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GUIDELINES FOR THE USE OF NON-STANDARD ROAD SIGNS – POLISH EXPERIENCES

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The aim of the paper is to present the procedure of non-standard road signs and markings implementation in Poland to improve road safety and traffic performance of road infrastructure. The authors investigated the following cases: road and its surroundings' perception and understanding improvement; warning of increased risk of accidents ; road works; speed management and ITS. The procedure was developed on the basis of interdisciplinary research, including: observation of drivers behaviour in real traffic; comparative crash analysis on sections with and without non-standard signs or markings; surveys on the understanding signs and marking; driving simulator experiments. As a result of the research, an implementation procedure for non-standard signs and markings, in the form of flowchart, was developed. In the designed procedure the following study of non-standard signs can be distinguished: questionnaire studies, eye tracking tests and driving simulator tests. The choice of the test method depends on the preliminary assessment of sign understanding, based on the results of the questionnaires. Moreover, thresholds for the declared understanding level, which determines the selection of additional tests to be done prior to the implementation of the sign, are given. The guidelines for conducting tests, analysis and monitoring of implementation were described as well.

*Keywords***:** road safety, non-standard road signs, driving simulator

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1. INTRODUCTION

The road users decision-making process depends to a significant degree on the perception of road infrastructure and space . If any perceptual distortions occur (e.g. physical, physiological or cognitive limitations), drivers' and other road users' decisions may lead to improper maneuvers. This may interfere with the traffic flow, but it might also result in collisions and accidents. Thus, measures that facilitate environmental perception of road infrastructure and space and assessment of vehicle movement, play an extremely important role. Among others, these measures include proper use of traffic signs and markings. This applies particularly to non-standard road infrastructure designs, locations with an increased hazard of accidents, areas of road works, places of adverse atmospheric phenomena, etc.

The variety of road designs and traffic situations sometimes requires the use of non-standard signs to improve safety and traffic performance. This applies to cases in which information provided by standard signs and markings (described in the applicable Polish guidelines) is not sufficient to properly understand infrastructure, traffic situation or do not cause the desired reaction. Thus, due to the unusual form or additional information elements, non-standard signs and markings may increase driver awareness in specific situations. Therefore, it can be hypothesized that in specific cases, of atypical forms of supplementary informative elements, may lead to increase drivers' attention, resulting in making correct decisions. However, such a hypothesis requires verification, and in particular, it necessitates answers the following questions:

- when is it justified to use non-standard signs and what conditions have be met to cause a positive effect on traffic performance and safety?
- what form should the non-standard signs take to make their information message understandable and cause the desired drivers' reactions?

Answering these questions is particularly important when making decisions regarding the widespread use of non-standard signs.

Study on the effectiveness of non-standard signs, together with an attempt to regulate the principles of its implementation, were undertaken in Poland as part of the research project " Experimental road marking in terms of behaviour of road users" (DZP/RID-I-36/5/2016) supported by the National Centre for Research and Development and the General Director for National Roads and Motorways. Selected results of this project, referring to practical recommendations for the use of non-standard signs, are presented in this paper.

In Poland, the pilot deployment and own studies on non-standard signs were preceded by case studies of its use in other countries. The results of these studies are the following insights:

- the use of non-standard signs in most cases includes: road markings as optical speed reduction means; inscriptions and pictograms on the road encouraging additional speed reduction; signs reminding about a general speed limit; signs on toll plazas; signs and markings on road works; additional "warning" signs and markings on horizontal curves [1-11];
- in many studies, the most effective non-standard signs were the transverse vibroacoustic strips. Their use resulted in a speed reduction of up to 12.5 km/h (30%) [2, 12];
- road markings in a form of "optical brakes" have proven to be effective for speed reduction measures [1, 2, 9-11, 13];
- non-standard signs can have a positive effect on the change of speed dispersion;
- the effectiveness of various forms of non-standard signs depends on place of application and local conditions. The same form of signs and markings may be effective or inefficient depending on local circumstances [13, 15];
- it is necessary to use surrogate safety measures in assessing the effectiveness of non-standard signs. Using only direct measures (e.g. number of crashes) often leads to ambiguous or erroneous conclusions regarding the impact of non-standard signs on drivers [13, 17];
- some of the previous studies indicate a decrease in the beneficial effects of non-standard signs on the driver behaviour. Thus, if a non-standard marking is used for a long time in one location, its effectiveness decreases, which may undermine the desirability of introducing non-standard signs [12].

Polish pilot research on non-standard markings covered the following cases:

- speed management signs, e.g. road markings with speed reduction functionality, warning signs or standard mandatory signs with additional content indicating the reasons for the restrictions. This group also includes signs informing about general speed limits, individual lanes restrictions, non-standard signs on horizontal curves (Figure 1a). "Pamiętaj" = remember;
- signs reducing the risk of rear-end collisions (speed limits and specific headways) (Figure 1b), "We mgle" = "In the fog"; "Obserwuj punkty" = "Watch points"; "Widzisz 1 (2) punkt(y)" = "You see 1 (2) point(s)";
- information signs in the area of road interchanges (inscriptions on the road identifying directions, road signs containing additional information facilitating the selection of the direction, signs identifying the interchange, signs facilitating the choice of the direction in emergency situations - detours, road signs restricting the possibility of lane change) (Figure 1c);

- signs facilitating queuing to toll booths (inscriptions or pictograms on the roadway identifying the purpose of the lane or informing about lanes with different payment method) (Figure 1d);
- signs informing about the purpose of additional lanes [18] or other elements on the road (Figure 1e), "Nie zmieniaj pasa" = "Keep lane", "Zjazdy" = "Driveways".

Fig. 1. Examples of non-standard signs and markings tested in Poland

2. STUDIES ON NON-STANDARD SIGNS AS BASIS FOR DEVELOPING GUIDELINES FOR THEIR USE

2.1. STUDY METHODOLOGY

Three groups of study methods were used to test the effectiveness of non-standard signs:

- surveys;
- real-conditions study ("before and after" studies, cross-sectional analysis including control groups studies);
- simulation study (driving simulator and laboratory tests regarding the perception of signs and markings, using an eye-tracking system).

The purpose of surveys was to focus on assessing the intelligibility of signs. This was achieved with reference to the declared potential road user's behaving manner, considering response to a specific sign. The survey took into account the substantive criterion, aimed at verifying the basic function of non-standard signs, which is to provide drivers with information that results in smooth traffic flow. Studies were carried out using surveys developed on the basis of ISO 9186-1 [16]. Also, individually developed surveys were used. They aimed at assessing the comprehension level of studied signs and markings, in reference with the personal characteristics of the respondents.

Research in real traffic took into account various measures of assessing the effectiveness of signs. They were selected regarding the expected result and the studied impact of the applied sign on the drivers. A summary of the proposed assessment measures is given in Table 1.

Studies in simulation conditions included tests in a driving simulator and laboratory tests of sign perception, using an eye-tracking system. Research using driving simulator (AutoSim AS 1200 with a 6 DOF motion platform) has been limited to selected signs, that in the survey obtained a low level of understandability, but there were premises to formulate the hypothesis that in "specific conditions" the effect of the sign on drivers may be effective. Such "specific conditions" can be mapped in the driving simulator. Studies in the driving simulator eliminate the risk of conflicts that could arise when trying to use signs with a low level of understanding in real traffic. In addition, analysis of "questionable" non-standard signs in a driving simulator enables their safe (without risking health and life) studies in various atmospheric conditions (e.g. snow, rain, fog), with different pavement conditions (e.g. slippery, icy, wet), times of the day, surroundings and in conditions that cannot be imitated in real traffic (e.g. sudden pedestrian intrusion into the road, forcing right-of-way).

The collected experience indicates the legitimacy of conducting studies in the driving simulator in relation to the following groups of road signs:

- prohibition and direction road signs;
- road signs with symbols suggesting unexpected maneuvers on the road (other than the purpose of using the sign);
- road markings other than "duplicating" road signs (e.g. speed limit).

In laboratory studies, using the eye-tracker, the driver's attention was focused on specific elements of the photo showing the selected road situation and the studied sign. Such studies gave the opportunity to compare several variants of non-standard signs, e.g. to assess the maximum amount of information that can be presented on a given sign and its location in the sign. The study using the eye-tracker was also aimed at eliminating sign patterns that could have caused a hazard by excessive driver attention.

Table 1. Summary of Exemplary Measures in the Initial Assessment and Monitoring of Non-Standard Signs

Purpose of Application	Possible Assessment Measure
Results	
Improving traffic safety by reducing the number of accidents	– total number of accidents – the number of accidents associated with the circumstances that should be eliminated by non-standard signs – collision concentration – accidents density
Improving traffic safety by reducing the number of accidents of a specific type or in a specific group of road users (pedestrians, cyclists, motorcyclists, etc.)	– number of accidents of a specific type – accident structure – the concentration of specific types of crashes – the accidents density of a specific type
Improving traffic safety by reducing the severity of accidents	– number of victims per 100 accidents – number of fatalities per 100 accidents – number of fatalities and seriously injured in 100 accidents related to specific circumstances, which should be eliminated by non-standard signs – accidents costs – the concentration of accidents of a specific severity – the accidents density of a specific severity
Improving traffic performance (also for a selected group of road users)	– traffic volume – generic structure of traffic – queues at intersection inlets and before service facilities – number of vehicle stops – lost time e.g. when crossing a designated road section – traffic density – share of vehicles moving in platoons – speed and its parameters
Reducing environmental nuisance associated with traffic	– noise emission – exhaust emissions – vibrations generated by vehicles
Effects	
Changing the road users' behaviour, potentially affecting the improvement of traffic safety (indirect measures of traffic safety)	– speed – the percentage of drivers exceeding the speed limit – values of speeds exceeding the limit – vehicle gaps – the number of traffic conflicts with reference to time or traffic volume – the number of "dangerous" manoeuvres with reference to time or traffic volume
Changing the road users' behaviour, potentially affecting the improvement of traffic performance	– free flow speed – vehicle gaps – the number of people using dedicated road facilities e.g. designated lanes
Increasing the level of understanding of traffic rules, especially in "difficult" locations	– share of people declaring a better understanding of traffic rules (from surveys)

2.2. SELECTED STUDIES AND THEIR RESULTS

This subchapter presents selected results of non-standard markings and signs effectiveness in real-conditions study and surveys conducted by authors.

2.2.1. QUESTIONNAIRE STUDY

The level of understanding declared in the research questionnaire on non-standard signs varied widely. In the survey took part 381 respondents, in different age groups and with different experience in driving. The results are as follow:

- for transverse strips (Figure 1a): 62% of correct answers. Cluster analysis of survey responses showed that the marking is correctly interpreted mainly by people who were already familiar with it. This group includes a large sample of truck drivers traveling over 40,000 km per year. Drivers aged 36-45, travelling less than 20,000 km per year, usually gave incorrect answers [17];
- for speed limit signs dedicated to selected lanes (Figure 1a): 24% of answers were correct. Although, the outcomes refer to standard speed limit sign used in non-standard way, the results were surprisingly low [17].

2.2.2. VEHICLE SPEED STUDY

Empirical studies on transverse strips combined with speed limit sign dedicated to selected lanes implemented on interchange (Figure 1a) ramp, fully confirmed the positive effect of non-standard signs on vehicle speed (Table 2) [17].

In comparison to the lanes without non-standard signs, the average speed on lanes with transverse strips and dedicated speed limit of 90 km/h was lower by 22.6 km/h (19.5%) on the left lane and 18.8 km/h (17.6%) on the right lane. This speed difference may partly be due to lane functions (through lanes - no marking, interchange ramp lanes – with non-standard signs). Additionally, a comparison with a control group with identical parameters, but without the use of non-standard signs, shows that the average speed on lanes with non-standard signs is lower than speed on control lanes by 16 km/h (14%) and 4.3 km/h (4.6%) respectively on the left and right lane. Results confirm the positive effect of non-standard signs implementation. However, on the lanes with a dedicated speed limit of 90 km/h, the 85th percentile of speed is significantly greater than the speed limit (by 22.7 km/h and 15.4 km/h respectively on the left and right lane) [17].

Table 2. Speeds on Approach to Interchange Ramp with Transverse Strips Combined with Speed Limit Sign Dedicated to Selected Lanes and Control Group

	Treated location (with transverse stripes and speed limit sign)				Control group – approach to interchange ramp	
	Approach to interchange ramp with non-standards signs		Through lanes without non-standards signs			
	Left lane	Right lane	Left lane	Right lane	Left lane	Right lane
Average speed [km/h]	97.3	88.6	120.9	107.4	113.3	92.9
85th percentile of speed [km/h]	112.7	105.4	140.5	124.1	142.8	105.9
Standard deviation [km/h]	20.01	18.63	25.84	23.15	28.73	19.03

2.2.3. ACCIDENT DATABASE STUDY

In research on non-standard signs, a simple comparison of the accidents number and non-injured accidents in the before and after periods were carried out as well [19]. Because of low number of injured crashes and other factors impact in the vicinity of toll plazas only comparisons for non-injured crashes are presented. An increase in the PDO (property damage only) crashes for 4 toll plazas (Figure 1d) was observed. The average number of collisions for all locations increased by 23.5% (317 and 393 collisions, respectively for the before and after period of 18 months). The analysis of the PDO crash circumstances does not show any significant changes in their structure (Figure 2). An increase in the number of PDO crashes occurs in groups with fewer circumstances. In the case of crash types (Figure 3), an increase in the accidents number can be observed for the after period in the group of side impacts and hitting obstacles. This may indicate distraction of the driver and inattention due to difficulties in understanding the signs. This was also accompanied by a significant decrease in the number of rear-end collisions. The observed changes in the circumstances structure and accidents types indicate an inconclusive impact of non-standard markings on road safety [19].

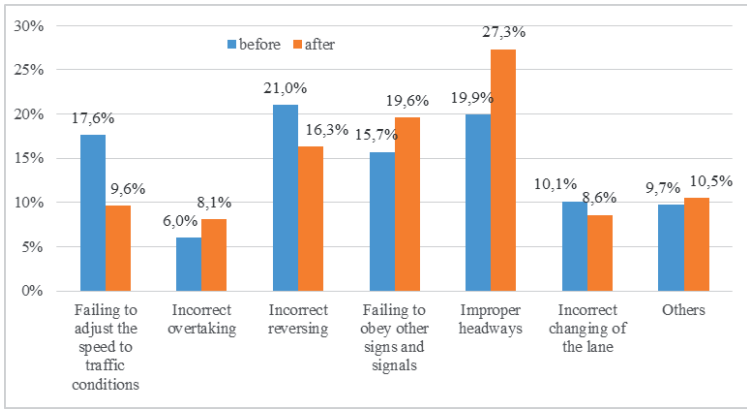

Fig. 2. The percentage share of PDO crash circumstances for the before and after periods

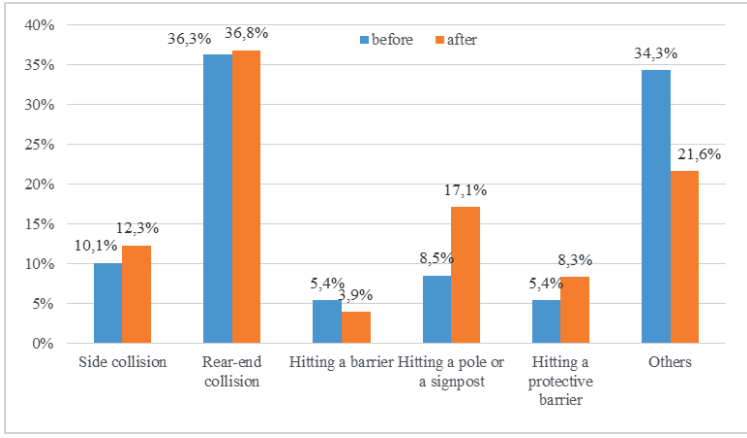

Fig. 3. The percentage share of the PDO crash types for the before and after periods

2.2.4. DRIVING SIMULATOR STUDY

Driving simulator research was conducted with AS 1200-6 high fidelity car simulator using the methodology provided in the earlier paper of authors [20]. The RSSQ method based on a questionnaire developed by Kennedy et al. [21] for monitoring of simulator sickness symptoms occurrence was applied. All non-standard signs and markings in the driving simulator considering differences in comparison to the reference scenarios (where standard or none signs were provided) were analyzed. The road route implemented in the driving simulator was similar to the real road

research conditions. After driving participants fill the questionnaire about the perception of used signs. 76 participants (31 female and 45 male) age between 18yo and 71yo took part in a study.
One of the conducted tests included non-standard marking of horizontal curves on a two-lane road. 3 Three horizontal curves were selected under real conditions, for which four scenarios (Figure 4) were used:

scenario 1. warning chevrons in changing sizes, increasing while approaching the road curve,

scenario 2. non-standard warning sign,

scenario 3. horizontal marking as an optical means of reducing the speed before the horizontal curve,

scenario 4. standard sign and marking.

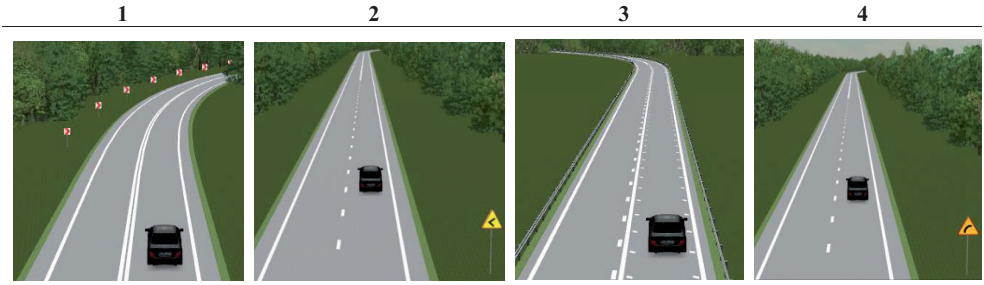

Fig. 4. Standard and Non-standard signs used on curves in the simulator experiment

To analyze differences in speed for individual curves with standard and a non-standard signs, the univariate intra-group ANOVA analysis was performed. Table 3 and table 4 presents the results of this analysis.

Table 3. Intra-object Factor and Error on Curves with Standard and Non-standard Signs

	SS	*df*	*MS*	*F* *	*p*	η^2
Intra-object factor	21116.43	4.81	4389.06	67.76	< 0.001	0.48
Error	23060.39	356.03	64.77	-	-	-

* – the Greenhous-Geisser correction was applied when the assumption of data sphericity was not met

The results show the statistical significance of the differences between scenarios. Based on results The post-hoc analysis for pairs of mean speeds was conducted. The results were shown in Figure 5. Next, the post-hoc tests for pairwise comparison of means were conducted. The mean speeds for each scenario of signing were shown in Figure 6. Post-hoc analyses using the Bonferroni test showed that the speeds in the condition of non-standard warning chevrons were statistically significantly lower than the speed in the condition of the additional non-standard warning sign ($p < 0.001$) and the

standard warning sign condition ($p < 0.001$). Besides, the speeds under the condition of the optical reduction means were lower than the speed under the condition of the additional non-standard warning sign ($p < 0.001$) and the standard warning sign condition ($p < 0.001$). Speeds in the condition of non-standard warning chevrons compared to speeds in the condition of optical reduction means did not show differentiation at the level of statistical significance.

Table 4. Speeds on Curves with Standard and Non-standard Signs

Type of non-standard sign/no of curve	Speed	
	M [km/h]	*SD* [km/h]
Non-standard warning chevrons		
Curve 1	79.03	14.49
Curve 2	78.10	15.81
Curve 3	83.31	16.01
Non-standard warning sign		
Curve 1	86.73	16.33
Curve 2	86.93	14.70
Curve 3	77.30	13.13
Optical reduction means		
Curve 1	83.99	16.24
Curve 2	70.99	13.37
Curve 3	87.25	16.93
Standard sign		
Curve 1	81.39	12.76
Curve 2	82.85	15.66
Curve 3	87.78	14.14

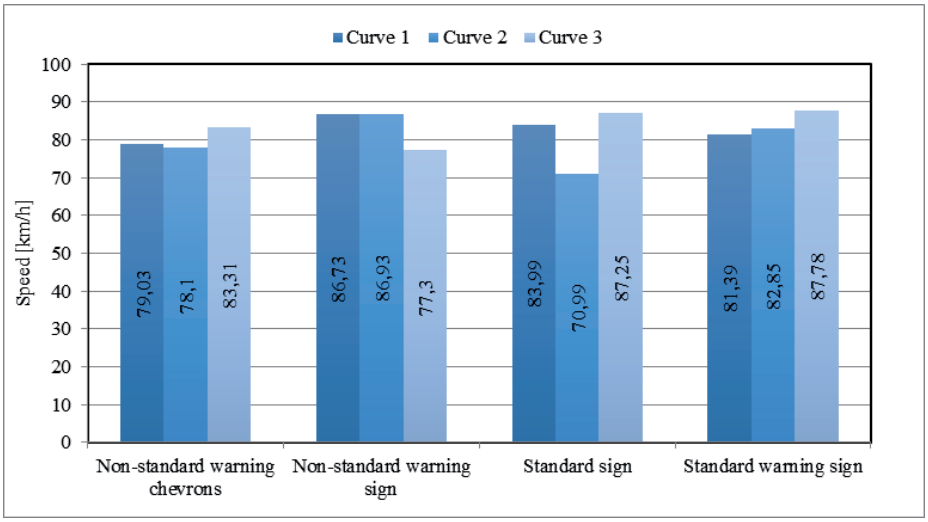

Fig. 5. Comparison of mean curve speed for different scenarios

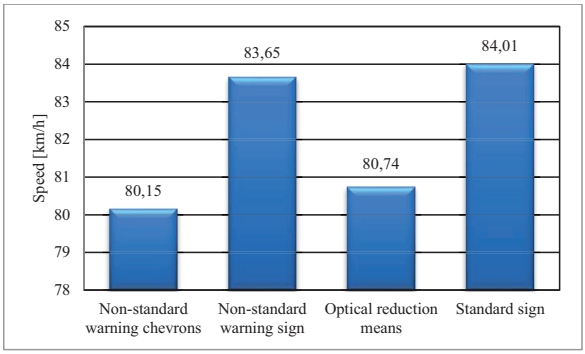

Fig. 6. Comparison of mean speeds within different experimental scenarios

Application of non-standard warning chevrons (scenario 1) and optical reduction means (scenario 2) results in the greatest, as well as statistically significant, reduction in speed of drivers in relation to standard sign (scenario 4, Figure 6).

2.3. PROCEDURE FOR IMPLEMENTING NON-STANDARD SIGNS

Non-standard signs, as a design used in exceptional situations, should be implemented only in special cases. At the same time, it was noted that such signs could fill significant gaps in the current way of providing information and in such situations could find wider application. Therefore, a procedure has been developed that may be used to control the implementation of the non-standard signs, so that it is used only in justified cases. This procedure also sets out the rules and criteria for assessing non-standard signs in terms of the possibilities and needs of implementing these signs in the foreseen standard signs and markings catalogue.

The following groups of possible cases of using non-standard signs were identified in the developed procedure:

- signs improving the perception of the road space and its understanding due to traffic rules. In such cases potential benefits (effects) include, among others: improving traffic flow, reducing the number of dangerous manoeuvres, choosing a lane without obstructing other road users, better adapting to traffic rules adopted in a given location;
- signs used for more efficient use of road infrastructure elements. In such cases potential benefits (impacts) include, among others: correct lane selection, even saturation of lanes, smooth traffic

flow, limiting the number of unnecessary and dangerous manoeuvres, better adaptation to traffic rules adopted in a given place, deviating from typical solutions;

- signs with a warning function in locations with an increased hazard of accidents where the perception of road and traffic space is difficult. In such cases, potential benefits (impacts) include, among others: adaptation of the speed to the actual level of hazard, reduction of the number of dangerous manoeuvres, better adaptation to the traffic rules adopted in a given place that deviate from typical designs;
- signs of speed management, including the non-standard use of speed limit signs; road signs and markings containing supplementary information on the desired speed; markings causing instinctive speed reduction. In such cases potential benefits (impacts) include, among others: speed adaptation to desired values in changing traffic conditions, increase in speed homogeneity, overspeeding reduction, reduction of the number of dangerous manoeuvres associated with sudden vehicle braking, increase in decision-making correctness (easier analysis of the traffic situation as a result of extending the time to make decisions);
- signs improving safety and traffic performance in particularly difficult circumstances. This applies to e.g. adverse weather conditions at different times of the year, visibility restrictions caused by a lack of lighting or fog, etc. In such cases, potential benefits (impacts) include, among others: speed adaptation to desired values in adverse traffic conditions and visibility restrictions, overspeeding reduction, maintaining safe gaps between vehicles or reducing the number of dangerous manoeuvres associated with sudden braking of the vehicle;
- signs in the areas of road works with an increased hazard of accidents. This applies especially to work zones with atypical traffic organization or carried out in adverse weather and traffic conditions. In such cases potential benefits (impacts) include, among others: speed reduction in work zones with increased hazard of accidents, reduction in speeds exceeding the speed limit; maintaining safe vehicle gaps, limiting the number of dangerous lane change manoeuvres or sudden braking of the vehicle, increasing awareness when driving through location with conflicts with the vehicles related to road works, earlier responding to commands from road work safety services;
- signs supplementing intelligent traffic management and control systems. The scope of this group of non-standard signs reflects the main purpose of its use, which is to improve the flow of information about the traffic performance and recommendations on road users behaviour. Potential benefits (impacts) are closely related to the type of used ITS non-standard signs, which is not yet defined but may relate to the functions of the signs groups listed above.

The procedure for analysing the appropriateness of implementing non-standard signs and determining the conditions for the practical introduction of such signs is schematically shown in Figure 7.

In the scheme presented in Figure 7, three main groups of actions can be distinguished regarding the following decisions in relation to the proposed non-standard signs:

1. Assessment of the need for the signs, adopting its form and approving pilot deployment or rejecting the proposed signs (blocks 1, 2 and 3);
2. Approval of pilot application specifying additional conditions for such use and an indication of the type of signs impact studies in real traffic conditions (block 4);
3. Removal of the studied signs after a set period or its preservation, recommendations for dissemination (blocks 5 and 6).

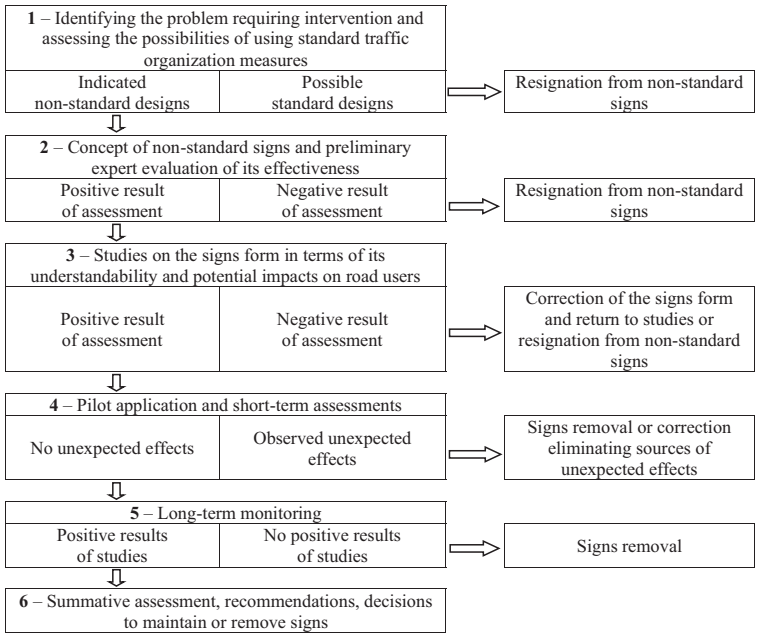

Fig. 7. Scheme of the procedure for analysing a non-standard signs

The most important notes to selected elements of the procedure, listed in subsequent blocks of the procedure presented in Figure 7, are given below:

Block 1 – a detailed analysis of the observed problems is required, justifying the need for non-standard measures to improve traffic performance and safety. It is necessary to explain why standard

traffic designs cannot be used. If a standard design can be used, further considerations about non-standard signs should be rejected.

Block 2 – the applicant presents a design of non-standard signs, i.e. its graphical form and location on the road. An application form is also provided for a detailed description of the prediction effects related to the implementation of non-standard signs. It is also necessary to indicate the basis for formulated predictions. The formalized application is subject to expert assessment. It was assumed that the new design of the signs should not:

- duplicate the meaning of other signs and markings already set in regulations (domestic and foreign);
- contain complicated or overly complex graphic or written information;
- be similar to existing signs and markings;
- be understood only by a selected group of road users, unless it is targeted at them;
- show similarities to identifiable signs and symbols occurring in the public space (e.g. trademarks, company logos);
- contain textual information if the intended information message can be expressed by graphic symbols.

Block 3 –the scope of studying the form of signs in terms of its understandability and potential impact on road users is determined in stages. The study begins with relatively easy surveys. If the level of understanding of the sign exceeds the required threshold in a given group of signs, the sign may be directed to pilot application. Otherwise, the sign may be examined with an eye-tracker or modified. The key issue in surveys is to determine the threshold values, describing the understanding of the sign. The following classification thresholds were adopted in the described procedure:

- A – satisfactory level with the declared level of sign understanding (over 70%);
- B – the average level at the declared level of sign understanding (50-70%);
- C – the low level at the declared level of sign understanding (25-50%);
- D – very low level - insufficient, with the declared level of sign understanding (below 25%).

The presented classification thresholds refer to the overall sign assessment. In the decision-making process, the sign acceptance thresholds for a pilot application depend on the used survey method and the procedure of processing the results. In the case of studies carried out in accordance with the ISO3864 standard (regarding warning, prohibition and direction signs), the required threshold for directing a sign for pilot application is stated at 85% of the understanding level of the sign [22]. For the remaining signs it is 67% [23].

The signs, that in the understandability studies will not reach the above thresholds but exceed the 40%, are directed to modifications and additional studies, including eye-tracking system. Only specific cases are addressed to driving simulator studies.

Block 4 - the technical characteristics and location of the non-standard signs must comply with the general requirements for standard signs and markings. An important element of the pilot application is the short-term assessment of its impact on road users. In this case, surrogate measures are used. The purpose of this assessment is to prevent any unexpected effects of using non-standard signs or to make adjustments that can improve sign efficiency. If the applied signs need to be modified, the procedures in block 3 are repeated.

Block 5 – long-term monitoring includes typical "before and after" or cross-sectional studies. The scope of study results from the adopted measures of assessing the effectiveness of implemented signs. A set of possible measures is given in Table 1.

Block 6 – based on the results of monitoring assessment, conclusions are made regarding the possible maintenance of the used signs. In addition, recommendations are made regarding the possibility of implementing the studied signs in another location. It is also possible to apply for including non-standard signs in the catalogue of standard signs and markings (change of national regulations).

3. CONCLUSIONS

The procedure for pilot introducing and studying non-standard signs described in the paper was developed to limit the use of non-standard signs in Poland only to the necessary cases. When such signs are needed, the presented procedure introduces uniform national rules for its application based on criteria of the necessity of application (Block 1), understandability in different phases (Block 3), technical characteristics (Block 4), impact on road safety in short and long-term periods (monitoring) (Block 5). Only selected values for rejection or acceptance of signs or marking are presented. Unfortunately, it is not possible to add all values of criteria because these depend on the study method (driving simulator, empirical, eye tracker, questionnaire), as well as, sometimes values for rejection or acceptance of signs or marking are relative.

Authors' studies on non-standard signs in Poland indicate the following problems related to the operating and assessment of these signs:

- used signs include those which declared level of understanding is very low (insufficient). At the same time, these signs in a similar or close form (e.g. directing to electronic toll gates, directing to detour roads) have already been used in other countries and have been positively evaluated.

This may indicate the need to organize dedicated information campaigns explaining the purpose of using certain non-standard signs. No such actions were carried out in Poland yet;

- in the group of tested signs, there were also standard signs and markings with non-standard locations (e.g. speed limit applies only to a selected lane). The low, less than 25%, level of declared sign understanding was surprising. Despite this, it was found that the sign was effective due to a real reduction in vehicle speed on the lanes it was located above;
- an example of a sign, with a large discrepancy between the results of the survey assessment regarding the level of understanding and the actual effectiveness, is the sign of so-called multi-functional lanes. The discrepancy between the survey assessment and the actual behaviour of drivers may result of the fact that the sign indicates the use of an additional lane, which is used only by local residents (permanent road users). This means that regular road users quickly assimilate the specific meaning of non-standard signs;
- in the studies on the effectiveness of non-standard signs, satisfactory results were obtained for some of the signs from the speed impact group. This may be caused by the fact that for these signs, respondents quite often confirmed that they had the opportunity to meet with similar signs on the roads;
- some of the used non-standard signs could not be assessed in real-world traffic conditions, as they related to exceptional situations (e.g. directing traffic to detours). In such cases, surveys and eye tracker surveys are of the greater importance. The purpose of the real traffic observation is to asses if such sign don't cause undesirable manoeuvres;
- it was confirmed that the complex graphics in the sense of symbolism usually reduce the level of its understanding. Despite this, in many cases, the positive impact of such a sign can be obtained with its gradual "learning".

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LIST OF FIGURES AND TABLES:

WYTYCZNE DOTYCZĄCE STOSOWANIA NIESTANDARDOWYCH ZNAKÓW DROGOWYCH – POLSKIE DOŚWIADCZENIA

Słowa kluczowe*: bezpieczeństwo ruchu drogowego, oznakowanie eksperymentalne dróg, symulator jazdy*

STRESZCZENIE

Celem artykułu jest przedstawienie procedury wdrażania eksperymentalnego oznakowania dróg w Polsce w celu poprawy bezpieczeństwa i warunków ruchu infrastruktury drogowej. Autorzy zbadali następujące przypadki: poprawa postrzegania i rozumienia infrastruktury drogowej wraz z jej otoczeniem; ostrzeżenie o zwiększonym ryzyku wypadków; roboty drogowe; zarządzanie prędkością i rozwiązania z zakresu Inteligentnych Systemów Transportowych. Procedura została opracowana na podstawie interdyscyplinarnych badań obejmujących: obserwację zachowania kierowców w ruchu rzeczywistym; porównawczej analizy zderzeń na odcinkach z niestandardowymi znakami i bez nich oraz porównań „przed i po" wprowadzeniu oznakowania; badań dotyczących zrozumienia oznakowania; eksperymentów z wykorzystaniem symulatora jazdy. W wyniku przeprowadzonych badań opracowano procedurę wdrażania oznakowania eksperymentalnego, którą przedstawiono w postaci schematu blokowego. W zaprojektowanej procedurze można wyróżnić badania oznakowania eksperymentalnego, w tym: badania ankietowe, badania okulografowe oraz testy na symulatorze jazdy. Wybór metody badawczej uzależniony jest od wstępnej oceny stopnia rozumienia znaków przy użyciu badania ankietowego. Ponadto podane są wymagania, dla deklarowanego poziomu zrozumienia, które determinują dobór dodatkowych badań do wykonania przed wdrożeniem znaku. Opisano również wytyczne dotyczące przeprowadzania badań, analiz i monitorowania oznakowania w rzeczywistych warunkach drogowych.

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