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RELIABILITY MATHEMATICAL MODEL FOR SYSTEMS OPERATOR FUNCTIONALITY

Abstract

In this article considered safety and reliability question on railway transport. In diagrams seen that too much failures depends on operator factor in train and maneuver work. That is why came an idea to make mathematical model, including operator factor. It means that in system can be two different failure types – "technical" and "man" factor. Using this model is possible to find out system with optimal parameters.

1. INTRODUCTION

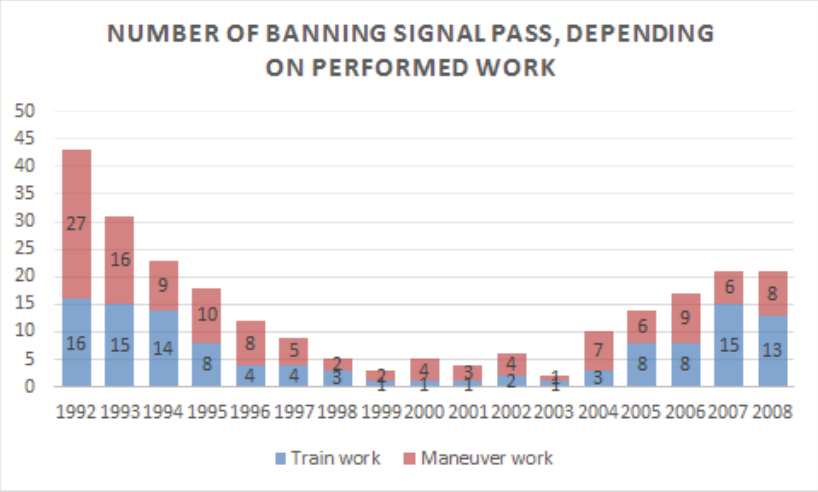
Systems optimal choice for providing maneuver works are used only on the reliability parameters value quantity analysis bases, which calculated for different system types. Because systems qualitative parameters, which gives developers, not always confirmed in the practical exploitation real process.

Using different literature analysis were researched diagrams, which shows how much failure comes out as operators mistakes sequence.

As the result made different models to calculate system reliability.

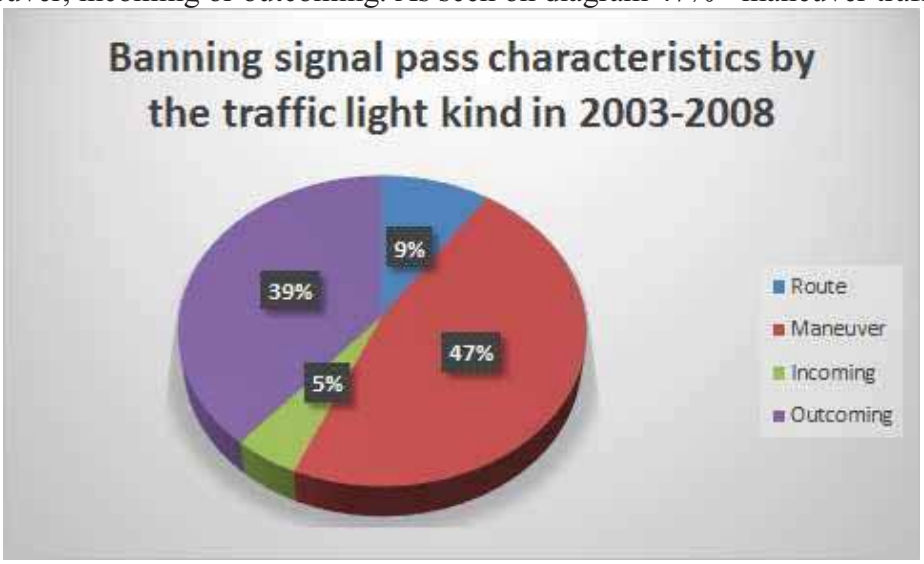
2. FAILURE ANALISYS

Number of banning signal pass, depending on performed work. As shows Picture 1, number on train work is near to number of maneuver works.



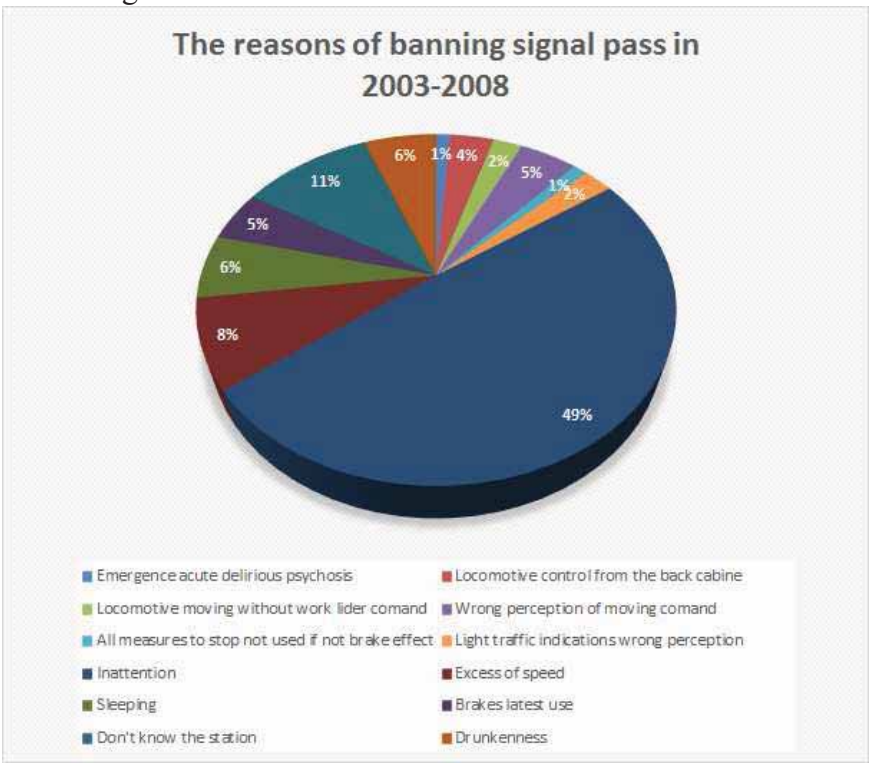
Picture 1. Number of banning signal pass, depending on performed work

On the Picture 2 showed how many banning signals passed in different traffic lights – route, maneuver, incoming or outcoming. As seen on diagram 47% - maneuver traffic lights.



Picture 2. Banning signal pass characteristics by the traffic light kind

On the next picture – Picture 3 – was mined main reasons, why was passed banned signals. As seen on diagram – inattention and it is a man factor.



Picture 3. The reasons of banning signal pass

3. MAN FACTOR ON SYSTEM SAFETY

Maneuver man – device functional safety depends on not failure operator action, which take part in maneuver works realization.

Using "unsafe elements" conception definitions and admissions in systems operators' mathematical models used following initial data:

m – number of operators,

$\lambda_4 = 1/T_\lambda$ – failure flow total intensity, which defined, using statistical data for researched railway stations maneuver region,

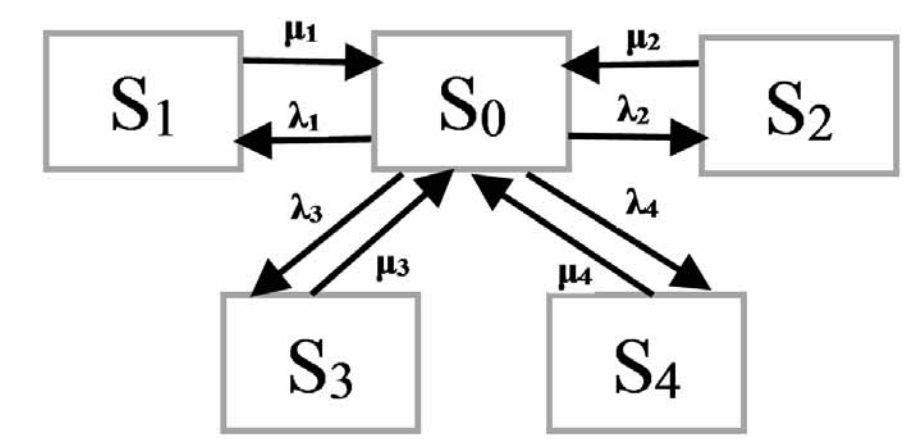
T_λ – random intervals mean value between the failures,

$\mu_4 = 1/T_\mu$ – operators failure fixing mean intensity, which defined, using statistical data for researched railway stations maneuver region,

T_μ - operators failure fixing mean time value.

In the maneuver works exploitation period the system can be in one of the following conditions – S0,

S1, S2, S3 – that is defined with systems technical elements condition. If systems operators make a mistake, system becomes in a not safe condition S4.



Picture 4. Graph of systems conditions.

Using system graph it is possible to make differential equation system of Kolmogorov and solving this system find systems probability conditions as time functions. Then, using initial data and norming condition, solving algebraic equations system find limiting probabilities.

Differential equations of Kolmogorov

$$\frac{d}{dt}P_0 = \mu_1 P_1 + \mu_2 P_2 + \mu_3 P_3 + \mu_4 P_4 - P_0(\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4)$$

$$\frac{d}{dt}P_1 = \lambda_1 \cdot P_0 - \mu_1 P_1$$

$$\frac{d}{dt}P_2 = \lambda_2 \cdot P_0 - \mu_2 P_2$$

$$\frac{d}{dt}P_3 = \lambda_3 \cdot P_0 - \mu_3 P_3$$

$$\frac{d}{dt}P_4 = \lambda_4 \cdot P_0 - \mu_4 P_4$$

Initial data

$t := 0$

$P_0(t = 0) = 0$

$P_1(t = 0) = 0$

$P_2(t = 0) = 0$

$P_3(t = 0) = 0$

$P_4(t = 0) = 0$

Norming condition

$$P_0 + P_1 + P_2 + P_3 + P_4 = 0$$

Limiting probabilities

$$\mu_1 P_1 + \mu_2 P_2 + \mu_3 P_3 + \mu_4 P_4 - P_0(\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4) = 0$$

$$\lambda_1 \cdot P_0 - \mu_1 P_1 = 0$$

$$\lambda_2 \cdot P_0 - \mu_2 P_2 = 0$$

$$\lambda_3 \cdot P_0 - \mu_3 P_3 = 0$$

$$\lambda_4 \cdot P_0 - \mu_4 P_4 = 0$$

As a result will get limiting conditions values – P_1, P_2, P_3, P_4. Probability P_3 – systems not safe conditions probability as result of not safe elements in systems technical devices, P_4 – systems not safe condition as result of operators failure. Both probabilities P_3, P_4 – inconsistent events. That is why systems not safe condition probability is consequence of the "technical" factor with probability P_3 and "man" factor with P_4 impact equal to those probabilities sum.

CONCLUSION

In this article considered safety and reliability question on railway transport. In diagrams seen that too much failures depends on operator factor in train and maneuver work. That is why came an idea to make mathematical model, including operator factor. It means that in system can be two different failure types – "technical" and "man" factor. Using this model is possible to find out system with optimal parameters.

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