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UML DIAGRAMS OF THE MANAGEMENT SYSTEM OF MAINTENANCE STATIONS

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Abstract. *Vehicle uptime is becoming increasingly important as transportation solutions become more complex and the transportation industry looks for new ways to be competitive. Traditional fleet management systems are gradually being extended with new features to improve reliability, such as better maintenance planning. Typical diagnostic and predictive maintenance techniques require extensive experimentation and simulation during development. This is not possible for the entire vehicle as it would require too many engineering resources. The developed diagrams presented in the article reflect the processes that take place at service stations. Various factors affecting quality and speed, such as the availability or ordering of spare parts, were taken into account when developing the service charts. With the help of the proposed diagrams, the client can independently decide whether to use the services of an authorized car service. Before using the services of a car service, it is advisable to familiarize yourself with the information presented on the website. This will help you choose a car service that meets all your expectations in terms of professional assistance. It is worth looking for a service station combined with an inspection station. Then you can fully check the performance of the car.*

Keywords: car, modeling, automation, service station

SCHEMATY UML SYSTEMU ZARZĄDZANIA STANOWISKAMI UTRZYMANIA

Streszczenie. *Sprawność pojazdów staje się coraz ważniejsza, ponieważ rozwiązania transportowe stają się coraz bardziej złożone, a branża transportowa szuka nowych sposobów na zachowanie konkurencyjności. Tradycyjne systemy zarządzania flotą są stopniowo rozszerzane o nowe funkcje poprawiające niezawodność, takie jak lepsze planowanie konserwacji. Typowe techniki diagnostyki i konserwacji predykcyjnej wymagają szeroko zakrojonych eksperymentów i symulacji podczas projektowania. Nie jest to możliwe w przypadku całego pojazdu, ponieważ wymagałoby to zbyt wielu zasobów inżynieryjnych. Opracowane diagramy przedstawione w artykule odzwierciedlają procesy zachodzące na stacjach. Przy opracowywaniu kart serwisowych wzięto pod uwagę różne czynniki wpływające na jakość i szybkość, takie jak dostępność lub sposób zamawiania części zamiennych. Za pomocą proponowanych schematów Klient może samodzielnie podjąć decyzję o skorzystaniu z usług autoryzowanego serwisu samochodowego. Przed skorzystaniem z usług serwisu samochodowego wskazane jest zapoznanie się z informacjami prezentowanymi na stronie. Pomoże to w wyborze serwisu samochodowego, który spełni wszystkie oczekiwania w zakresie profesjonalnej pomocy. Warto szukać stacji obsługi połączonej ze stacją kontroli. Wtedy będzie można w pełni sprawdzić osiągi samochodu.*

Słowa kluczowe: samochód, modelowanie, automatyka, stacja obsługi

Introduction

In today's world, owning a personal vehicle is very convenient and comfortable, as it eases the problem of transportation and saves time. However, along with the convenience of owning a vehicle, there can also be problems related to technical malfunctions. Regular technical inspections and maintenance are necessary to ensure long-term functionality and safe operation.

The problem is that many drivers do not always have access to quality and reliable technical service. This can lead to unforeseen costs, road accidents and other problems.

Another problem is the lack of understanding by users of the processes involved in the operation of forecourts.

The benefits of our diagrams are convenience and clarity, providing a detailed description of all the processes that take place in the business.

1. Literature review

In the work [12], the operation of automobile service stations and the possibilities for their optimization in the context of the country's current economic challenges are examined. The study explores foreign experiences in implementing high-quality automotive services. It has been established that with the increase in the number of vehicles, the need for creating new and maintaining existing technical service enterprises grows.

The authors of the work [8] consider three groups of factors that influence the operation of car service stations: 1) unmanaged (location and regional features); 2) managed (nomenclature of services and specialization of service stations, number of production workers; number of posts, total area of service station premises); 3) partially managed (quality of work performed, price policy of service stations, qualification of production personnel, configuration of production premises, time of creation of service stations). A well-founded practical approach in choosing and expanding the specialization of a car maintenance station, which took place in conducting a survey of car owners – questionnaires or using the results of expert assessments. The relationship between the uncontrollable factor "demand/demand for auto service services" and the controllable factor "service nomenclature and service station specialization" is established. The scheme of the most advanced configurations of the placement of car service stations is presented, and it is found that the most optimal is a straight building, which makes it possible to use the space for the repair area as much as possible. It is justified and practice shows that the location of service stations on the central streets of cities is impractical due to their negative impact on street traffic and the architectural style of the car service building.

The components and interrelationships of factors affecting the functioning of car service stations are clarified. It was established that at the initial stage of operation of service stations, the main factor is the need of car owners for car service services. The results of the performed research can be used by car service stations both at the initial stage of activity and at the expanded range of car service services provided. For service stations, recommendations are given regarding: choosing the location of the service station, the need to use the results of a questionnaire of car owners and expert evaluations of the service station, the importance of selecting qualified personnel.

In work [4], the authors analyzed the structure of car maintenance stations, taking into account modern approaches and technologies in the field of car maintenance and repair services. Ways of forming a rational structure of technical service stations, ensuring high quality of service provision and a high level of customer satisfaction are proposed.

The authors of the paper [2] proposed a UML diagram of the activity of a car shop and service management system, which shows the flows between the activities of service delivery, shop, cars, and payment. The main activities involved in this UML activity diagram of the car store and service management system are as follows: service delivery, delivery activity, store activity, car activity, payment activity. The Login Activity Diagram of Automobiles Store and Service Management System, shows the flows of Login Activity, where admin will be able to login using their username and password. After login user can manage

all the operations on Store, Services, Delivery, Payment, Automobiles. All the pages such as Delivery, Payment, Automobiles are secure and user can access these page after login. The diagram below helps demonstrate how the login page works in a Automobiles Store and Service Management System. The various objects in the Payment, Store, Services, Delivery and Automobiles page – interact over the Activity, and user will not be able to access this page without verifying their identity. The Use Case Diagram is a graphic depiction of the interactions among the elements of Automobiles Store and Service Management System. It represents the methodology used in system analysis to identify, clarify and organize system requirements of Automobiles Store and Service Management System. The main actors of Automobiles Store and Service Management System in Use Case Diagram are: super admin, system user, mechanic, customers, who perform the different type of use cases such as Manage Automobiles, Manage Store, Manage Customers, Manage Services, Manage Charges, Manage Delivery, Manage Payment, Manage Users and Full Automobiles Store and Service Management System Operations.

In this paper [1] deals with the problem of detection of some automobile fault type and causes; repairing or maintaining an automobile through the use of expert system; and finding an alternative to replace human expert in automobile repair and maintenance. This system was designed for the detection of various automobile fault based on the efficient utilization of the past design experiences of the designer. An expert system is a computer system that emulates the decision-making ability of human expert. It was designed to solve complex problems by reasoning about knowledge base. They are represented primarily by if-then rules. The expert system was designed using Microsoft Visual C# programming language as it is an object-oriented type and has supports for generics and functional programming paradigms. For easy interaction with the user, graphic user interface (GUI) of the system was designed using window presentation framework (WPF) from Microsoft in order to achieve fluid and vector based on the interaction of the system with the user. This system works accurately during the process according to the various classes of fault presented to the programmer. This expert system saves time and energy needed by car owners and human expert in diagnosing, repairing and maintaining a vehicle.

The authors of the work [9] the scheme of interrelations between components of values of projects of creation of motor transport enterprises and hybrid projects which they realize is offered. The affiliation of the values of hybrid projects of motor transport enterprises for stakeholders is substantiated. It is established that there are causal links between the values of hybrid projects of motor transport enterprises (volumes, terms, timeliness, etc.). By changing these relationships, you can create the maximum system value for a given project environment and minimize their risk. Based on the proposed approach, it is established for a given design environment (Mustang Trans LLC) that the risk of obtaining the desired value is minimal at the planned system value, which is in the range of 0.1 … 0.25 Euro/km. The obtained results are the basis of substantiation against risky measures and increase of efficiency of acceptance of administrative during realization of hybrid projects of motor transport enterprises.

The article [3], using the method of hierarchy analysis and probabilistic method, identifies and determines the contribution of risks. The factors that form the risks of road transport enterprises' activities are defined for these types of enterprises. It has been found that the application of the hierarchy analysis method is a more time-consuming process and provides a deeper analysis of each risk. The probabilistic method is easier to apply, but it requires a high qualification of experts who will assess the risks. The results of surveys conducted by road transport enterprises indicate the application of elements of a risk-oriented approach. The availability of risk information makes it possible to implement appropriate precautions not only within an individual enterprise, but also on a more global scale.

2. Researches methodology

When studying the operation of a vehicle service station, particular attention should be paid to the process of transitioning equipment from the use phase to the repair phase. This aspect is critical to improving maintenance efficiency, which in turn allows for longer and more reliable vehicle operation.

The use of Unified Modeling Language (UML) [6] can fundamentally change this approach, as UML provides the tools for creating detailed diagrams that can reflect all aspects of the operation of car service stations. The application of UML allows tracking data flows and processes at each stage of service provision, from order acceptance to its execution and final quality control. Such modeling can significantly improve the understanding of internal processes and, as a result, contribute to the optimization of work procedures and overall efficiency. For instance, detailing diagrams for different departments can reveal redundant steps that delay customer service. In turn, this will provide greater transparency of processes and facilitate their simplification and acceleration.

The advantages of using UML are many. First of all, it is a formal language with a precise semantics. Secondly, it is widely used and understandable by both business people and software developers [7].

Any vehicle maintenance services do not provide detailed schemes and diagrams of their work. They offer a general list of services or a superficial scheme. Several diagrams have been proposed that reflect the processes of car service stations. The first diagram demonstrates the service operation (Figure 1).

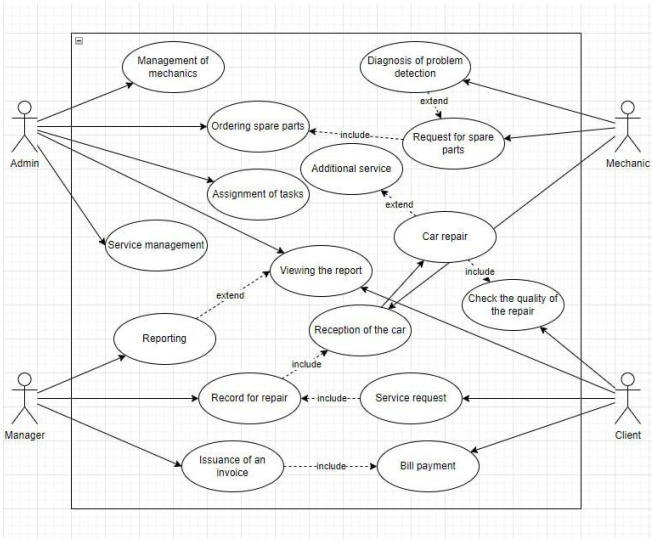

Fig. 1. Diagram of precedents for displaying the work of the car service station

The use of use case diagrams effectively illustrates the various ways users can interact with the service station. The diagram is a visual representation of possible interaction scenarios, specifically describing the actions that users can perform while using the station's services. For a deeper understanding of these processes, Table 1 is used in the work, detailing the interactions between actors (process participants) and use cases (defined interaction scenarios).

When studying the operation of a service station, particular attention should be paid to the transition process from the usage phase to the repair phase, as this allows for improved service efficiency and ensures longer and more reliable operation of the equipment. Repair work [11] begins with diagnosing problems that arose during operation and determining the optimal plan for their resolution. Therefore, a smooth transition between these two stages is crucial to prevent unnecessary downtime and reduce repair costs. Optimizing the transition process from one state to another requires clear communication among all participants in the process, as well as the use of modern diagnostic and repair techniques.

Table 1. Description of the car service station workflow diagram

Administrator	Manages mechanics be assigning tasks to them, orders missing spare parts and managers the service center
Mechanic	The mechanic receives the car, conducts diagnostics, repairs it, and installs additional equipment if necessary
Customer	Makes a service request, pays and checks the quality of repairs
Manager	Enrolls the client for repairs, issues an invoice for payment, and prepares a report for the administrator

3. Results

Thus, to clearly illustrate the mentioned processes, we used a state diagram. It demonstrates the interaction of each element of the vehicle with others, which can help improve the repair process by identifying key touchpoints and opportunities for enhancing service efficiency (Figure 2).

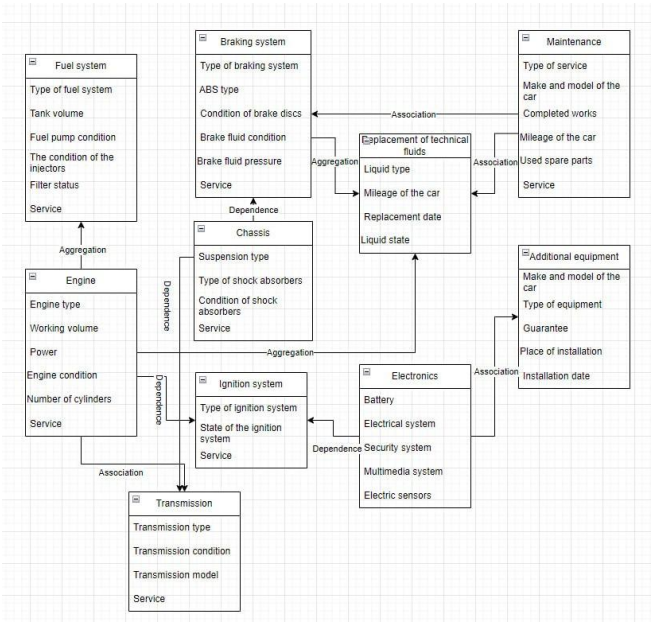

Fig. 2. State diagram for demonstrating the dependence of car elements

A detailed description of the components is provided in Table 2.

Table 2. Description of car components and their interaction

Engine	Engine repair and maintenance, including replacement of parts, adjustment of the ignition system, replacement of belts, gears, pistons, etc.
Fuel system	Repair and maintenance of the fuel system, including replacement of the fuel pump, filters, injectors, fuel pressure adjustment, etc.
Transmission	Transmission repair and maintenance, including transmission oil changes, repair or replacement of clutches, reducers, connecting rods, etc.
Chassis	Repair and maintenance of the chassis, including replacement of shock absorbers, wheel bearings, steering rods, adjustment of the steering system, etc.
Braking system	Brake system repair and maintenance, including replacement of brake pads, discs/drums, brake hoses, brake cylinder service, etc.
Ignition system	Ignition system repair and maintenance, including replacement of spark plugs, ignition coils, wires, sensors, etc.
Electronics	Repair and maintenance of electronics, including diagnostics and restoration of electrical systems, repair of computer units, security systems, multimedia, etc.
Maintenance	Scheduled maintenance, including changing oil, filters, checking the condition of parts and systems, adjusting, cleaning, etc.
Replacement of technical fluids	Replacement of fluids in cooling systems, brake system, transmission, engine, etc.
Additional equipment	Installation, repair and maintenance of additional devices, such as navigation systems, rear view cameras, alarm systems, video recorders, etc.

Diagnostics [5, 10] at service stations is a critical step that precedes any repair or maintenance. This process involves a thorough inspection of the vehicle, the use of specialized equipment and software to identify faults and assess the overall condition. The purpose of diagnostics is not only to identify the symptoms and causes of problems, but also to prevent future breakdowns that may negatively affect the efficiency and safety of vehicle operation (Figure 3).

A more detailed description of the diagnostic process is presented in Table 3.

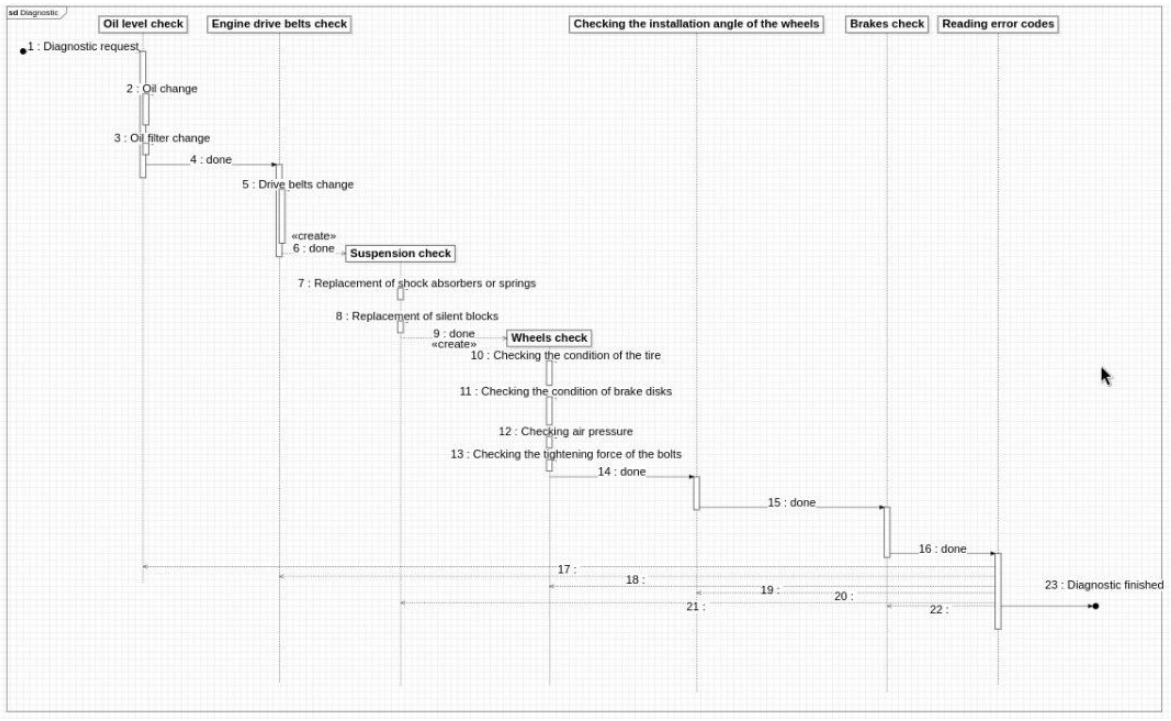

Fig. 3. Sequence diagram to demonstrate the diagnostic process

Table 3. Description of the components of a sequence diagram for displaying processes

Checking the oil level	Checking the level of motor oil in the engine to ensure its proper level and quality, which is critical for proper engine operation.
Checking engine drive belts	Inspect and assess the condition of the drive belts that provide the driving power in the engine system for signs of wear or damage.
Checking the suspension	Checking the condition of suspension components such as shock absorbers, springs, tie rods and bearings to determine if they need to be replaced or adjusted.
Checking the wheels	Checking the condition of the wheels, including tire wear, tire pressure and correct balancing, for safe and efficient operation.
Checking the angle of installation of the wheels	Checking the angles of the wheels to ensure the correct stability, handling and wear resistance of the tires.
Checking the brakes	Inspection and testing of the brake system to detect any problems such as worn brake pads, leaking brake fluid or damaged parts.
Reading error codes	Using diagnostic equipment to read error codes from the vehicle's electronic control systems that may indicate potential problems or malfunctions.

No one can guarantee that a particular part needed to repair a vehicle will be in stock or in working order. We have the unique opportunity to look under the hood of the parts ordering and inspection process at a service station (see Figure 4).

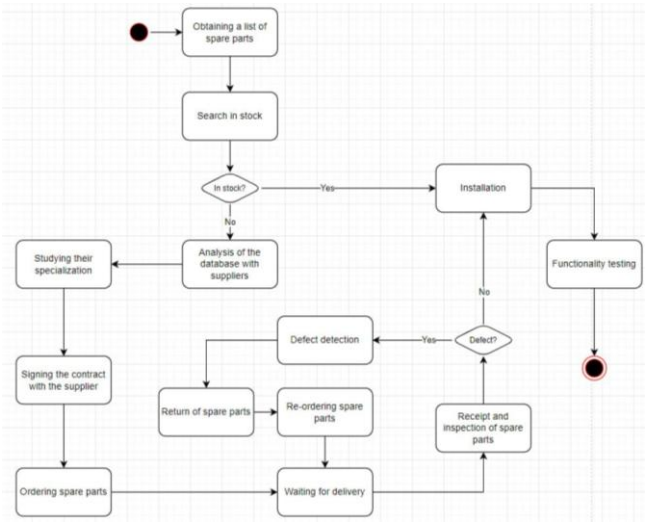

Fig. 4. Activity diagram demonstrating the parts ordering process

From the start of the search for components to the moment they are installed and tested, each step is carefully analyzed to ensure seamless operation and high quality service.

The proposed diagram describes the entire chain of events, starting with the receipt of the list of required parts, through their search and stock analysis, to the critical analysis of data with suppliers, leading to the ordering of the required parts. The process then continues with delivery control, followed by receipt and inspection of the parts, and finally their installation and testing. Such detail not only improves the understanding of the service station's operations, but also identifies potential points of delay and inefficiency, providing opportunities for optimization. A more detailed description is given in Table 4.

The previous diagram shows the path of the part from the moment of receiving the request to its installation in the car. There are many different suppliers in the auto parts market that offer their range. Spare parts may vary in quality and price. The diagram shows the various ways to choose a supplier (Figure 5).

For better understanding, Table 5 describes the actors of the diagram.

Table 4. Detailed description of the parts ordering process

Obtaining a list of spare parts	Obtaining a list of spare parts that need to be replaced or purchased for repair work
Search in the warehouse of the technical service station	Checking the availability of spare parts in the own inventory of the service station or car service
Analysis of the database with suppliers	Analysis of information about suppliers of spare parts in order to choose the most profitable or reliable ones
Studying their specialization	A detailed study of the specialization of suppliers and their assortment of spare parts
Signing a contract with suppliers	Conclusion of an agreement with selected suppliers, which regulates the terms of supply and other important aspects of cooperation
Ordering spare parts	Placing an order for the necessary spare parts from selected suppliers
Waiting for delivery	Waiting for the delivery of the ordered spare parts to the car service or service station
Inspection of spare parts	Inspection of the delivered spare parts for damage and compliance with the ordered
Return of spare parts	Return of unusable parts to supplier in case of failure or defect
Installation	Installation of purchased spare parts on a car or vehicle in need of repair
Functionality testing	Conducting testing to check the functionality and correct installation of spare parts

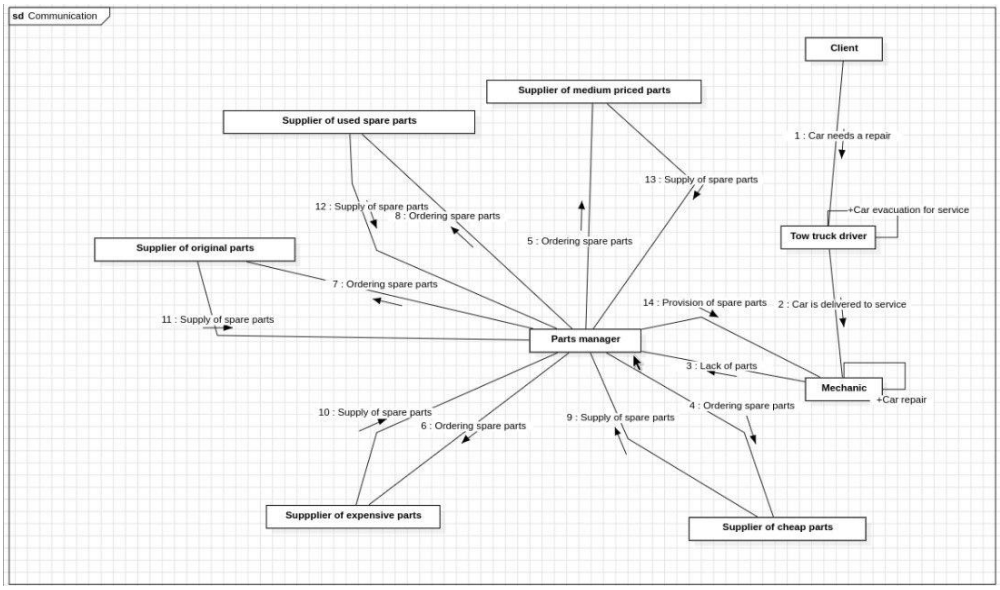

Fig. 5. Communication diagram to demonstrate the supplier selection path

Table 5. Description of diagram actors

Spare parts manager	A person responsible for the management of spare parts stocks in a car service or service station. His responsibilities include inventory management, ordering new parts from suppliers, interacting with customers and mechanics.
Client	A person who applies to a car service or service station for the purpose of obtaining repair or technical services. The client can order spare parts, make inquiries about the condition of his car and pay for the services provided.
Provider	An organization or company that supplies auto parts. The supplier can be a manufacturer or distributor of spare parts. Their responsibilities include supplying spare parts, handling shipping issues and providing technical support.
Tow truck driver	This is a specialist who drives a tow truck and transports vehicles in need of repair or breakdowns to a car service or other place for further maintenance.
Mechanic	A professional specialist who repairs and services cars. Mechanics diagnose problems, correct malfunctions and replace spare parts in order to restore the technical condition of the car.

4. Conclusions

Information systems design is one of the most important stages in software development. In order to create a highquality and effective information system, it is necessary to use special tools and methods, such as UML diagrams. The work presents various diagrams that reflect the processes of service stations. The case diagram provides a clear overview of how a maintenance station works from a software development perspective. This diagram shows how the service station is organized and helps developers quickly understand the components used to develop software. It takes into account many components of a service station, such as service personnel, customers, services and vehicles.

A car is a complex mechanism that contains many parts. In general, they are divided into several main components: body, chassis, transmission, control system and electrical equipment. All these auto parts interact with each other, forming a single system. Mostly, drivers do not need to remember in detail what the structure of the car consists of. However, knowing the basic design elements of the machine will allow you to operate it safely and correctly identify the malfunction. In turn, the state diagram shows the dependencies between the elements of the car. In order for driving to be comfortable and safe, it is desirable to know the general description of the car, as well as to regularly check the condition of its parts. This will make it possible not only to detect the malfunction correctly and in time, but also, in some cases, even to eliminate it yourself.

To better visualize the area covered by technical diagnostics, a sequence diagram is proposed. Diagnostic information makes it possible to optimize the technological process of restoring the quality of a specific car based on knowledge of its true technical condition. Car diagnostics is an important stage of its maintenance. It allows you to identify potential problems in the early stages and prevent their development. This can save time and money on car repairs in the future. An activity diagram and a communication diagram were used to demonstrate the process of ordering spare parts and their delivery. Diagrams were developed in such a way that it was visually and intuitively understandable for everyone. It is designed so that a user without experience working with similar systems can easily navigate the system environment and find the product he needs.

A modern car service in many countries of the world has at its disposal a wide-ranging and welle-stablished network of enterprises, both for servicing cars and for trade, spare parts and materials for them, as well as their storage. The socioeconomic significance of the car service lies in the fact that it is an integral part of the road transport system, regardless of the form of its ownership. Thanks to the car service, regularly using its services, the multimillion army of car owners ensure the operational efficiency of their cars, are provided with the necessary spare parts and materials, receive reliable information regarding the technical operation of cars and their trade, which is an important social factor in the growth of the welfare of the country's population. In the future, the following development tasks will be solved: Introduction of technical maintenance and repair processes, based on modern innovative approaches; Implementation of new methods and means of diagnosing the technical condition of the car. Development of recommendations for maintenance and repair of motor vehicles.

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