAT,* etc.). These software packages are complex licensed prod-

3 Корчан М. С., Ковкін В. М., Малько Ю. М., Кріштоп А. Ю. та ін. Експертна оцінка дорожньо-транспортних ситуацій, у яких водії виконували маневр на перехресті : метод. рек. Харків, 2012. 32 с.

4 Кошкаров А. Д. Розслідування дорожньо-транспортної пригоди та визначення причинно-наслідкових зв'язків між несправностями транспортного засобу. *Теорія та практика судової експертизи і криміналістики :* зб. наук. пр. 2020. Вип. 21. С. 422—431. DOI: 10.32353/khrife.1.2020_29 (date accessed: 25.11.2021).

5 Li R., Pereira F. C., Ben-Akiva M. E. Overview of traffic incident duration analysis and prediction. *European Transport Research Review.* 2018. Rev. 10, 22. DOI: 10.1186/s12544-018-0300-1 (date accessed: 25.11.2021).

6 Amini S., Papapanagiotou E., Busch F. Digital Mobility Platforms and Ecosystems / Digital Mobility Platforms and Ecosystems. München, 2016. P. 187—197. DOI: 10.14459/2016md1324021 (date accessed: 25.11.2021).

7 Fellendorf M. Traffic Modelling of Large Events — A Summary of Selected German Examples. *IFAC Proceedings Volumes*. 2006. Vol. 39. Is. 12. P. 17—24. DOI: 10.3182/20060829-3-NL-2908.00004 (date accessed: 25.11.2021).

8 Anbaroglu B., Heydecker B., Cheng T. Spatio-temporal clustering for non-recurrent traffic congestion detection on urban road networks. *Transportation Research Part C: Emerging Technologies.* 2014. Vol. 48. P. 47—65 DOI: 10.1016/j.trc.2014.08.002 (date accessed: 25.11.2021).

ucts designed to simulate TC, problem situations on the road, simulation of Vehicle contact, and other participants in TC. Due to the complexity of use, these packages are not always acceptable when solving local road-accident analyses to determine the parameters (initial data) of the TC mechanism (e.g., to set parameters of the Vehicle or Vehicle and pedestrian, provided that one of the TC participants appears due to object that limits visibility).

In order to simplify the solution of such issues specialists of National Scientific Center «Hon. Prof. M. S. Bokarius Forensic Science Institute» developed *TASolver* software package which allows to quickly and easily simulate the situation of TC with the appearance of danger due to the object that limits visibility. This software package is used to determine the relative position of several Vehicles or Vehicle and the pedestrian at different times in the presence of relevant initial data with the result in graphic format, as well as calculations of stopping (S_o), time of movement of Vehicle in the braked state until collision (t'_T), and distance (S_a). The results of the study can be saved in *".tas"* format for further work during the preparation of the expert's opinion.

TASolver software package makes it possible to determine the location of Vehicle in relation to the place of collision in conditions of limited visibility by the driver through the object that may be temporarily immovable (restriction of visibility through another Vehicle moving in the cross direction), stationary (a house, fence, etc.) or movable (restriction of visibility due to a pedestrian moving on the carriageway for the driver of one Vehicle to another Vehicle moving in the opposite or passing direction).

TASolver software package allows to display the results of calculations on the monitor screen and graphical constructions in two languages (Russian and Ukrainian), as well as perform graphical constructions in the scale selected by the user. It has a database of vehicles that can be fulfilled with Vehicles with new technical parameters.

After launching the program, the dialog box displays the title, menu bar, toolbar, work area (fig. 1).

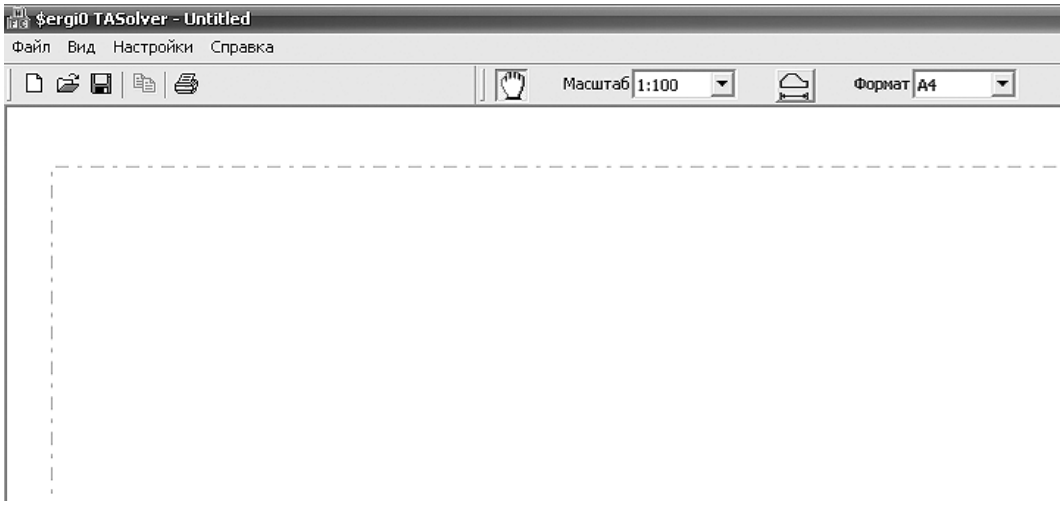

Fig. 1. Fragment of *TASolver* dialog box

The menu bar provides access to program features that allow opening, saving, printing files, selecting research options (movable or immovable obstacle), as well as editing the title, and changing the language. Some program features are displayed on the toolbar (in particular, change the scale (possible scales 1:100, 1:150, 1:200, 1:250), display the dimensions of Vehicles, change the print format (A3, A4)). The work area has the form of an empty where the results of studies will be displayed in the future (the printing area is marked with a dotted line).

Let's consider various examples of determining the distance for TC that occurred under conditions of limited visibility using *TASolver* software package.

1st example

Visibility of the pedestrian crossing the carriageway from right to left in relation to the direction of movement of Vehicle-1, limits the Vehicle-2, which moves on the opposite side. It is necessary to establish the distance at which Vehicle-1 was at the time of the pedestrian in the driver's field of vision due to accompanying Vehicle-2. The accident occurred under the following road conditions and circumstances:

- asphalt concrete carriageway, dry, horizontal profile, for one direction of movement, 12.0 m wide;
- Vehicle-1 (Lexus), moving at the speed of 50 km/h, the distance from the right gauge to the right edge of the carriageway - 5.5 m;
- Vehicle-2 (Mercedes Vito), moving at the speed of 30 km/h, the distance from the right side of the Vehicle-1 to the left side of the Vehicle-2 - 2.0 m;
- direction of the pedestrian's movement - from right to left (relative to the direction of movement of the Vehicle-1), from the moment of exit to the carriageway to the moment of collision, the pedestrian covered a distance of 6.0 m in 2.8 s;
- before collision Vehicle-1 and Vehicle-2 were moving without braking and maneuvering.

First, in the *"Settings"* menu bar you should choose: Obstacle → Movable. Then the *"Parameters"* dialog box appears, in which the initial data is entered according to the given instructions (fig.2).

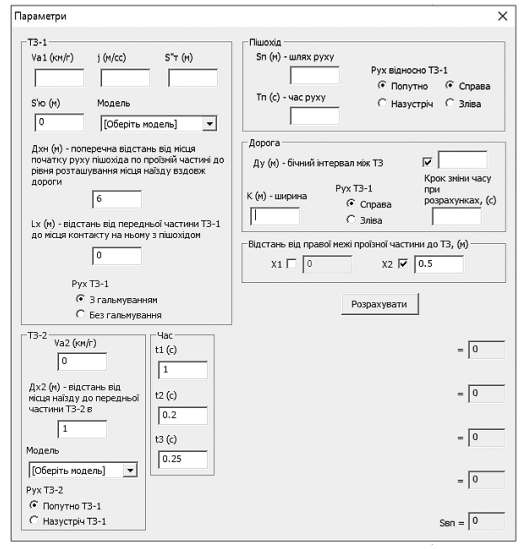

Fig. 2. Data entry dialog box in case of a moving obstacle

Models Vehicle-1 and Vehicle-2 are selected from database of Vehicles. For adding to the database in the *"Model"* window you should choose *"Details"* then the dialog box *"Edit Vehicle models"* will appear. The program saves the technical parameters of the Vehicle, they can be used in further work without re-entering. Coordinates of the driver's location in the Vehicle are denoted as follows: B_x and B_y, length — I, width — W, overhang — F, base — B (fig. 3).

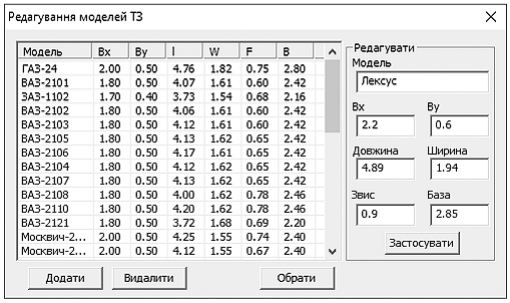

Fig. 3. View of technical parameters editor of the Vehicle

The initial data section of the dialog box is divided into four zones: Vehicle-1, Vehicle-2, Pedestrian, Road. After entering the data, characterizing the specific situation of TC, to calculate and build the graphical scheme you should click *"Calculate"*. The program calculates parameters of the relative position of the Vehicles-1, Vehicle-2, and pedestrian at the time when the pedestrian went on the carriageway, as well as at the moment when the pedestrian appeared in the field of view of the driver of Vehicle-1 due to the Vehicle-2. Calculations will be displayed in the dialog box *"Parameters"* (Fig. 4), after closing which in the work area will form a graphical diagram depicting the Vehicle-1, Vehicle-2, and pedestrians at the above points.

During the study to the given initial data it was established: the drive of Vehicle- 1 could not see the moment of the pedestrian's exit to the carriageway as visibility of the pedestrian was limited by Vehicle-2; at the moment of pedestrian's exit to the carriageway Vehicle-1 was from a place of collision on the distance of 38,89 m (S_{a1}); stopping distance of Vehicle-1 — 35,12 m (S_o); Vehicle-1 was at the distance of 26,93 m from the place of collision at the time of appearance of the pedestrian in the driver's field of vision due to the accompanying Vehicle-2 ($S_{ВП}$).

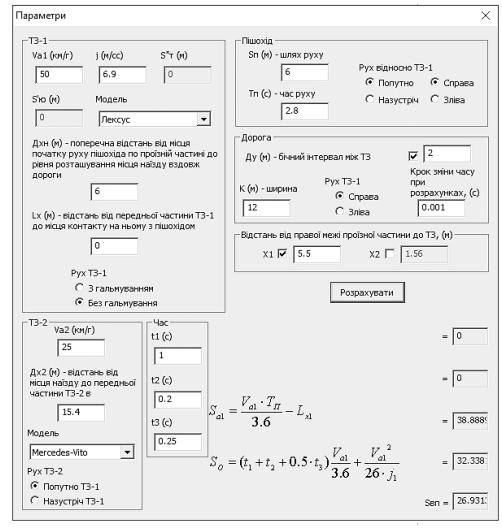

Fig. 4. Calculations of the relative position of Vehicle-1 and pedestrian at the time of the latter appeared in front of Vehicle-2

Also, on the graphical scheme the time of pedestrian's movement from the moment of his exit to the carriageway until the moment of appearance in the field of view of the driver of the Vehicle-1 (Fig. 5).

Capabilities of *TASolver* program also include research for the following TC situations:

- when the collision with the pedestrian occurred during the movement of Vehicle-1 in a braked state (for this purpose in the data area *"Vehicle-1"* in the window $S''_т$ or $S'_ю$ you should indicate the distance covered by the Vehicle-1 before the collision in braked condition, or the length of braking trace from the moment of its display to the moment of collision);
- when the pedestrian gets out of immovable *"Vehicle-2"* (in this area of initial data *"Vehicle-2"* in the window V_{a2} it is necessary to specify the speed of 0 km/h);

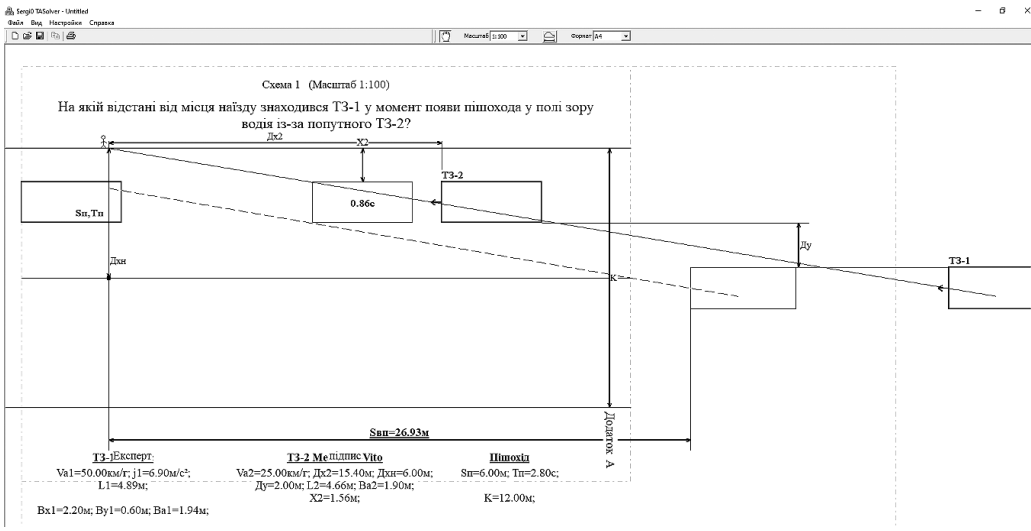

Fig. 5. Graphic disply of the relative position of Vehicle-1 and pedestrian at the time of the latter in the field of view of the driver from the front of Vehicle- 2

- if the Vehicle-2 moves in the opposite direction (in the area of initial data *"Vehicle-2"* it is necessary to indicate the direction of movement of the Vehicle-2 *"Towards the Vehicle-1"*);
- when the pedestrian crosses the carriageway at the angle (in the area of initial data *"Pedestrian"* it is necessary to indicate the movement of the pedestrian relative to the Vehicle-1 (incidentally, right, oncoming, left);
- when the collision of Vehicle-1 with the pedestrian occurred on the side (it is necessary to establish the distance from the front of Vehicle-1 to the point of contact with the pedestrian L_{x1}).

In addition, with the help of *TASolver* program, it is possible to investigate TC that occurred in conditions of limited visibility through an immovable stationary object (a house, fence, etc.). To solve this task, first in the *"Settings"* menu bar you should choose: Obstacle → Immovability. Then the *"Parameters"* dialog box appears, in which the initial data is entered according to the given instructions (Fig. 6).

2nd example

TC occurred at the crossroad in conditions of limited visibility, namely: visibility of Vehicle-2 to the driver of Vehicle-1 is limited to an immovable stationary object (the fence). It is necessary to establish the distance at which Vehicle-1 was at the time of Vehicle-2 in the driver's field of vision due to the object that limited visibility. The incident occurred under the following road conditions and circumstances:

- unequal crossroad, asphalt-concrete carriageways, dry, horizontal profile, each for the movement of Vehicles in one direction, the carriageway in the direction of traffic Vehicle-1 width — 8.0 m, in the direction of traffic Vehicle-2 — 6.0 m;

- Vehicle-1 (Lexus) moved at the speed of 60 km/h at a distance of 2.0 m from the right edge of the carriageway and 6.0 m from the object which limits visibility;
- Vehicle-2 (Mercedes Vito) moved at the speed of 40 km/h at a distance of 2.0 m from the left edge of the carriageway and 8.0 m from the object which limits visibility;
- direction of the movement of Vehicle-2 from right to left relative to the movement of the Vehicle-1;
- direction of the movement of Vehicle-1 from left to right relative to the movement of the Vehicle-2;
- before collision Vehicle-1 and Vehicle-2 moved in an unbraked state without maneuvering.

The initial data characterizing the specific situation of TC is entered into the dialog window of the program (Fig. 7).

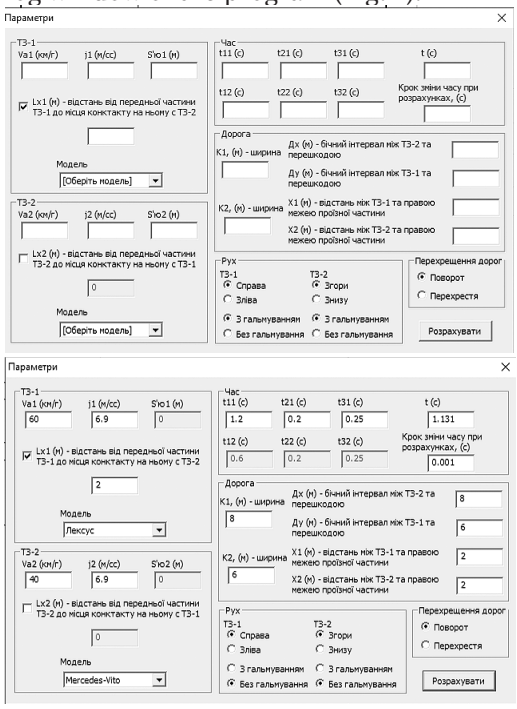

Fig. 6, 7. Dialog windows (before and after initial data)

To perform calculations and build the graphical scheme you should click *"Calculate"*.

The program will graphically display the relative position of Vehicle-1 and Vehicle-2 at the time of Vehicle-2 in the field of view of the driver of Vehicle-1 due to the immovable obstacle that limits visibility (Fig. 8).

Conducting research on the given initial data allowed to establish: at the moment of appearance of Vehicle-2 in the field of view of the driver of Vehicle-1 due to immovable stationary object Vehicle-1 was at a distance of 16.83 m (S_{a1}); at that time Vehicle- was at a distance of 12,56 m from the collision place (S_{a2}).

The graphic diagram also shows the time of movement of Vehicle-2 in the field view of the driver of Vehicle-1 before the collision (Fig. 8).

The capabilities of TASolver program also include research for TC when the collision occurred during the movement of Vehicle-1 and Vehicle-2 (or one of them) in a braked state. To do this, in the area of initial data *"Vehicle-1"* or *"Vehicle-2"* in the window $S'_{ю}$ it is necessary to specify the length of the braking trace from the moment of its display to the collision.

Conclusions

The given examples of TC studies, which occurred in conditions of limited visibility, show that the use of *TASolver* software package developed by specialists of National Scientific Center «Hon. Prof. M. S. Bokarius Forensic Science Institute» helps to improve the quality of studies, reduces the labor costs of the expert to conduct examinations, as well as increases the probative value of the expert's opinion.

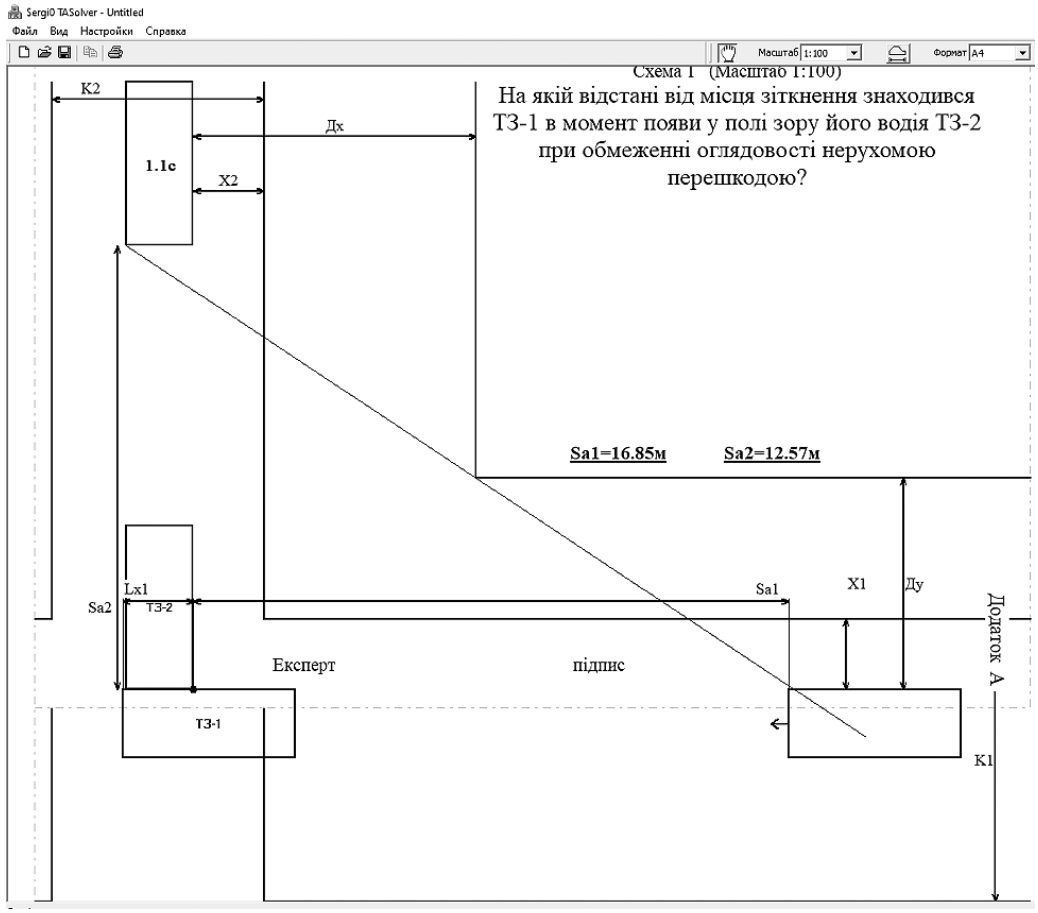

Fig. 8. Graphic display of the relative position of Vehicle-1 and Vehicle-2 at the time of the latter appeared in the field of view of the driver of Vehicle-1 due to an immovable object that limited visibility

Застосування програмного комплексу *TASolver* у дослідженні обставин дорожньо-транспортних пригод, що сталися в умовах обмеженої оглядовості

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До впровадження в експертну практику комп'ютерної техніки та програмування взаєморозташування учасників дорожньо-транспортної пригоди під час автотехнічної експертизи визначали за допомогою побудови графоаналітичної моделі. Сучасні іноземні програмні комплекси дають змогу моделювати механізм розвитку дорожньо-транспортної пригоди на різних її стадіях, проте вони складні й ліцензійні, отже — доволі дорогі.

У статті розглянуто приклади дослідження дорожньо-транспортних пригод, які сталися в умовах обмеженої оглядовості, із застосуванням програмного комплексу TASolver, розробленого в Національному науковому центрі «Інститут судових експертиз ім. Засл. проф. М. С. Бокаріуса». Застосовуючи

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графоаналітичний метод, цей програмний комплекс визначає відстань, на якій перебував транспортний засіб від місця наїзду (зіткнення) у момент виникнення небезпеки для подальшого руху. Використання програмного комплексу TASolver допомагає визначати взаєморозташування як транспортного засобу й пішохода під час наїзду, так і кількох транспортних засобів у разі їх зіткнення. Програмний комплекс TASolver дає змогу швидко й доволі легко змоделювати ситуацію дорожньо-транспортної пригоди, що сталася через об'єкт, який обмежував оглядовість.

Метою статті є вдосконалити якість проведення експертиз та експертних досліджень, скоротити трудовитрати експерта, а також підвищити доказове значення висновку експерта, чому сприятиме застосування для дослідження дорожньо-транспортних пригод, які сталися в умовах обмеженої оглядовості, програмного комплексу TASolver.

Ключові слова: *автотехнічна експертиза; дорожньо-транспортна пригода; дослідження; обмежена оглядовість; транспортний засіб; програмний комплекс; зіткнення; наїзд; графоаналітичний метод.*

Применение программного комплекса *TASolver* при исследовании обстоятельств дорожно-транспортных происшествий, произошедших в условиях ограниченной обзорности

Флорин Руситору, Александр Свидерский, Виталий Варлахов

До внедрения в экспертную практику компьютерной техники и программирования взаиморасположение участников дорожно-транспортного происшествия в автотехнической экспертизе определяли посредством построения графоаналитической модели. Современные иностранные программные комплексы позволяют моделировать механизм развития дорожно-транспортного происшествия на различных его стадиях, однако они сложные и лицензионные, а значит — довольно дорогие.

В статье рассмотрены примеры исследования дорожно-транспортных происшествий, произошедших в условиях ограниченной обзорности, с применением программного комплекса TASolver, разработанного в Национальном научном центре «Институт судебных экспертиз им. Засл. проф. Н. С. Бокариуса». Применяя графоаналитический метод, этот программный комплекс определяет расстояние, на котором находилось транспортное средство от места наезда (столкновения) в момент возникновения опасности для дальнейшего движения.

Использование программного комплекса TASolver позволяет определять взаиморасположение как транспортного средства и пешехода в случае наезда, так и нескольких транспортных средств при их столкновении. Программный комплекс TASolver позволяет быстро и достаточно легко смоделировать ситуацию дорожно-транспортного происшествия, случившегося из-за объекта, ограничивавшего обзорность.

Целью статьи является совершенствование качества проведения экспертиз и экспертных исследований, сокращение трудозатрат эксперта, а также повышение доказательственного значения заключения эксперта, чему будет способствовать применение для исследования дорожно-транспортных происшествий, произошедших в условиях ограниченной обзорности, программного комплекса TASolver.

Ключевые слова: *автотехническая экспертиза; дорожно-транспортное происшествие; исследование; ограниченная обзорность; транспортное средство; программный комплекс; столкновение; наезд; графоаналитический метод.*

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