Regulatory legal and technical confirmation with the risk analysis while mounting ITS (intelligent transport systems) auxiliary equipment or replacing power units

O I Girutskiy\(^1\) and K A Kirillov\(^2\)

FSUE "NAMI", Moscow, Russian Federation

E-mail: \(^1\) giruzki@nami.ru, \(^2\) kirillov_kirill@inbox.ru

Abstract. This paper contains the analysis of materials and propositions for expert assessment of technical regulations in the automotive industry in case of design modifications by mounting the perspective technical equipment: computer vision, navigation systems, auxiliary equipment, on-board and stationary systems for modeling traffic conditions and traffic control. The international integration in the economy allows to establish the unified principles and mandatory safety requirements for standardization, metrology, accreditation, conformity assessment, monitoring (control), as well as for eliminating the technical barriers in commerce. The system of technical regulation in Russian automotive industry is built according to the international harmonized requirements for ensuring the road traffic safety. An illustrative registration procedure algorithm to introduce design modifications at the stage of operation in the Russian Federation is shown by infographics. An independent professional multi-stage check of the design safety is adapted to the modern realities and allows supporting the vehicle owners' technical initiative. The application of risk-oriented approach, unified forms and the methodology is another step in the improvement of the regulatory and technical basis in the field of the automotive industry. The paper gives commentaries to the effective national legislation, the summary dwells on the prospects of further scientific research. The article also presents information about the preparation of the national regulatory legal acts which are to establish relations in motor vehicles operation controlling. The analysis of the risks related to the vehicles design safety and security of road traffic is provided in details.

1. Introduction

The world level of road transport safety significance (TSS) is determined by sad statistics of road traffic incidents and accidents. According to the researches made by the safety institutions of the European Union countries, Japan and the USA, together with the results of studies conducted by various automobile companies, about 30% of all fatal accidents are caused by the loss of controllability and stability during braking [1]. Nowadays the Russian park of wheeled vehicles is approaching 60 million units. Annually there occur more than 2 million road accidents in the Russian Federation [2]. At that, the official tragic statistics covers only those that result in deaths and injuries. In Russia the main reason for more than 3% of accidents is a technical malfunction [3]. According to the data of Russian Federal Center for Forensic Expertise of the Russian Federation Ministry of Justice, the structural faulty elements that cause accidents could be presented statistically as follows: braking control system - 48.4%; steering system - 28%; chassis and transmission - 8.7%; wheels and tires - 9.4%; lighting devices and
electrical equipment - 1.6; other - 3.7% [4]. Thus, the condition of braking and steering systems has the greatest impact on the road safety system throughout the entire park of operating vehicles. Therefore, the greatest potential damage associated with the death and injury of people as a result of an accident can be associated with the wrong interference in these systems.

From the terminology point of view, this interference is named a design modification or re-equipment (tuning), which is carried out both before the use of the component or in its operation. So, according to the current technical regulations, making changes to the installation or re-equipment of components which had not been provided by the design of the vehicle before its release into operation and affect road safety is an exception from the rules [5].

Changes to the design of vehicles in the Russian Federation, their "re-equipment" over the past 10-15 years have become widespread. Every year, the technical supervision departments of traffic police of the Russia Ministry of Internal Affairs issue 200 thousand safety certificates of vehicles conformity to safety requirements. It is estimated that the number of vehicles in which design changes have been made is at least twice higher, and there is a steady upward trend in these indicators.

The main reasons for a necessary "modification" are:
- insufficient number and diversity of vehicles manufactured by industry for intended purposes;
- an unfavorable economic situation in most of the enterprises operating motor vehicles, which does not allow them to order expensive specialized rolling stock and forces them to "modify" available vehicles;
- rather a long service life of the vehicles in operation, while the production of a considerable number of them has stopped;
- the stoppage of production and the supply of automotive components for a number of types of vehicles, primarily of a foreign make.

In practice, the modification of the design (re-equipment) is the adaptation of a wheeled vehicle to:
- specific conditions of transport work (operation);
- specific types of passenger and/or cargo transportation (specialization);
- individual needs and tastes, in order to optimize (improve) the technical parameters, characteristics and economic indicators to satisfy the end-user’s wishes for using a unique design ("stylization" or “customization”);
- extention of the existing vehicle life while ensuring road safety, in spite of the absence of components not produced any longer [6].

The changes in the electronic control units of the vehicle, which lead to a change in the control algorithm provided by the program code, are equated to the introduction of modifications in the design [7].

Thus, the modification (re-equipment) makes a material and / or informational impact on the vehicle design safety and in case of ADAS (Advanced Driver Assistance Systems) installation, it has an impact on the active safety, that is the systems of braking and steering. In this case, as interference in these systems leads to the most unfavourable consequences, it should be officially authorized.

The exception is the case of installation of technical (additional) equipment that passed the conformity assessment as part of the type. Otherwise, for example, if changes are made to the design before its being released, the manufacturer or an official representative is required to conduct certification tests according to UN Regulation No. 10 with regard to electromagnetic compatibility as part of a complete vehicle and re-register the modified type. Afterwards a certificate of conformity for spare parts is issued according to a new complete set or a negative certification decision for a specific component is made.

2. Main part
Generally, experimental scientific developments (innovations) of Universities are carried out on vehicles in operation, registered in the traffic police, while tests are made at closed test sites. In such cases, there are difficulties with the delivery of testing equipment, as it is an unauthorized design modification which, according to the traffic rules, is subject to administrative punishment and results
in a ban on the vehicle operation until the modification is eliminated.

In this article, we consider the longest stage in the life cycle of automotive products - their operation.

The modified systems must have legal and technical confirmation, that is, when installing technical means of perspective transport vehicles the structure safety requirements must be met and checked, namely: technical vision, navigation systems, additional equipment, on-board and stationary systems for modeling traffic conditions and traffic management, multimedia and computer equipment, communication equipment and their fasteners, security alarms, means of protection against unauthorized use of a vehicle, emergency call devices, other equipment of ADAS systems, the safety requirements for the design, such as unhindered access, the elimination of accidental or incorrect operation or failure, data protection, attachment reliability, identification and diagnostic capability, visibility, injury safety, fire safety, electromagnetic compatibility, electrical safety, cyber security. The requirements allow to estimate correctness, serviceability and interface operation of additional systems by monitoring them with minimal cost and time, and it should be done during the check of technical condition at the point of technical inspection.

The automotive industry designs and manufactures a huge number of components, including auto electronics. At the moment, the objects of technical regulation subject to mandatory conformity assessment include the following vehicle components: the tachograph, speed limiting device, electronic control unit, emergency call device, satellite navigation equipment and some others. "Vehicle components" are the components of the vehicle’s construction, delivered to the manufacturing assembly plants as replacement parts for vehicles in operation.

Therefore, according to the certification rules, conformity certificates must be issued for these components.

In addition to the components certification conformity provided by technical regulation in Russia there is a Decree of the Government of the Russian Federation of September 26, 2016 N 969 "About approval of requirements to the functional properties of technical means of transport security provision" and "Rules of mandatory certification of technical means of transport security provision", according to which a wide range of technical systems and means of notification, access control, inspection, intelligent video surveillance, video recording, audio recording, reception and transmission of information, notification, collection and processing of information used to ensure transport security is subject to certification in Federal agencies, for example: FSB — in relation to systems and tools of screening, intelligent video surveillance of the Ministry of Internal Affairs of Russia in respect of systems and alarms, access control, audio and video recordings; the Ministry of the Russian Federation for civil defense, emergency situations and elimination of consequences of natural disasters in relation to the means of notification; Rossvyaz — in relation to communications, transmission and reception of information; the Ministry of Transport of Russia — in relation to information collection and processing systems.

The installation approval procedure for vehicles with a high degree of operating autonomy is carried out in accordance with the Decree No. 413 of 06.04.2019 of the Government of the Russian Federation "On approval of Rules changes in the design of operating wheeled vehicles and the follow-up to verify compliance with the requirements of technical regulations of the Customs Union "On safety of wheeled vehicles". Developed previously interstate standard GOST 33995-2016 “Motor vehicles. The procedure for assessing conformity assessment after the retrofitting” and approved by Rosstandart of September 21, 2017 No. 1194-st with administrative aspect has a voluntary character [8] (Figure 1). At the moment, the Ministry of internal Affairs of Russia is developing administrative regulations to provide public services for the registration of permits and certificates. The current regulations include individual transport vehicles making changes to the design, since a unified approach is used to assess the installation of additional equipment on both conventional vehicles and ITV.

The list of modification types in the design is not exhaustive and is determined by the level of scientific and technological development of society and its expanding needs.
There come issues of providing methodological support and development of standards. A comprehensive program for developing standards for automotive products of the future until 2025 involves the development of a number of current ITS standards (about 100 standards) based on ISO, SAE, UN Regulations, GOST R and PNST, as well as of new ones, for example: “Motor vehicles. Safety requirements for the technical condition and methods of vehicles inspection with a high degree of control automation” [9].

So, the unauthorized changes to the design of the vehicle should be detected when its technical condition is checked at the point of regular technical inspection. An example is “chip tuning”, which is gaining popularity, but its regulatory and technical confirmation is not properly implemented. A preliminary technical examination should be made to assess the state of delivered vehicles by means of diagnostic tools and identify the state of the electronics before making changes, and then determine the modification procedure according to the developed criteria.

Market leaders for ADAS systems are manufacturers such as Bosch, Continental, Valeo, Magna, Denso, Delphi, ZF, Avtoliv, Takata and others. A non-profit organization of European car manufacturers is testing ITS applications, V2X communication technologies, and the consortium includes well-known car manufacturers and component suppliers. Collective creativity has several advantages, but there are also disadvantages associated with joint responsibility.

Particular attention should be paid to cyber security, as the rest of the above requirements are typical of traditional wheeled vehicles, the test methods of which were established earlier.

As part of the development and testing of cyber security of technical means, including intelligent systems, standards and instructions are applied: practical recommendations of SAE, international standards ISO, DEF STAN (Defense Standards), NIST (National Institute of standards and technology (USA)) and others. The list provided is not exhaustive. Other standards and guidelines may be applied. In our point of view, it is advisable that, with respect to specific technologies or processes, corporations should review all applicable standards or guidelines that may be relevant to the process, as well as any new standards developed in this area to improve road safety. Thus, devices should be controlled considering both existing and new standards. Of course, the topic of modification (re-equippment) and road safety is typical not only of our country, but is also widespread abroad. International approval of the wheeled vehicles usage is of utmost importance in view of ensuring maximum safety for all road users. For the convenience of vehicles owners in countries from Australia to Europe, practical
information about the engineering assessment of re-equipment of motor vehicles has been prepared including technically possible modifications of vehicles, and, if possible, subsequent registration procedures by making notes in identifying documents based on current national legislation [10].

Accredited persons conduct individual inspections of a specific complete vehicle, including the necessary studies with the help of certified measuring instruments and certified software, by identifying the components used and technical inspection. As a result of examinations, all changes made to the vehicle are listed, at that only approved components and positive results of the technical inspection are used.

On the basis of documents received from experts and containing information on assessing the results of individual technical creativity, as well as of re-equipment in accordance with the requirements of road safety, car owners apply to the authorities of the area to carry out registration actions in the documents identifying vehicles. For this reason, it is necessary to ensure proper control in this area.

All safety requirements must be properly tested before being permitted to participate in road traffic on public roads.

For example, according to the American media, during the certification tests, the US Federal Aviation Administration (FAA) granted broad authority to assess the safety of Boeing itself, as a consequence, two planes crashed, which raised questions about the objectivity of the tests. A similar practice was used in certification of other liners. In case of small batches certification of wheeled vehicles, the current technical regulation allowed the use of the internal factory tests results and the 7D declaration scheme was applied. Thus, we can conclude that having a permit for internal testing is not enough and requires independent examination and testing in an accredited testing laboratory for the standard ISO/IEC 17025.

As part of a legal experiment in Russia, Yandex conducts tests of autonomous vehicles and implements a project for assessing the first vehicle with autonomous control system based on Toyota/Hyundai passenger cars on public roads. In this case, there is a need for regulatory and technical confirmation of changes to the design, according to the above algorithm. Therefore, the Yandex drone is passing the necessary tests at the test site in the NAMI Test Center.

An example of equipping a vehicle with technical means is the creation of a universal multiservice platform (UMP) for buses, electric buses and trolleybuses. The purpose of the creation is the use of innovative technologies to monitor passenger flow using modern navigation and multimedia equipment in a perspective passenger vehicles with various power plants. This system involves the unification of exterior and interior modules, which allows to reduce the time and financial costs for the production, maintenance and repair of machines, to reduce their curb weight and, thus, achieve improved environmental performance. When retrofitting parks of buses in operation, a regulatory and technical confirmation procedure will be required.

It is also worth noting that the metrological component of technical means assessment of perspective transport is also important. For example: technical means of controlling drivers' modes of movement, work and rest (tachographs) are a measuring instrument and are registered as measuring instruments.

As in the TR CU 018/2011 the requirements for the location navigation error and speed of the vehicle are determined formally as the measurements provided by the Russian Federation legislation of technical regulation belong to the state regulation sphere of measurements uniformity in accordance with the rules prescribed in the Federal law from 26 June 2008 № 102-FZ, part 4 of article 1,, "On ensuring the uniformity of measurements"

In accordance with part 1 of art. 9 of the Law No. 102-FZ in the state regulation sphere of ensuring the unity of measurements, the measuring instruments have been approved and verified in accordance with the requirements of this Federal law. The compliance with the mandatory requirements established by the legislation of the Russian Federation has been ensured and established concerning the unity of measurements, including mandatory metrological requirements for measurements, measuring instruments to be used, and established by the legislation of the Russian Federation on technical regulation of mandatory requirements.

The risk analysis of the introduced metrology testing component into the accuracy determination of coordinates and speed of movement with the purpose of approving and verifying the measuring
 instrument type (the primary and repeatedly used in operation) shows that the introduction of these requirements is associated with risks of different nature (legal, organizational, technical, economic, reputational).

Periodic verification of technical means installed on the vehicle in operation will make it necessary (which is most appropriate from the point of view of providing "one window" services) to combine this procedure with periodic technical inspection of the vehicle at the relevant technical points. The approach, in turn, will require the additional accreditation of each point of technical inspection to verify the unity of measurements. Namely, it will require the providing of each point with necessary testing equipment and technical means and methods of verification without dismantling the vehicle, as well as competent technical specialists. There is also a more complex option of independent preliminary search of metrological services and timely verification or calibration.

With regard to the world experience in the application of the problem under consideration, the following can be noted. For example, the UN Regulation No. 144 developed on the initiative of Russia in respect of emergency call systems (devices) establishes requirements for the accuracy of determining coordinates using Global Navigation Satellite System signals, but they are not considered by the Rules as measuring instruments and they are not subject to "metrological" forms of conformity assessment - tests for the type approval of measuring instrument, as well as their verification.

At the same time, in the course of timely maintenance and repair of technical means, a set of operations is implied:

- to confirm or update the data set stored in the memory: vehicle identification parameters and special characteristics of individual devices (sensor parameters, vehicle technical specifications, and other characteristics of the vehicle, etc.);
- to adjust (if necessary) the current time values and odometer indications.

A "third" package of amendments to TR CU 018/2011 is being prepared for vehicles in operation, which clarifies a number of the above terms, partially simplifies the procedure for re-equipment and introduces a number of requirements for typical cases of making changes to a vehicle design, and also specifies requirements for checking the technical condition in operation.

In addition to TR CU 018/2011, two more regulations are applied in the EAEU: TR CU 004/2011 Technical Regulations of the Customs Union "On the Safety of Low-Voltage Equipment" and TR CU 020/2011 Technical Regulations of the Customs Union "Electromagnetic Compatibility of Technical Means," but we need to note that TR CU 004/2011 is not applied to electrical equipment designed for use on land transport, while electromagnetic compatibility is tested under UNECE Regulations No. 10 and in accordance with the Treaty on the Eurasian Economic Union of May 29, 2014, when mandatory requirements for products may be imposed exclusively by the Union technical regulations.

According to the bill, part of the supervisory reform, the changes made by the "regulatory guillotine" do not extend to road safety control. At the same time, in the context of control and supervisory activities, the Government of the Russian Federation made a list in which the road safety priority was stressed and which included 45 working groups together with the head department of the Ministry of Internal Affairs and the Ministry of Transport and Rostransnadzor head department. The list also covered: road transport: Rostransnadzor (Ministry of Transport, Ministry of Internal Affairs, Rosavtodor) and conformity assessment: Rosaccreditation (Ministry of Economic Development, Ministry of Industry and Trade, Rosstandart). The principle of operation groups was based on the implementation of the "Road map" to bring to life "regulatory guillotine" and was built in three stages:

1. determination of the objects that should be generally excluded from the list of supervised;
2. analysis of risks that will be controlled by the new regulatory system;
3. formulation of the risk management method.

From our point of view, the risk-based approach should influence not only the frequency of inspections, but also the composition of mandatory requirements, licensing activities and administrative responsibility for non-compliance and elimination of duplication of inspections by various departments.

For automatically controlled wheeled vehicles there exist the following traditional risk operations associated with the vehicle design: - the occurrence of an accident and the severity of the consequences;
- fire; - environmental damage to the environment; - theft; - electric shock; - interference with the operation of electronic equipment; - technical failure of elements (components) affecting road safety; - poor-quality work (services) on maintenance and repair, and also on modification of a design and additional: - geo-location errors, data loss, improper interaction with the driver (remote operator), unauthorized interference with the control system and technical failure [11].

The greatest aftermaths of an accident are buses, especially when transporting children, cars carrying dangerous goods, cars with gas equipment. In operation these vehicles are subject to more frequent checks. Table 1 presents a risk-based approach matrix for some types of retrofitting and identifies the resulting risk. For the conditional quantitative analysis we will accept five levels: - extremely high - "5"; - high - "4", - moderate - "3", - low - "2", - insignificant - "1" (Table 1).

| Type of vehicle modification | Probability of an accident due to system failure during conversion (probability of occurrence) (V) | Indicator of severity of social potential negative consequences (public response) (T) | Number of appeals with this type of conversion (N) | Total risk (potential danger) (R) |
|-----------------------------|-------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------------|----------------------------------|
| Braking system              | 5                                                                                               | 1-2                                                                           | 2                               | 10-20                            |
| Steering                    | 5                                                                                               | 1-2                                                                           | 1                               | 5-10                             |
| Into bus                    | 1                                                                                               | 5                                                                             | 2                               | 10                               |
| ADR                         | 2                                                                                               | 5                                                                             | 3                               | 30                               |
| Gas equipment               | 4                                                                                               | 3                                                                             | 5                               | 60                               |
| Uninstallation of seats     | 1                                                                                               | 1-2                                                                           | 3                               | 3-6                              |
| Body kit 4x4                | 2                                                                                               | 2                                                                             | 3                               | 12                               |
| Replacing the engine        | 1                                                                                               | 1                                                                             | 3                               | 3                                |

Thus, the following formula is used in the processing of group expert evaluation of objects during direct evaluation:

\[ R = \sum_{i=1}^{n} (V_i \times T_i \times N_i) \]  

where \( n \) is the number of possible types of structural changes. If there is only one type of design changes, the range of the total risk is from 1 to 125. Based on this approach, you can make a rating and schematically present it in a three-dimensional form as a surface with a gradient fill, where the color changes from green to red in terms of danger (Figure 2). The total risk is proposed to be divided into two groups: up to 30 and over 30, for increased attention when assessing the possibility of making changes to the design.

A risk-based approach in assessing the impact of changes in vehicle design on road safety during the control and supervision activities of the traffic police may be the subject of further research in case of collecting reliable statistics. For a detailed assessment it will be necessary to use the multi-measuring experiment of the State traffic inspectorate and to collect statistics on the following parameters: the number of yearly issued approvals, the vehicle types, the number of refitted vehicles in operation, the detailed analysis of a forensic examination results if re-equipment provoked or exacerbated the consequences of an accident.
Figure 2. - Risk assessment for certain types of modification.

Only a systematic analysis will allow us to move from the total control to selective control and risk management, in which the intensity and volume of the checks by controlling organizations depends on the potential risk of harm level to the life and health of citizens. The work will help to compile the annual risky rating of organizations (technical inspection point, car service station, accredited persons) and determine the frequency of planned monitoring activities.

The input data for studying danger impact issue of re-equipment can be various classifications of both the main structural elements and additional equipment and their related properties.

By structural elements: - brake system; - steering; - lighting equipment; - glazing and mirrors; - wheels; - engine; - other; - weight and overall parameters; - reliability of additional elements;

By properties: - braking properties; - sustainability; - manageability; injury safety; - traction and speed properties; - visibility; - fire safety; - visibility in the dark; - evacuation ability; - environmental friendliness; - stability of the operation of ITS elements; - registration of vehicle motion parameters; - cyber-security; - software updates and security aspects of integrated electronic systems.

Naturally, there is a risk associated with the quality of work (services) in the system: - component manufacturer; - servicing; - diagnostics at a technical inspection point; - expertise by an accredited person. It is worth noting that the position of the manufacturer and servicing is more or less clear, the situation with checking the technical inspection remains risky since at present, in many cases the control of the technical condition is not factually carried out.

In accordance with Part 1 of Article 27 of Federal Law dated December 28, 2013 No. 412-FZ “On Accreditation in the National Accreditation System”, the federal state control over the activities of accredited persons is carried out using a risk-based approach, while in accordance with paragraph 5 of Part 2 of Article 5 Federal Law No. 412-FZ accreditation is based on the principle of voluntariness. At the moment, one of the main risks is ensuring impartiality. Thus, even the expert organizations that have long existed on the certification market, do not exclude the possibility of personnel actions leading to risks though they are minimized due to multi-level control. Using a unified approach to the examination of the vehicle design amendments allows ensuring the objectivity and independence of the procedure.

3. Conclusions

1. In most cases when retrofitting by installing additional equipment or replacing the existing units there is an improvement of technical parameters and characteristics, at that the risk depends on operating conditions and specialization. In case of using certified components, providing quality services when replacing and installing components as well as assembling additional equipment followed by the proper inspection, the modification, as a rule, is safe, which is confirmed by the final certificate.

2. Complicated work is to be done to improve regulatory and technical documents, taking into account a risk-based and verified approach in accordance with current and future standards together with the rejection of inspections duplication.
3. Based on existing experience, internal testing does not always guarantee the required safety and therefore independent expertise is required.
4. The application of a unified approach will improve the level and quality of inspections, and will make the basis for the collection of reliable statistics.
5. The costs of control and supervision activities may be higher than the prevented potential damage, therefore, a preliminary assessment of the socio-economic effect, that is the cost of administrative resource and obtaining useful result, is required.
6. One of the possible directions for the development of expert activity is the notification of expert organizations (inspection bodies).

References
[1] Bakhmutov S V, Endachev D V, Mezentsev N P 2018 Development of intelligent driver assistance systems (ADAS) in the Russian Federation Transport systems, 4 17–21 Information on https://www.transport-systems.ru/images/2018/2018_04_003.pdf
[2] Information on the state of road safety in the Russian Federation for 2018. Information on https://stat-gibdd.ru/
[3] Kirillov K A 2016 Regulatory prospects and some monitoring results of the vehicle design and its technical condition in operation Trudy NAMI 265 66–75
[4] Kapustin A V 2016 Technical inspection as an element of vehicle safety Report at the plenary session of the 95th international scientific and technical conference AAI at the Dmitrov autopoligon Information on: http://autoengineer.org/meropriyatiya/materials/konferenciya-aai-95.html
[5] Information system "Techexpert: 6 generation" Intranet. Information on http://lab2.cntd.ru/
[6] Kirillov K A 2016 Regulation of requirements for the transport vehicle safety in the Eurasian economic Union (EAEU) in case of design modifications. Trudy NAMI 266 63–72
[7] Kisulenko B V, Gusakov N V, Bocharov AV, Shchepkin A I, Mironov A A, Anikeev S A 2015 Technical regulation in the automotive industry. Conformity assessment procedures. Moscow, 256 p. ISBN 978-5-9906820-6-1
[8] Girutsky O I, Kirillov K A 2017 The new standard on the administrative aspect of registration of changes in the design of the vehicle. Izvestiya MGTU "MAMI" 34 83–92
[9] Comprehensive program for the development of standards for automotive products in the future until 2025.: Information on: https://www.gost.ru/portal/gost/
[10] Kirillov K A 2016 International experience in conformity assessment concerning safety requirements of vehicle design, including in operation. Trudy NAMI 267 61–70
[11] Kisulenko B V 2017 Normative legal regulation of vehicles with a high degree of control automation: strategy and tactics of implementation in Russia. Report at the international automotive scientific forum MANF-2017. Information on: http://iasf.nami.ru/about/archive/2017/programm.php