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**A.V. GUSEV, O.M. PAPCHENKO**

***National Transport University, Ukraine***

# DEVELOPMENT OF METHOD FOR ASSESSING THE EFFICIENCY OF VISUAL INFORMATION ACQUISITION BY THE OPERATOR

The method for estimation of the efficiency of visual information acquisition by the operator is presented. The major principles are stipulated and the criteria proposed.

**visual information acquisition, efficiency of visual information acquisition, operator, operator's skills**

## Introduction

According to the world's statistics the operator (i.e. driver, pilot, train operator) is considered responsible for corresponding accident in 55-80% of all cases [1]. Moreover in 50% of all cases accidents occur due to erroneous, untimely and/or inadequate visual information acquisition (VIA) by the operator [2]. The above statistics endorses the necessity for further research aimed at studying the patterns of VIA by certain type of operator (for example, the driver) and aimed at developing comprehensive method for assessing the efficiency of VIA by the operator [2].

## Principles of the problem

The method for assessing the efficiency of VIA by the operator should enable to solve the following tasks:

– define the feed-back between the trainee and the training process (also, serve for the purposes of the adaptive training);

– provide the assessment and estimation of the operator skills level;

– control of changes in operator's skills levels in time (in the process of professional activity).

The proposed method includes the following stages:

1. The primary collection of data concerned (i.e. testing the trainees).
2. Definition of the criteria and the design values of specific visual activities (for specific operator's task).
3. Justification of particular indexes characterizing the operator's visual activities and skills.
4. Justification of overall (integral) index.
5. Calculation and evaluation of VIA.
6. Conversion of the resulting data to specific marks.

***The primary collection of data concerned (i.e. testing the trainees).*** The VIA patterns of operator are studied with the help of NEC Eye-Mark Recorder. For example, for the case of the driver's task, testing of trainees is carried at five typical road sections (at fixed driving speeds: 20, 40, 60, 80 и 100 km/hour) [2].

***Definition of the criteria and the design values of specific visual activities (for specific operator's task).*** The probabilistic principle of defining the design values is being applied for acquiring designated design parameters. The design value is calculated using the following equation:

$$X_n = X_{cp}\left(1 - a \cdot C_v\right), \quad (1)$$

where: $X_p$ – design value of particular parameter; $X_{cp}$ – average value of given parameter out of $n$ measurements (taken in conditions close to design); $a$ – factor, which depends on number of repetitions $N$, of the variation ratio $C_V$ and asymmetry ratio $C_S$ . The above ratios $C_V$ and $C_S$ are calculated using:

$$C_v = \frac{\sum_{i=1}^{n}\left(\frac{X_i}{X_{cp}} - 1\right)^2}{n-1}, \quad (2)$$

$$C_s = 2C_v \,. \tag{3}$$

The factor $a$ is defined according to (2) and (3) using [2].

***Justification of particular indexes characterizing the operator's visual activities and skills.*** The visual activities of the driver are described by the following parameters: 1) duration of sight (eye) fixation; 2) duration of searching, observing and estimating components of sight (eye) movements (components of driver's visual activity); 3) distance toward so-called visual information zones (three major zones are anticipated); 4) sequence (algorithms) of visual information acquisition and proper timing of acquisition of specific relevant information (timely eye movements), etc.

All above stated parameters should be taken into account while judging the operator's (for example, driver's) visual skills. There are two principal ways of defining the overall assessment of driver's activity. In the first case the assessment of operator's activities is done using both particular and overall factors. For the purpose of obtaining the particular factors the operator's activities are subdivided into several groups (duration of sight (eye) fixation, duration of visual activity, distances toward information zones, shifts of attention, etc). Each group is has one or several factors ($m_i$) which defines partial mark of operators activity.

All the particular specific parameters, in accordance with their influence on the final efficiency, are divided into two groups: one being of so-called increasing nature (i.e. dependability, safety, efficiency, timeliness, etc.), the other of decreasing nature (i.e. expenditure, time of information acquisition, etc.). Thus the norm-setting is done in accordance with the following:

*for increasing parameters*

$$Э_i = \frac{E_i}{E_{\max i}} \,, \tag{4}$$

*for decreasing parameters*

$$Э_i = \frac{E_{\min i}}{E_i} \,, \tag{5}$$

where $Э_i$ и $E_i$ – accordingly, the standardized and the absolute value of $i$ particular parameter; $E_{max}$ and $E_{min}$ – maximum (minimum) value of $i$ particular parameter, which the present system or the system being design possess.

***Justification of overall (integral) index.*** The overall (integral) index can be defined using the following criteria:

$$h = \sum d_i \sum \beta_{ij} Q_{ij} \,, \tag{6}$$

where: $n$ – number of groups of particular marks; $d_i$ – weighing factor, which takes into account the importance of $i$ particular mark; $m_i$ – the number of parameters in every group of particular marks; $\beta_{ij}$ – weighing factor, which takes into account the importance of $j$ parameter in $i$ group; $Q_{ij}$ – mark of $j$ parameter for $i$ group.

The factors $d_i$ and $\beta_{ij}$ are comfined by the following conditions:

$$\sum_{i=1}^{n} d_i = 1, \quad \sum_{i=1}^{m} \beta_{ij} = 1 \quad (j = 1, 2, 3, \ldots, m_i). \tag{7}$$

The first approach implies the use of generalized mark R, which is weighted mean mark of all particular separate parameters marks.

The second approach is bases on the use of particular conditional relative units of measurement for assessment of operator's activity. Afterwards the obtained conditional relative units are transferred (using one of the available estimation scales) into marks (for example, into four-grade mark system. Linear function is commonly used for acquiring the relative mark $r$:

$$r = \sum_{i=1}^{n} d_i q_i \,, \tag{8}$$

where $q_i$ – standardized value of $i$ particular parameter of operator's activity. The standardization should be done in accordance (4) and (5). The standardizing values are chosen in such a manner that the results of operator's activity are characterized by relative figure within the margins from 0 to 1.

For acquiring the integral mark the combination of all particular parameters is considered. Then the particular parameters are included in the overall mark each with its own specific "weight" (the later corresponds the importance of particular parameter within the considered system). Since each considered parameter has its own physical nature and its own according units of measurement, all the parameters must be "scaled" to standardized non-dimensional form.

Efficiency of operator's visual activity is presented as some totality of particular parameters. The assessment of visual activity using the additive function:

$$Э_{ЗД} = \sum_{i=1}^{n} a_i Э_i \,, \qquad (9)$$

where $a_i$ – "weighing" factors, the sum total of which should equal 1; $n$ – number of particular parameters under consideration.

With above conditions met, the visual activity efficiency $Э_{ЗД}$ stays within margins of 0 to 1 and represents the "coefficient of VIA efficiency".

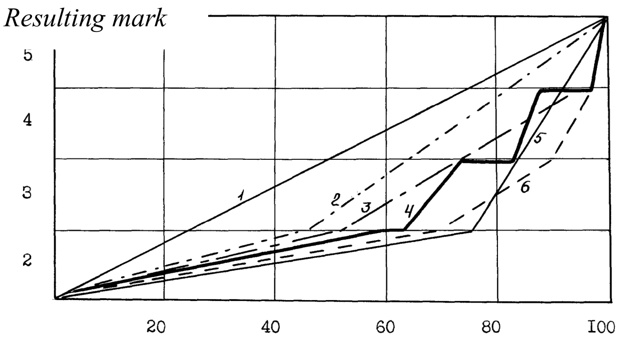


Fig. 1. Transfer scales
(from relative values to final marks):
1 – linear scale; 2 –5 – subjective scales;
6 – computer scale

***Conversion of the resulting data to specific marks.*** Conversion of the resulting data to specific marks is done using the marks scales (fig. 1). The most accurate scale 6 is used for automated operator training (computer-based) [2].

The efficiency of operator's activity assessment is significantly increased by the automation of the assessment process and marks calculation. The automation of assessment process allows the use of algorithms, specific criteria and mathematics, which rule out undesired subjectivity. The automation of the assessment process also allows to process vast amount of information promptly and thus to achieve real-time assessment of operator's activities.

One more important task is the control of acquiring and loss of skill by the operator in time (fig. 2) [2]. The above could be described by the equations:

$$I(t) = I_C - (I_C - I_H) \cdot e^{-\alpha t} \,; \qquad (10)$$

$$I(t) = I_C + (I_C - I_H) \cdot e^{-\beta t} \,, \qquad (11)$$

where $I_H$ и $I_C$ – correspondingly initial and stationary levels of operator's skills levels (judged by overall index); α и β – the rate of acquiring and loss of skills correspondingly.

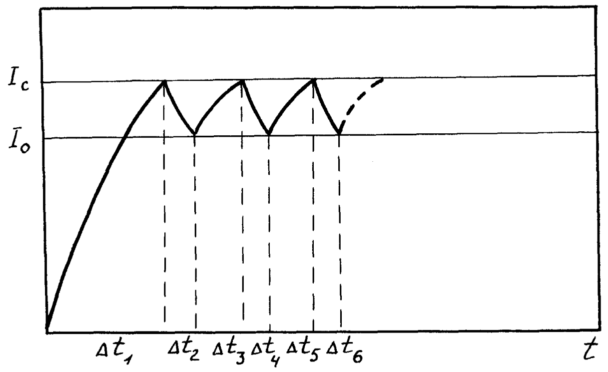


Fig. 2. Acquiring - loss of skill by the operator in time

## Conclusions

The implementation of methods for enhancement of visual information acquisition by the drive and methods for assessing the efficiency of visual information acquisition by the operator are two important directions for increasing the transport safety.

## References

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**Рецензент:** д-р техн. наук, проф. Н.Н. Дмитриев, Национальный транспортный университет, Киев.