Digital technologies in the survey of road sections

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Abstract. There are different approaches to road safety surveys [1-5]. To date, the issue of applying a risk-based approach in the road industry is relevant. The authors used the procedure of inspection of road sections in Atkarsk district of Saratov region by road laboratory with the use of digital technologies, dispersion analysis and risk theory for safety on curves in the plan. As a result of the survey, the average values of radii and standard deviations of rounding, tolerances for deviations of the studied parameters, the probability of hazards on the curve in the plan were determined. In the laboratory processing, all obtained mean radii corresponded to the acceptable level of risk. It also shows the critical values of the radii at which the skid or rollover of the vehicle will occur, obtained when determining the risk of loss of stability of the car on the curve in the plan. The methodology was based on the existing regulatory framework for road building requirements of Technical regulations of the Customs Union «Road Safety» TR CU 014/2011, namely taking into account the risk theory.

1. Introduction
The priority strategic development project «Safe and quality roads» is being implemented in the Russian Federation from 2017 to 2019. The project itself is aimed at bringing the roads of regional importance in the regulatory state and to bring the road network of urban agglomerations in the regulatory state. It is also necessary to transfer the system of control and supervision for two years to a risk-based approach using elements of digital technology.

2. Problem statement
Examination of roads by automated systems taking into account the theoretical and probabilistic approach: standard deviations of the studied parameters, dispersions, critical values that allow one to assess and take into account risks, according to mathematical models of Professor V.V. Stolyarov ensuring road safety is an actual and interesting problem. This article provides techniques to analyze curves in the plan with full statistical and probabilistic number series. Accounting for mathematical statistics gives a better and more accurate result. Also adaptation of a set of numbers to mathematical models and analysis of variance was performed.
3. Materials and methods

3.1. Examination of the curves in the plan on the high accident roads

To ensure the safety of public road sections, the survey was carried out with the help of a road laboratory (figure 1), using the RDT-Line software package. RDT-Line software package allowed working in conjunction with the measuring road laboratory. This software works with distance measuring systems; a geometrical parameters measuring system; a video recording system; the geographic coordinate system. The survey obtained information needed for further post-processing of data, namely the GPS data (mark of the path, km; degree of North latitude; degrees of East longitude; azimuth; elevation above sea level), these parameters are the inputs of a large array applicable in digital technologies.

3.2. Cameral processing of the obtained results

According to the diagnosis of the road, «Google Maps» points are applied using the GPS coordinates on the map itself. This helps to see the trajectory of the car, repeating the extreme right lane of the road.

We set the average value of the radius of the circular curve (Rср) and its standard deviation (σR), and determine the risk of loss of vehicle stability when driving at a design speed on a circular curve with parameters Rср, σR using the methods of the professor of Transport Construction Department of Saratov State Technical University Gagarin U.A. Viktor Vasilevich Stolyarov [6].

Let us determine the actual radii of the circular insert by the formula:

\[ R = \frac{d^2}{|Y_{pr}-2Y_{int}+Y_{sub}|} \]  

(1)

d – segments of constant length on the chord tightening the arc of rounding, m;
Y_{pr}, Y_{int}, Y_{sub} – previous, intermediate and subsequent coordinates defined by:

\[ Y_{pr} = |f - Y_i|; \]

(2)

\[ Y_{int} = |f - Y_{i+1}|; \]

(3)

\[ Y_{sub} = |f - Y_{i+2}|; \]

(4)

Y_{pr}, Y_{int}, Y_{sub} – measured sequentially ordinate from the chord using equal parts d, m; f is the Y coordinate located in the middle of the chord method, m.

Thus, we calculate 100 values of radii, which are fixed in the table «Actual radii of circular insertion». As a result, we have a statistical set given for processing the radii of the curve in the plan. Ultimately, applying to the data of the table «Statistical processing of the radii of the curve in the plan», using the multiplicative method, we obtain the value of the radius Rср and standard deviation σ:

\[ R_{int} = X_a + \frac{d}{n}B; \]

(5)

\[ \sigma = \frac{d^2}{\sqrt{n-1}} \left( \frac{A - \frac{M^2}{n}}{n} \right); \]

(6)

\[ R_{int} = U_k - d \cdot \frac{M}{n} - 1; \]

(7)

\[ \sigma = \frac{d^2}{\sqrt{n-1}} \left( 2 \cdot \Sigma T - M - \frac{M^2}{n} \right). \]

(8)

3.3. Determination of the critical radius with which the car will skid or roll over

According to the method of V. V. Stolyarov [7] we determine the actual risk of loss of stability of the car on the curve in terms of [8]. The technique is based on the existing regulatory framework for road building requirements of Technical regulations of the Customs Union «Road Safety» TR CU 014/2011, namely taking into account the theory of risk [9–10].

The risk of loss of vehicle stability when driving at design speed on a circular insert with parameters Rср, σR located at the following parameters to be defined: the longitudinal component of the friction coefficient; the standard deviation of the friction coefficient and driving speed; the rolling resistance coefficient; coefficient of traction force; the critical value of the radius of the curve in the plan (this parameter is fundamental in the study), corresponding to a 50% chance of losing vehicle stability; the
standard deviation of the critical radius curve in plan. This procedure for calculating the risk has been repeatedly described by Professor V. V. Stolyarov in monographs and scientific articles (V.V. Stolyarov Proektirovanie avtomobil’nyh dorog s ispol’zovaniem teorii riska [Design of roads using the theory of risk] [7]). The longitudinal slope is calculated at each turn of the surveyed road.

It is known that the category of the diagnosed road is III.
Adopted design speed is 100 km/h (SP 34.13330.2012 [11]).
The type and condition of the coating-asphalt concrete are dry, clean.
The super elevation rate – $e = 0.04$.
The wind speed – $V_w = 0$ km/h.
Acceleration of gravity – $g = 9.81 \text{ m/s}^2$.
To calculate the risk, the vehicle used in the diagnosis of the road is taken: Renault Duster.

Development of working hypotheses, construction of models of the research object

Previously, statistical data were transformed by determining the mean and standard deviation of the curve radius in the plan. Next, it is necessary to establish on the basis of Pearson’s criterion the correspondence of the histogram of the distribution of radii to the normal distribution, since most often this distribution corresponds to many construction parameters [11]. According to the method of V. V. Stolyarov [6] we make sure that the parameters are really distributed according to the normal law, this allows us to apply the risk theory at this stage.

We build a table «Comparison of the actual distribution of the radii of the curve in terms of the law of normal distribution», in which we specify the bits of intervals and the absolute frequency of falling into these bits.

Then we determine the probability of falling into the category of measurements:
$$P_i = F\left(\frac{H_{i+1} - H_{\text{int}}}{\sigma_H}\right) - F\left(\frac{H_i - H_{\text{int}}}{\sigma_H}\right)$$  \hspace{1cm} (9)

$F(u)$ – Laplace transform;
$H_i$ (min) and $H_{i+1}$ (max) – left and right boundary of radii in bits;
$H_{av}$ and $\sigma_H$ – the average value of the radius of the curve in terms of soil and its standard deviation.

For the theoretical distribution the number of degrees of freedom was determined by the formula:
$$\nu = k - r,$$  \hspace{1cm} (10)

$k$ – number of digits;
$r$ – the number of superimposed relations (for the normal distribution law $r=3$).

We write out the probability by which the correspondence of the theoretical distribution law to the measurement results (histogram):
- best value at $P>0.5$;
- good value when $P=0.3+0.5$;
- good match when $P=0.1+0.3$;
- satisfactory correspondence with $P<0.1$.

We determine the correspondence of the histogram (the value of the curve radius in the plan) to the density of the normal distribution [12].

The Romanovsky criterion was also used to compare the theoretical and empirical distribution

According to the criterion of V. I. Romanovsky:
$$R = \left(\sum \chi_i^2 - \nu\right)/(2 \nu)0.5.$$  \hspace{1cm} (11)

If the Romanovsky criterion is less than 3, the hypothesis of the correspondence of the actual distribution curve to the theoretical distribution law is accepted. Otherwise, with $R \geq 3$, we concluded that the chosen theoretical distribution law does not correspond to the measurement results.

4. Discussion of results

The article describes the full procedure for performing the survey for turn no. 1.

Using «GoogleMaps» we put points with GPS coordinates on the map itself (figure 1). This helps to see the trajectory of the car, repeating the extreme right lane of the road.
Figure 1. Drawing points from GPS coordinates on the map of the surveyed area: (a) – satellite image: turn no. 1; (b) — map: turn no. 1

Next, you need to set the angle of rotation. Along the contour from the beginning and end of the diagnosed area, two segments intersecting at the point of the curve vertex are drawn. The rotation angle of 35° is determined (figure 2).

Figure 2. Determining the angle of rotation

The points of the beginning and end of the rounding are 86 and 134, respectively (table 1).

Table 1. Round start and end coordinates

| Mark of the path, km | Degrees North latitude | Degrees East longitude | Azimuth, degrees | Elevation above sea level, m | Signal quality | No. |
|---------------------|------------------------|------------------------|-----------------|-----------------------------|---------------|-----|
| 1.705               | 51°52’52.29”           | 44°56’35.38”           | 293.0           | 176                         | 11            | 134 |
| 861.144             | 51°52’41.49”           | 44°56’58.25”           | 325.0           | 158                         | 11            | 86  |
With the help of computer-aided design and drawing software AutoCAD a part of the circle according to the results of diagnosis (GPS coordinates) is drawn.

It is known that the length of the chord is 537 m.

The constant length of the segment on the chord tightening the arc of the circle is 26.85 m.

The chord is divided into 20 equal segments (figure 3).

![Figure 3. Results of the rounding survey](image)

With \( d = 26.85 \) m we define 19 values of radii. For example, if \( Y_1 = 0.00 \) m, \( Y_{i+1} = 7.51 \) m, \( Y_{i+2} = 13.40 \) m, we obtain:

\[
Y_{pr} = |39.27 - 0.00| = 39.27 \text{ m};
Y_{int} = |39.27 - 7.51| = 31.76 \text{ m};
Y_{sub} = |39.27 - 13.40| = 25.87 \text{ m};
R = \frac{26.85^2}{|39.27 - 2 \cdot 31.76 + 25.87|} = 445.0139 \text{ m}.
\]

The results of calculations (19 values of radii at \( d = 26.85 \) m) are entered in column 3 of table 2.

With \( d = 2 \cdot 26.85 = 53.7 \) m we determine 17 values of the radii of the curve. For example, if \( Y_1 = 0.00 \) m, \( Y_{i+1} = 13.40 \) m, \( Y_{i+2} = 23.75 \) m, we get:

\[
Y_{pr} = |39.27 - 0.00| = 39.27 \text{ m};
Y_{int} = |39.27 - 13.40| = 25.87 \text{ m};
Y_{sub} = |39.27 - 23.75| = 15.52 \text{ m};
R = \frac{53.7^2}{|39.27 - 2 \cdot 25.87 + 15.52|} = 945.47 \text{ m}.
\]

The obtained radii values (at \( d = 53.7 \) m) are entered in the fourth column of table 2.

In the same way we calculate 15 values of the radius when \( d = 3 \cdot 26.85 = 80.55 \) m, 13 values of \( R \) with \( d = 4 \cdot 26.85 = 107.4 \) m, 11 values of \( R \) with \( d = 5 \cdot 26.85 = 134.25 \) m, 9 values of \( R \) with \( d = 6 \cdot 26.85 = 161.1 \) m, 7 values of \( R \) with \( d = 7 \cdot 26.85 = 187.95 \) m, 5 values of \( R \) with \( d = 8 \cdot 26.85 = 214.8 \) m, 3 values of \( R \) with \( d = 9 \cdot 26.85 = 241.65 \) m, 1 value of \( R \) with \( d = 10 \cdot 26.85 = 268.5 \) m (with \( Y_1 = 0.00 \) m, \( Y_{i+1} = 39.27 \) m, \( Y_{i+2} = 0.00 \) m). The results of the calculations are shown in table 2.

### Table 2. Statistical processing of curve radii in plan

| Sections of sediment size intervals, m | Middle discharge, Um | Absolute frequency, \( h_m \) | Partial sum, \( S_m \) | Cumulative frequency, \( T \) | The middle of the conditional interval, \( l_m \) | Multiplications |
|---------------------------------------|----------------------|------------------|------------------|-------------------|-------------------------|----------------|
| 0–200                                 | 300                  | 5                | 5                | 5                 | −3                      | −15 9 45       |
| 200–400                               | 500                  | 5                | 10               | 15                | −2                      | −10 4 20       |
| 400–600                               | 700                  | 20               | 30               | 45                | −1                      | −20 1 20       |
| 600–800                               | 900=\( X_a \)        | 29               | 59               | 104               | 0                       | 0 0 0          |
| 800–1000                              | 1100                 | 20               | 79               | 183               | 1                       | 20 1 20        |
| 1000–1200                             | 1300                 | 5                | 84               | 267               | 2                       | 10 4 20        |
| 1200–1400                             | 1500                 | 2                | 86               | 353               | 3                       | 6 9 18         |

\( n = 86 \)  \( M = 353 \)  \( \Sigma T = 972 \)  \( B = −9 \)  \( A = 143 \)
Table 3. The actual radii of the circular insert calculated by the formula (1)

| Ordinate, m | Measured from the chord $Y_i$ | Calculated by formula $Y = |f - Y_i|$ | 26.85 | 53.7 | 80.55 | 107.4 | 134.25 | 161.1 | 187.95 | 214.8 | 241.65 |
|-------------|-------------------------------|----------------------------------------|-------|------|-------|-------|--------|-------|--------|-------|--------|
| 0.00        | 0.00                          | 39.27                                  |       |      |       |       |        |       |        |       |        |
| 7.51        | 31.76                         | 445.01                                 |       |      |       |       |        |       |        |       |        |
| 13.40       | 25.87                         | 2483.94                                | 945.47|      |       |       |        |       |        |       |        |
| 19.00       | 20.27                         | 848.14                                 | 1456.40| 1007.50|      |       |        |       |        |       |        |
| 23.75       | 15.52                         | 72092.25                               | 1135.31| 1126.44| 1096.46|      |        |       |        |       |        |
| 28.51       | 10.76                         | 421.59                                 | 76.86 | 977.15| 990.95| 1015.38|      |        |        |       |        |
| 31.56       | 7.71                          | 1897.16                                | 1206.56| 1038.12| 1103.80| 1085.07| 1038.12|      |        |       |        |
| 34.89       | 5.04                          | 9011.53                                | 1386.38| 1192.70| 1102.75| 1063.93| 1016.17| 705.25|      |       |        |
| 36.89       | 2.29                          | 387.59                                 | 921.30| 1005.93| 954.07| 921.89 | 898.03 | 672.71| 998.89|      |        |
| 37.87       | 1.40                          | 1413.57                                | 1148.88| 1070.67| 975.86 | 886.52 | 898.96 | 750.74| 946.44| 770.98|        |
| 39.27       | 0.00                          | 431.69                                 | 838.28| 729.02 | 752.92 | 813.31 | 960.51 | 647.85| 914.00| 1838.62|        |
| 39.54       | 0.27                          | 1181.84                                | 610.95| 693.19 | 725.45 | 965.34 | 864.81 | 655.54| 893.99| 2305.35|        |
| 38.12       | 1.15                          | 393.94                                 | 543.06| 617.93 | 1003.89| 799.95 | 864.53 | 643.36| 879.00|      |        |
| 35.21       | 3.86                          | 639.19                                 | 730.04| 1716.48| 856.32 | 939.68 | 888.80 | 661.05|      |      |        |
| 31.66       | 0.72                          | 18023.06                               | 1122.05| 1340.55| 1228.40| 997.95 | 985.31|      |      |      |        |
| 27.87       | 11.04                         | 195.3                                  | 3392.57| 2191.99| 1233.66| 1094.29|      |      |      |      |        |
| 27.77       | 11.50                         | 88.02                                  | 312.76| 509.28 | 662.15 |      |      |      |      |      |        |
| 19.48       | 19.79                         | 207.75                                 | 779.37| 888.80|      |      |      |      |      |      |        |
| 14.66       | 24.61                         | 294.25                                 | 1860.44|      |      |      |      |      |      |      |        |
| 7.39        | 31.88                         | 6007.68                                |      |      |      |      |      |      |      |      |        |
| 0.00        | 39.27                         |      |      |      |      |      |      |      |      |      |        |
According to table 2, we determine the mean value of the radius \( R_{ср} \) and the mean square deviation of the radii \( \sigma_R \). In this case, we discard the abnormal radii in relation to the given population. These radii are beyond the limits of the discharges shown in table 3 (the value of these radii is separated from the main population at a great distance and on the basis of this feature is abnormal).

Applying the multiplicative method to the data of table 2, we obtain the value of the radius \( R_{int} \) and standard deviation \( \sigma \):

\[
R_{int} = 900 + \frac{200}{86} (-9) = 879.07 \text{ m};
\]

\[
\sigma = \sqrt{\frac{200^2}{86 - 1} \left( 143 - \frac{-9^2}{86} \right)} = 258.56 \text{ m}.
\]

By summation method (control of calculations):

\[
R_{int} = 1500 - 200 \cdot \left( \frac{353}{86} - 1 \right) = 879.07 \text{ m};
\]

\[
\sigma = \sqrt{\frac{200^2}{86 - 1} \left( 2 \cdot 972 - 353 - \frac{353^2}{86} \right)} = 258.56 \text{ m}.
\]

The average value of the radius of the curve in terms of plan – 879.07 m.

Standard deviation of radius – 258.56 m.

Determine the longitudinal slope of the road by the formula. Let us find the slope value at every fifth point (GPS coordinates) of the curve.

| Distance between points | Starting point | Ending point | Gradient |
|-------------------------|----------------|--------------|----------|
| 67                      | 159            | 161          | -0.029   |
| 66                      | 161            | 162          | -0.015   |
| 66                      | 162            | 164          | -0.030   |
| 63                      | 165            | 166          | -0.015   |
| 56                      | 166            | 167          | -0.009   |
| 55                      | 167            | 167          | 0.000    |
| 54                      | 167            | 167          | -0.037   |
| 54                      | 169            | 172          | -0.055   |
| 56                      | 173            | 175          | -0.035   |
| 46                      | 176            | 178          | -0.043   |

The average value of the longitudinal gradient, \( i \) -0.028

In subsequent calculations, the basic formulas of the risk theory described in the works of V.V. Stolyarov and other literary sources are used [13–16].

We determine the longitudinal component of the coefficient of adhesion:

\[
\varphi = 1 \cdot [0.89 - 0.0017 \cdot (100 - 20)] = 0.754.
\]

Standard deviation:

- coefficient of adhesion:
  \[
  \sigma_\varphi = 10 \cdot 0.754(1 - 0.754^2) \cdot \left( \frac{100 + 5}{100^2} \right) = 0.034;
  \]
- movement speed:
  \[
  \sigma_v = 0.05 \cdot 100 + 0.5 = 5.5 \text{ km/h};
  \]
- rolling resistance coefficient:
  \[
  f = 0.89 + 0.0002(100 - 20) = 0.03;
  \]
• coefficient of traction according to the formula:

\[ \mu_x = \frac{2}{1} \left( 0.03 - 0.0281 + \frac{0.35 \cdot 2.3686 \cdot 100^2}{13 \cdot 1360 \cdot 9.81} \right) = 0.099. \]

The critical value of the curve radius in the plan, corresponding to the 50% risk of loss of stability of the car:

\[ R_{cr} = \frac{100^2}{127 \cdot \left( \sqrt{0.754^2 - 0.099^2 + 0.4} \right)} = 99.998 \text{ m}. \]

Standard deviation of the coefficient of traction according to the formula:

\[ \sigma_{\mu_x} = \frac{2}{1} \sqrt{0.003^2 + (-0.001)^2 + \left( \frac{0.35 \cdot 2.3686 \cdot 100}{13 \cdot 1360 \cdot 9.81} \right)^2 \cdot 5.5^2} = 0.008; \]

\[ \sigma_f = 0.1 \cdot 0.03 = 0.003; \]

\[ \sigma_i = 0.05 \cdot (-0.0281) = -0.001. \]

Standard deviation of the critical radius of the curve in plan:

\[ \sigma_{R_{cr}} = \frac{100}{127 \cdot (0.754^2 - 0.099^2)} \cdot \sqrt{4 \cdot (0.754^2 - 0.099^2) \cdot 5.5^2 + \frac{100^2}{0.754^2 - 0.099^2} \cdot \left( 0.754^2 \cdot 0.034^2 + 0.099^2 \cdot 0.008^2 \right)} = 12.56 \text{ m}. \]

Risk of loss of stability of a vehicle traveling at \( V \) on a curve in a plan with a radius \( R_{int} \):

\[ r_{r.c} = 0.5 - F \left( \frac{879.07 - 99.99}{12585.65^2 + 12566^2} \right) = 0.5 - F(3.010). \]

Using the «Laplace transform table» \( F(U) \) is defined.

In this case, the value \( U = 3.010 \) corresponds to the value \( F = 0.49869 \).

Therefore, \( r_{r.c} = 0.5 - 0.49869 = 0.0013 \).

Conclusion: out of 10,000 cars moving along a given circular curve at a speed of 100 km/h, 13 cars will lose stability due to the geometric element (curve in plan).

The Pearson and Romanovsky criteria are based on a comparison of the actual and theoretical number of frequencies of the studied indicator in discharges (table 5).

**Table 5.** Comparison of the empirical distribution of the radii of the curve in terms of the law of normal distribution

| Level intervals | Absolute frequency, \( h_m \) | Probability of measurements falling into the category, \( P_i \) | Theoretical number of measurements in discharge (\( n_t \)) | \( \chi^2 = \frac{(h_m - n_t)^2}{n_t} \) |
|-----------------|-------------------------------|---------------------------------|-----------------------------|---------------------------------|
| <200            | 0                             | 0.00398                         | 0.342                       | 0.342                           |
| 200-400         | 5                             | 0.02764                         | 2.376                       | 2.895                           |
| 400-600         | 5                             | 0.10827                        | 9.310                       | 1.995                           |
| 600-800         | 20                            | 0.23966                        | 20.610                      | 0.018                           |
| 800-1000        | 29                            | 0.30013                        | 25.811                      | 0.393                           |
| 1000-1200       | 20                            | 0.21274                        | 18.295                      | 0.158                           |
| 1200-1400       | 5                             | 0.08529                        | 7.335                       | 0.743                           |
| 1400-1600       | 2                             | 0.01931                        | 1.661                       | 0.069                           |
| >1600           | 0                             | 0.00261                        | 0.224                       | 0.224                           |
| d = 200         | n = 86                        | \( \Sigma P_i = 0.9996 \)      | \( \Sigma \chi^2 = 6.84 \)  |

For the theoretical distribution, the number of degrees of freedom was determined by the formula (10):
\[ \nu = 9 - 3 = 6. \]

From the tables \( \chi^2 \) of the distribution, we obtain the probability by which the correspondence of the theoretical distribution law to the measurement results (histogram):

\[ P = 0.34. \]

The correspondence between the histogram and the density of the normal distribution should be considered good:

\[ R = \frac{6.84 - 6}{\sqrt{2.6}} = 0.24. \]

Since 0.24<3, the normal distribution is consistent with the experimental data. In this case, the Romanovsky criterion shows a good match.

Figure 4 shows a comparison of the histogram of the coverage width distribution with the density of the normal distribution.

Thus, surveys were performed on 9 curves in the plan. As a result of the survey, mean values of radii and standard deviations of rounding, probabilities of hazards, tolerances for deviations were determined and the normal distribution law was checked.

According to the data of laboratory processing, with obtained mean radii correspond to the acceptable level of risk. Table 6 shows the critical radii at which the vehicle will skid or roll over, obtained when determining the risk of loss of stability of the vehicle on the curve in the plan. In comparison with the average radii, the critical values are quite small.

We will also follow the values of risks and standard deviations at the actual risks and the risk equal to \( 1 \cdot 10^{-3} \) (columns 2, 3, 4, 5) of table 6.

![Figure 4. A histogram of the values of curve radii in the plan and the normal density at \( R_{\text{int}} = 879.07 \) m and \( \sigma = 258.56 \) m](image)

| № turn | \( R_{\text{int}} \) | \( \sigma_{\text{int}} \) | \( R_1 \cdot 10^{-4} \) | \( \sigma_1 \cdot 10^{-5} \) | \( R_{\text{cr}} \) | \( R_{\text{fact.}} \) |
|--------|----------------|----------------|----------------|----------------|----------------|----------------|
| 1      | 879.07         | 258.56         | 879.07         | 254            | 99.99          | 0.0013         |
| 2      | 2837.17        | 509.48         | 2837.17        | 900            | 100.74         | 0              |
| 3      | 805.77         | 141.70         | 805.77         | 227            | 103.48         | 4 \cdot 10^{-7}|
| 4      | 5598.68        | 2010.01        | 5598.68        | 1777           | 102.43         | 0.00312        |
| 5.1    | 2978.92        | 501.83         | 2978.92        | 935            | 100.71         | 0              |
| 5.2    | 3105.13        | 454.67         | 3105.13        | 970            | 101.00         | 0              |
| 6.1    | 1814.5         | 678.08         | 1814.5         | 555            | 101.89         | 0.00578        |
| 6.2    | 996.84         | 317.78         | 996.84         | 290            | 102.25         | 0.0025         |
| 6.3    | 619.10         | 202.43         | 619.10         | 167            | 100.21         | 0.0053         |
5. Conclusion
The article presents a method of consistent description of activities in the framework of accident analysis and decision-making for the elimination of these foci.

This technique allows the analysis of a single geometric element of the road (curve in plan) with a full statistical and probabilistic numerical series, which determines the quantitative characteristics of the investigated geometric element.

Advantages: this methodology is based on current regulations, road building requirements of Technical regulations of the Customs Union «Road Safety» 014/2011 TR TS [4], namely taking into account the risk theory.

Acknowledgements
The authors express their gratitude to Victor V. Stolyarov, doctor of technical Sciences, Professor of Transport Construction Department of Saratov State Technical University n.a. Gagarin U.A., for valuable advice during the research.

The authors also express their gratitude to the Federal state budgetary institution "Fund for the promotion of small enterprises in the scientific and technical sphere" (Fund for the promotion of innovation) for the financial assistance provided during this study and writing this article.

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