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SIMULATION TESTS OF FLEET VEHICLES PERIODIC INSPECTIONS TIMELINESS: A CASE STUDY

Summary. This study analyzed the case of a medium-sized workshop and the income from servicing individual customers. The management of the company observed some unused potential in the garage and plans to sign contracts with fleet customers for comprehensive maintenance of their vehicles. The key question was how many fleet vehicles could be additionally serviced without losing individual customers? In this work, a simulation model of a workshop was developed, treated as a system for queuing orders and vehicles. The model includes a subsystem of random generation of fleet vehicle mileage during the simulation. The idea of event-driven simulation and the Matlab/Simulink SimEvent environment library was used.
Keywords: fleet vehicles, periodic inspections, event-driven simulations

1. INTRODUCTION

Presently, companies with fleets of vehicles rarely have their own technical facilities that allow them to perform periodic inspections and repairs. It is common practice to outsource this type of service and sign contracts with specialist workshops [14, 17, 18]. When the fleet is

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unified in terms of brand or the vehicles are leased, inspections are usually carried out by authorized workshops of the vehicle manufacturer. Smaller companies with a diverse fleet usually look for local universal workshops.

The issue of periodic technical inspection is important in the case of fleet vehicles, as they usually have daily mileage of hundreds of kilometers. Periodic inspections are therefore performed very often, usually several times a year. Timely performance of periodic technical inspections, consisting of the replacement of fluids, filters, worn parts and visual inspection of the vehicle has a huge impact on maintaining the good technical condition of the vehicle [11, 19]. This translates into a reduction in the failure rate of the equipment, increasing road safety [9, 20]. It should also be mentioned here about the possibility of using new non-invasive vehicle diagnostic methods [5-8].

The relationship between a customer, his vehicle and the workshop can be described through the queue theory using queues (FIFO and priority queues) and servers imitating service work or waiting for a service [12, 24]. Most of the parameters and state variables of the customer-vehicle-workshop system are random. The mileage of vehicles based on which decisions on the inspection are made increases randomly. The events taking place in the system are also random, for example, issuing an order for a service or starting and ending a service. The assessment of the quality of the client-vehicle-workshop system operation can be obtained by the Monte Carlo method [16] by randomly generating events and observing the behavior of the system and the average values of state variables.

The described problem can be modeled using the event-driven simulation method [3, 4, 23]. Event-driven simulation methods are commonly used to solve tasks related to broadly understood customer service [2]. Many available computer programs enable this type of simulation [1, 10, 13, 15, 21]. The chosen tool for this work was the SimEvent library of the Matlab/Simulink environment [22, 25]. The choice of the modeling tool was determined by the high flexibility of the Matlab language, which significantly facilitated the programming of the elements of the customer-vehicle-workshop system, the creation of which is not supported by the SimEvent library itself.

The model of workshop operation developed by the authors, together with the simulation of fleet mileage, will be used to assess the workshop's potential in the field of technical inspections and repairs. The use of queuing theory elements and event-driven simulations in modeling the elements of the queue allows creating a realistic environment reflecting reality. The conducted simulation tests make it possible to detect any unfavorable phenomena in the operation of the workshop, for example, in the form of blockages and critical delays in the provision of services. The research will also make it possible to make the most favorable decisions for the company.

2. FORMULATING THE DECISION PROBLEM

This study examines the case of a medium-sized workshop that currently serves only individual customers. In the near future, signing contracts with fleet customers for comprehensive vehicle maintenance is being considered. Such a step would primarily provide the company with a steady stream of orders for its services, and also enable the plant to maximize its current unused capacity.

Based on the company's history, it can be stated that on working days an average of 8 individual customers visit the garage daily. Average service time is 4 hours. The workshop has 4 fully equipped and staffed workstations that work shifts for 10 hours a day. This means that, on average, 32 hours are used out of the 40 working hours available in a day.

This 20% of the unused potential of the workshop could be filled with services for fleet customers. Especially in the case of fleet customers who usually use their vehicles quite intensively, most of the services will be periodic vehicle maintenance. As a rule, activities related to periodic maintenance take less time than vehicle repairs.

However, signing contracts with fleet customers is associated with the need to ensure appropriate high standards of services. In this case, the speed of reaction to the breakdowns of fleet vehicles and short waiting times for periodic inspections and technical services are particularly important.

Of course, the company wants to retain its existing individual customers. Therefore, services performed for fleet customers cannot significantly affect the level of individual customer service. Therefore, it is difficult to introduce absolute priority for fleet customers.

The developed model of the workshop operation and the simulation tests performed on it should answer the following questions:

1. *What is the actual level of untapped potential of the workshop?* Due to the random nature of individual customer vehicle applications and random service times, the rough calculation of free capacity presented above does not have to be true. In addition, there is a constant flow of time, which means that the "lost potential" in a given day cannot be recovered due to a randomly smaller number of reports. Therefore, it is necessary to carry out a kind of "stress test" that will allow to determine the maximum number of individual customers that can be served by the workshop.

2. *What is the maximum number of fleet customers that can be served?* Assuming that the number of individual clients is at the previously mentioned level. It can be predicted that the results will largely depend on the selected analyzed set of fleet vehicles and the accuracy with which their basic features will be determined:

- vehicle make/model and the resulting maintenance frequencies, as well as their time and scope;
- average daily mileage of vehicles and standard deviation of mileage (assuming normal distribution truncated from left to zero).

3. *What strategy to reserve time in the work schedule of the workshop to choose?* Two possible strategies are considered. The first is to reserve time after the occurrence of an incident involving the vehicle exceeding the mileage limit or the time limit for scheduled maintenance. The second is to reserve time in advance based on the vehicle's mileage forecast or the number of days remaining until the service deadline is exceeded. The first strategy, assuming the equal treatment of fleet and individual customers, will involve systematically exceeding the limits. In the case of the latter, there is a high risk of prematurely performing the service, which will probably not be appreciated by the fleet customer.

3. SIMULATION SCENARIO

This paper adopted the following scenario of the workshop operation described below, which has a direct impact on the structure of the simulation model and the scope of empirical data that should be collected before performing the simulation tests.

First, it is important to define the relationship between *the real time* and *the time step* and *simulation time*. It was assumed that the work of a workshop would be simulated during one calendar year. Additionally, it was assumed that a fifteen-minute accuracy is sufficient to describe the duration of all essential activities. Vehicle waiting times and service times will be measured with such accuracy. Further, maintenance includes both periodic maintenance and repairs resulting from the wear of parts or their failure. This means that 1 second of simulation (time unit) will be equivalent to 15 minutes of real time.

The workshop is open on weekdays for 10 hours from 8.00 to 18.00 and on Saturdays for 6 hours from 8.00 to 14.00. To simplify the simulation scenario, it was assumed that one real-time day is 40 steps of the simulation time (working day). Non-working days are excluded and automatically excluded from the simulation time. Due to this simplification, the vehicles waiting in the service server modeling the workshop stands will not be completed outside the workshop's working hours, and all unfinished vehicles on a given day will naturally pass to the next day. This way, there is no need to stop the server so that it does not count down outside workshop hours. Saturday is a special day. In the simulation, it lasts the same as other working days with the servers working 10 hours. On Saturdays, however, work is planned for only 6 hours. This is true to some degree, as, on Saturdays, the workshop often stays open longer to complete the rest of the week's repairs.

Tab. 1

Summary of simulation times

Simulation Time	Real Time
1	15 minutes
40	One working day of the workshop (10 hours)
$\boldsymbol{40 \cdot N_w}$ **-** total simulation time	One-year period, excluding non-working days ($N_w \approx 303$)

Orders from individual clients appear at random intervals in the simulation time. It was assumed that this is done following the exponential distribution with *the average interval for individual vehicles*, which can be determined based on the workshop operation history. The estimated time of service performance is also drawn for each order. In actual conditions, this time is estimated based on an interview with the client and preliminary examinations made by the shift manager. It was assumed that *the forecast service time* has a normal distribution. The *actual service time* may differ from the forecast and is the sum of the forecast and a random disturbance also with a normal distribution. The service times cannot be simultaneously shorter than the assumed minimum (for example, 2-time units). The parameters of both normal distributions must be established based on the historical data of the workshop operation.

During the simulation, the fleet vehicles form a static set numbered consecutively from one to the *maximum number of fleet vehicles*. For each fleet vehicle, information should be collected on the model, its total mileage in kilometers, average daily mileage and standard deviation of the mileage. The daily mileage is assumed to follow the normal distribution truncated from left to zero. Daily random mileage is rounded to whole kilometers. During the simulation, the mileage and age of the vehicle will be constantly modified every day.

However, for each vehicle model, additional information on the periodic technical inspections should be specified: after how many kilometers or days maintenance should be performed and the estimated time of such inspection. In this case also, the estimated time will be randomly different from the real time.

There are three scheduled maintenance intervals for each vehicle model. The maintenance activities of the higher range include activities of all the lower ranges. Therefore, after performing the service of a given range, the mileage counters in kilometers and days should be reset, together with the counters of the lower ranges.

Fleet vehicles can also experience breakdowns that the workshop should fix as soon as possible. With intensive use of fleet vehicles, maintenance activities will occur much more often than breakdowns. To simplify the model, it was assumed that breakdowns of fleet vehicles are treated regardless of their technical services. They represent a certain disruption of the process that occurs in the system in time intervals subject to exponential decay with the *average failure interval of the fleet vehicles.* In connection with the failure events, they will be numbered consecutively and will not be related to the numbers of fleet vehicles. Distinguishing between fleet vehicles, breakdowns and vehicles of individual customers requires an additional parameter - status.

Each order requires time reserved in *the workshop's work schedule*. The schedule covers all the days in the calendar year and all service stations in the workshop. Holidays and Saturday afternoons are not available. Each service must be started and completed on one station. During the booking process, the work schedule is searched from the day following the day of reporting to find the first continuous and free period of time greater than or equal to the forecasted service time. Services for individual clients, the duration of which is longer than the assumed minimum, may start at the end of one working day and end the next. Services for fleet customers should start and finish in one working day (inspections usually take less time than repairs). Failures do not require booking a place in the workshop and go directly to the workshop.

To simplify the model, it was assumed that customers do not resign from previously agreed service dates and report to the garage promptly. In the future, the model can be supplemented with this type of additional random disturbance. Individual customers may cancel the reservation if the proposed free date is too distant (for example, exceeds 2 weeks). This does not apply to fleet customers referred for periodic inspections.

4. DESCRIPTION OF THE SIMULATION MODEL

The developed car workshop simulation model consists of 7 subsystems (Figure 1): generating daily mileage of fleet vehicles, generating orders for periodic maintenance of fleet vehicles, generating fleet vehicle failures, generating orders for individual customers' vehicles, booking places in the work schedule, modeling the operation workshop and a subsystem for saving and displaying simulation results. The SimEvent library of the Matlab/Simulink environment was used. The possibilities of the Matlab Function block and global variables were also intensively used to save information such as the current simulation day, workshop work schedule, information on working and non-working days, a table storing the mileage status of fleet vehicles, and a table associating the vehicle model with its periodic technical services (limits and service times).

The simulation entity can be interpreted in two ways in the model. It depends on where it occurs. At the beginning of its existence, the unit is an order for the performance of a service. Based on the order, a place is reserved in the workshop's work schedule. Then, the order awaits accepted orders on the server and is transferred to the workshop at the right time, resulting from the schedule. At this stage, the unit is already interpreted as a serviceable vehicle.

Each entity (order/vehicle) has a set of attributes that are used at different stages of the simulation. These are:

Status – 1 means a fleet vehicle in periodic maintenance, 2 - a fleet vehicle sent to the workshop due to a breakdown, 3 - a vehicle of an individual customer.

IdVeh –the number (from the pool of numbers) of the fleet vehicle intended for periodic maintenance or the sequence number of the generated individual customer vehicle or failure of the fleet vehicle.

Priority – priority used in the queue of vehicles waiting for the workshop. Fleet vehicles going to the workshop in an emergency have priority 2, others 1.

AverServTime – estimated time of the service. Randomly generated for individual customers' vehicles and fleet vehicle failures. In the case of fleet vehicles, it results from the type of periodic maintenance and is deterministic.

RealServTime –actual time of service in the workshop. It is a randomly disrupted forecast time.

Stand – the number of the service station in the workshop to which the vehicle is being driven.

TimeShift – allows specifying the first day from which the schedule will be searched for a free time. This way the service can be postponed.

WaitToServ – time spent in the *server of accepted orders.*

Path –auxiliary attribute, allows control of the entity movement in the simulation.

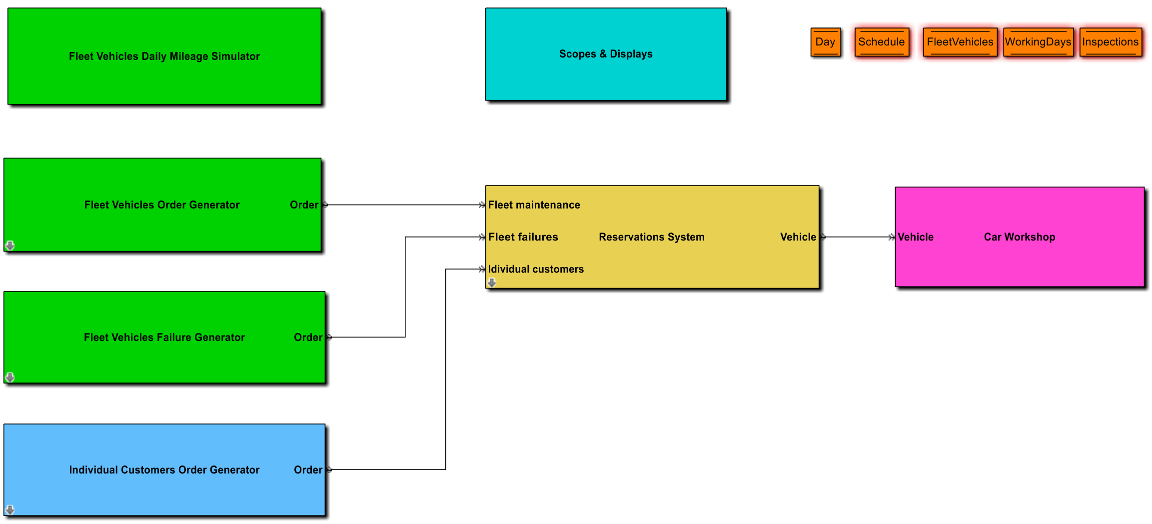

Fig. 1. A model simulating the work of the workshop and the daily mileage of vehicles

The subsystem of daily mileage generation for fleet vehicles modifies *the vehicle table* every working day by increasing the mileage counters in kilometers (randomly) and days. Non-working days, which are normally not included in the simulation, are also included in the mileage measured in days based on the working days' table. The subsystem also resets vehicle mileage counters after completion of maintenance. Modification of the vehicle table always takes place in 1 simulation time unit (15 minutes real time) before the end of the working day. This is to prevent simultaneous access to the table by the subsystem generating service requests based on it.

The current state of the vehicle table is saved in a journal and can be additionally analyzed later. An exemplary history of a selected fleet vehicle, the mileage of which was subject to the distribution N (469.68), is shown in Figure 2. During the calendar year (all days of the year were considered), the vehicle underwent consecutive inspections of 2,1,3,1,2,1,3 after covering 20,40 and 80,000 km, respectively. The timeline also shows the date of submission of the inspection request (asterisk) and the date of its actual completion (circle). Exceeding the mileage limits amounted to 1612, 970, 2382, 1543, 1829, 1990, and 2197.

An additional task of the subsystem is the modification of the global variable indicating the current day of the year, which is performed at the end of each working day. The current day of the year is used by the vacancy reservation subsystem.

The vehicle table contains the following fields: vehicle number, total mileage, age, average daily mileage, standard deviation from the daily mileage; and three sets of fields: inspection ID, odometer, and day counter; for each of the three maintenance areas. The last field is used to save the type of inspection and allows to distinguish the inspection resulting from exceeding the limit of kilometers or days. By changing the sign of the value in this field, the end of the service by the workshop is also signaled, which is the basis for resetting the counters. The inspection identification fields refer to an additional periodic maintenance table, which contains the following information: service limit in kilometers, limit in days, forecast duration of the inspection (deterministic), and variance of the random time disturbance (distribution $N(0, \sigma)$).

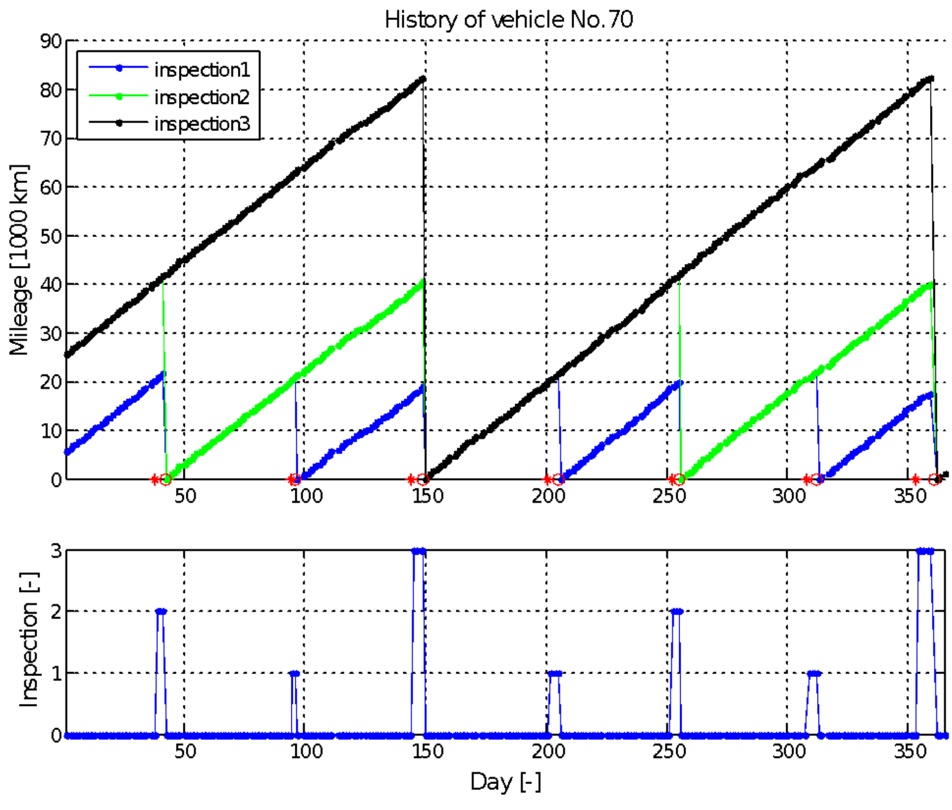

Fig. 2. An exemplary history of technical inspections of a selected fleet vehicle

In the fleet vehicle maintenance order generation subsystem, at the beginning of the simulation and the beginning of each working day, a unit stream corresponding to the full set of fleet vehicles is simultaneously generated. Based on the vehicle numbers and entries in the vehicle table and the inspection board, vehicles/orders sent to the workshop are selected. The remaining units are turned off. The "order exit" event is saved to the reservation system. Two strategies for selecting vehicles were implemented as described in paragraph 2. In the case of the first strategy, the delay in booking a place in the workshop work schedule is a random number of days with a Poisson distribution with a given average equal to, for example, 1 day.

This simulates the phenomenon of postponing the declaration of a fleet vehicle due to its involvement in early ordered transports. In the case of the second booking strategy, it is delayed by a fixed number of days; however, the booking decision is made well in advance.

The structure of the subsystems generating breakdowns of fleet vehicles and the orders of individual customers is very similar. Orders are generated based on the given *average failure interval* and the a*verage reporting interval* of an individual customer and are subject to an exponential distribution. Each order is assigned a predicted random service execution time and the real time resulting from a random forecast disruption. The real time of service performance will be needed only in the subsystem imitating a workshop. However, in the model, it does not matter at what stage this value is drawn. Each order generation event is recorded.

All orders of individual and fleet customers, as well as breakdowns, are sent to the reservation subsystem. The subsystem searches for a place in the workshop work schedule that is adequate to the forecasted time for the service and assigns a service station. Calculates the time when the vehicle should reach the workshop and stores the order in the order server until then. The unit leaving the reservation subsystem can further be interpreted as a vehicle headed for the workshop. Failures are prioritized, the least loaded workstation is searched for, and the vehicle with the breakdown is immediately directed to it. Optionally, the priority can be turned off, then failures will be treated in the same way as other orders.

Ultimately, all units/vehicles generated in the simulation go to the workshop, where they are allocated to stands. The time interval from the unit's arrival at the workshop to the time the unit is put out of service after the service is performed is measured. All service performance events are saved to a separate file. Information about the end of service for fleet customers is provided via the *vehicle table*.

It is assumed that normally vehicles arrive at the site exactly at the time planned in the schedule. Using the parameter *earlier arrival*, it is possible to force the appearance of the vehicle ahead of time (but not earlier than the beginning of the next working day). In this way, the free time of the service stations in the event can be used because the actual service time was shorter than planned. On the other hand, arriving earlier increases the total time the vehicle spends in the workshop.

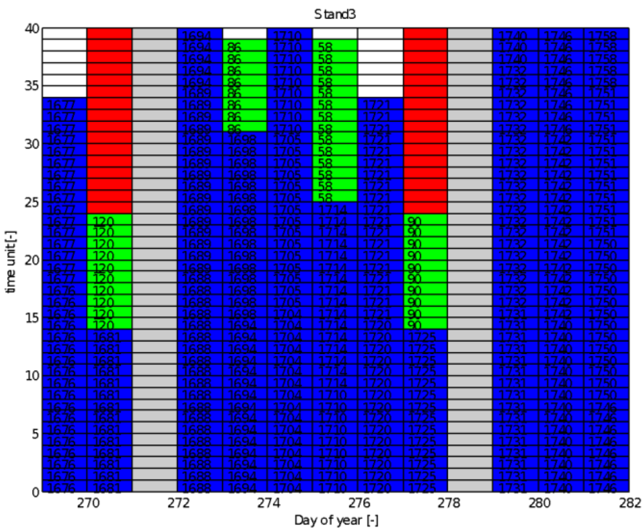

Fig. 3. A fragment of the workshop work schedule completed during the simulation

It is also possible to artificially thicken orders in the schedule using the *overbooking* parameter. In the model, this parameter can be used to shorten the forecasted service time, which, however, cannot be shorter than the assumed *minimum reservation time*. However, the use of overbooking is risky and will almost certainly cause at least temporary blockages and prolongation of the vehicle's stay in the workshop.

Naturally, at the end of the year, the workshop's work schedule is already full, and some of the vehicles must be diverted to the next year. The work schedule is available after the simulation is completed as a disk file, and on its basis, additional analyzes of the annual operation of the workshop can be made. Figure 3 shows an exemplary excerpt from the schedule, days 270 to 282, workshop stand number 3. Blue is for individual customer reservations; green is for fleet customers and white is unused space. Additionally, gray means non-working days and red means afternoon hours on Saturdays.

5. ASSESSMENT OF THE WORKSHOP POTENTIAL WITH SIMULATION METHODS

The simulation research started with the assessment of the workshop's potential. Only applications from individual customers were considered. A case was analyzed when the average interval between consecutive requests was 5-time units (approximately 8 clients per day). The customers arrived at the workshop exactly on time. There was no overbooking when booking seats. The projected service time was described with the N (16.2) distribution, while the real time was the sum of the forecast time and the disturbance with the N (0.4) distribution. At the same time, none of those times could be smaller than 2 units.

When analyzing Figure 4, it can be noticed that the most time spent in the workshop by individual customers' vehicles was within one working day. Only a few vehicles spent more time in the workshop, but not longer than 1.5 working days. Disregarding the "switch-on effect" at the start of the simulation, the average time spent in the workshop was stable at around 20 units (half a working day). The waiting time for the service was usually 3 working days. The degree of use of the individual workshop stands was between 70 and 80%. The uneven load of the positions results from the algorithm used for searching for vacancies - the established order of positions when viewing the workshop work schedule. During the 303 working day simulation, 2,322 repair orders were generated from individual customers. Subsequently, 2,314 vehicles were serviced, 7 vehicles were registered for another year, while the service of one vehicle was extended for another year.

After the simulation was completed, the workshop work schedule was analyzed and it was found that the following positions were not used at individual positions: 13.3, 11.3, 17.3, and 24.3% of the available time. The histogram of Figure 5 shows that the largest amount of free time periods is between 5 and 8 units. There are also sections with a length of 40 units (working day), and this applies mainly to stand number 4. Eventually, based on the results of the first simulation, it can be concluded that the level of customer service is high, while the degree of use of the stands is a bit too low.

The estimated time of the service plays an important role in the process of booking a visit to the workshop. In actual working conditions of the workshop, this time is assessed by the workshop manager based on an interview with the customer and a preliminary inspection of the vehicle. The accuracy of the forecast depends on the experience of the workshop manager. There is a tendency to systematically lower the service time. This phenomenon increases the occupancy of positions and the time spent in the workshop but does not affect the waiting time for the service itself (entries in the schedule). During the second simulation, the service time disturbance distribution was changed to a very pessimistic N (2,4), leaving the remaining parameters unchanged. The time spent in the workshop has significantly increased, and a minor blockage can be observed at the end of the year (Figure 6). The occupancy of positions increased by approximately 10%.

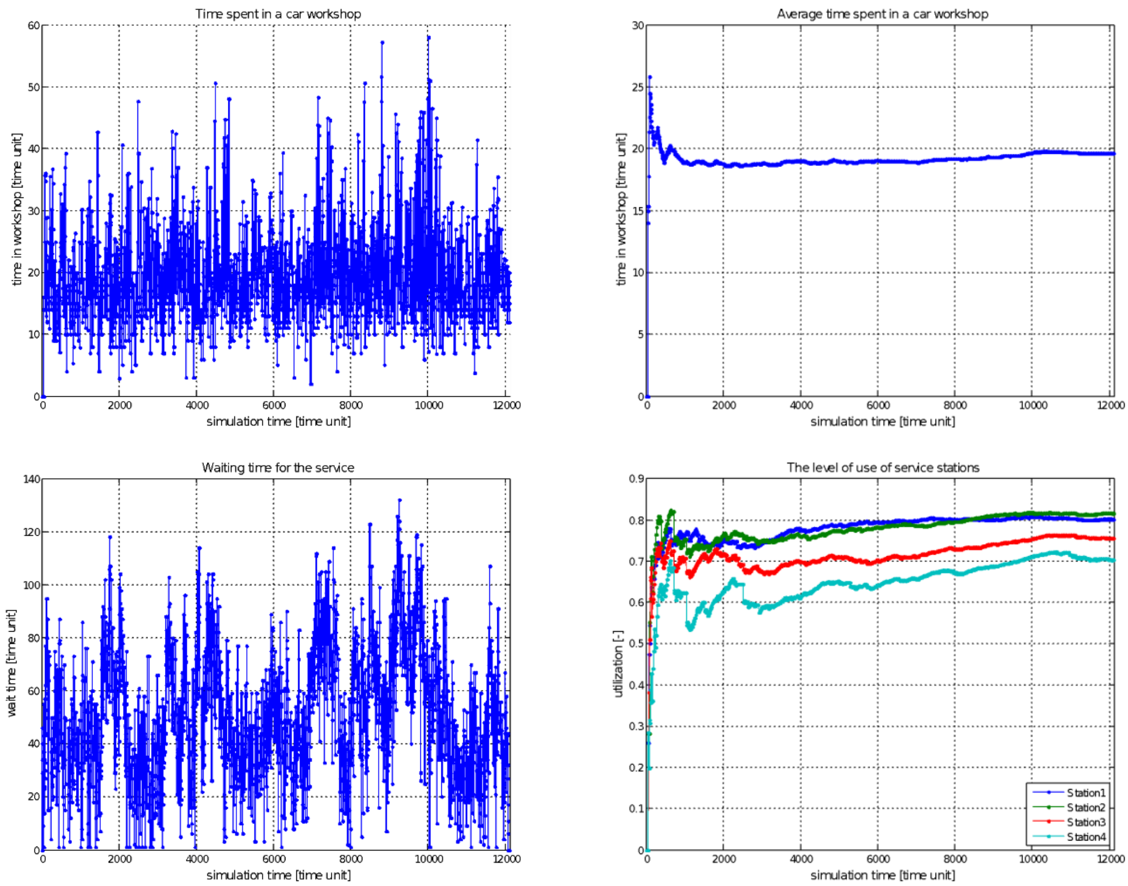

Fig. 4. Summary of the results of the first simulation (applications with interval 5)

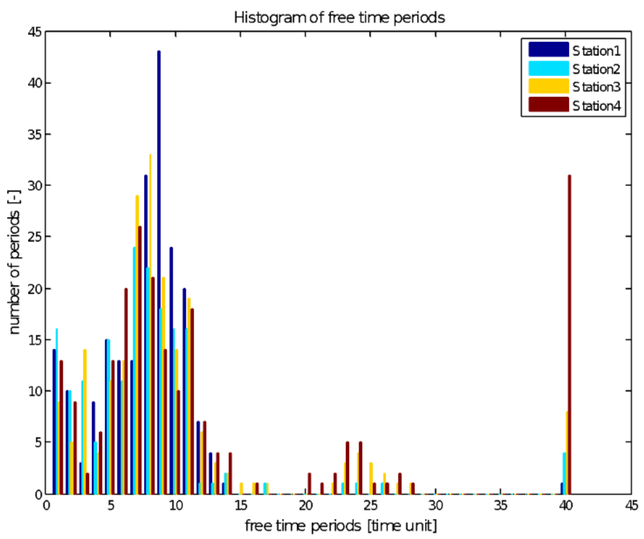

Fig. 5. Histogram of all free time slots in the work schedule

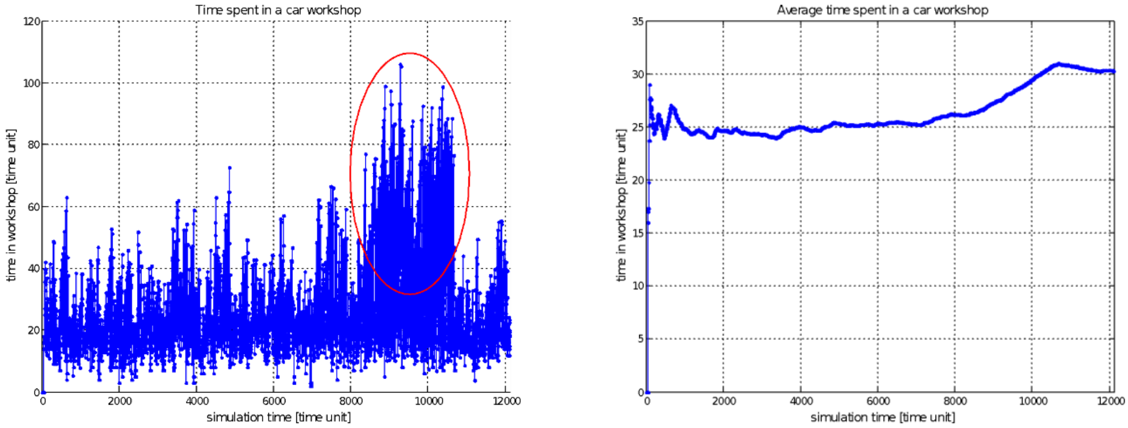

Fig. 6. Increase in service time due to the systematic decline in the forecast

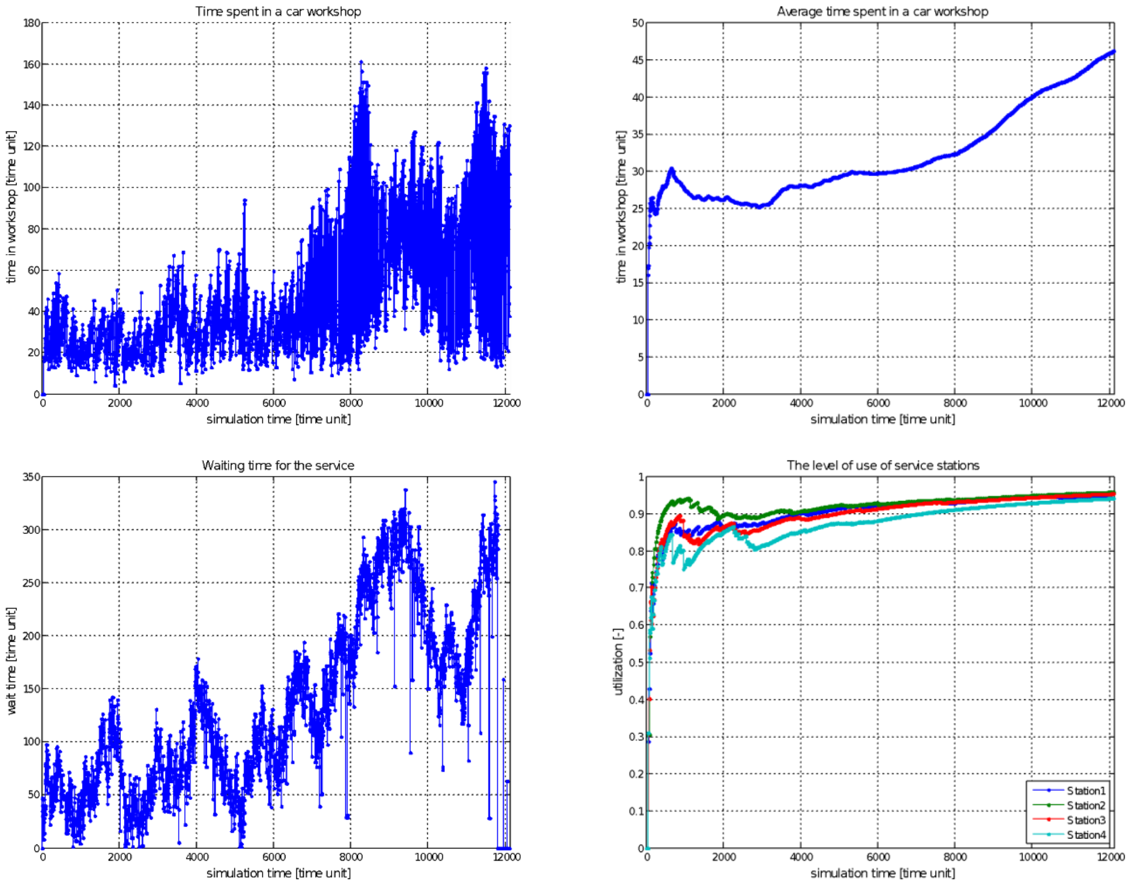

Fig. 7. Summary of the results of the third simulation (applications with interval 4.5)

The third simulation was carried out under the same conditions as the second one, however, shortening the interval between successive applications to 4.5 units. A total of 2,635 orders were generated, of which the workshop handled 2,534; 88 vehicles were registered for the next year, and the repair of 13 vehicles was extended for another year. Based on the analysis of the results (Figure 7), it can be concluded that with such a number of orders, the workshop has already reached its limit. The time spent in the workshop systematically increases over one working day. At the end of the year, there is a need to wait a long time for the service itself - about 8 days. The use of the positions reaches 95%.

Further shortening the reporting interval to 4 units generates 2,957 orders. However, the workshop serviced only 2,607 vehicles, which is a little more than what was achieved in the third simulation. On the other hand, as many as 257 customers resigned from subscribing because the waiting time for the service exceeded 14 days.

Summarizing the results of all simulations, it can be assessed that the workshop can handle orders appearing with an interval of 5-time units at a good level. The simulation shows that it will be slightly less than 8 clients a day. Therefore, it is the number that results from the observation of the history of the workshop to date. At the same time, at least a dozen or so percent of free time is left. These are often periods of time in the order of 2-3 hours that can be used for periodic fleet vehicle inspections.

The simulations also showed that even if the systematic error in forecasting the service time was extended by an average of plus 2 units (half an hour), the workshop was still operating efficiently enough. The available historical data on the work of the workshop does not allow assessing what exactly this error was.

6. RESEARCH ON THE IMPACT OF FLEET VEHICLES

Based on the parameters of the first simulation discussed in the previous paragraph, an additional stream of fleet vehicles was included in the model (periodic maintenance and breakdowns). The impact on the workshop operation of an additional 150 fleet vehicles is presented below.

To obtain the most reliable simulation results, it would be necessary to know the exact parameters of the entire vehicle population, including the average daily mileage. The owners of the fleet have this data. Due to the difficulties in obtaining data before signing the relevant contracts, a randomly generated virtual population of vehicles was used in the simulation. Seven classes of fleet vehicles with a load capacity of up to 3.5 t were selected, which meant 21 different scopes of technical inspection. The average daily mileage of the generated fleet was uniformly distributed from 50 to 500 km. It was assumed that the standard deviation of the daily mileage accounted for 10% of the average mileage. The failures were treated as events independent of technical inspections, occurring with an interval of 800-time units.

The simulation results are summarized in Figure 8. In total, 432 orders for the inspection of fleet vehicles and 17 failures were generated. The workshop serviced 2,717 vehicles during the year. Fifty-four orders were saved for the next year. The records of the fleet vehicles in the work schedule were carried out following the first strategy, that is, after the fleet vehicle exceeded a certain mileage or time limit. Observably, additional orders do not significantly affect the time spent by vehicles in the workshop. However, at the end of the year, there is a clear increase in waiting time for the service, which is even up to 10 days.

The second strategy for stocks of fleet vehicles was also tested, based on the forecasted mileage of 7 days in advance. In this case, the average service time did not change, but the waiting time for it increased. There was an unfavorable phenomenon - 28 individual customers resigned from subscriptions due to excessively long waiting times (Figure 9).

Figures 10 and 11 compare the exceedance of the mileage limit in the case of making entries to the workshop according to two strategies. It can be seen that in the case of earlier records, the maximum exceedances are almost halved, but it is also possible to perform an inspection prematurely. The calculated average for all vehicles with average individual exceedances is

1194 and *370* km, respectively, depending on the strategy. The number of *150* fleet vehicles is the limit value at which the workshop functions properly and does not discourage individual customers by waiting too long for the service. The first strategy for scheduling entries is more advantageous because on average, inspections take less time than repairs, and it is easier to fill the empty spaces with them. Of course, one has to consider that the limits of inspection kilometers will be exceeded, but as calculated, they are not too large. The second strategy causes blocking of the terms at the beginning of the working day, which makes it impossible to find a free period of time on the border of two days in the case of individual customers.

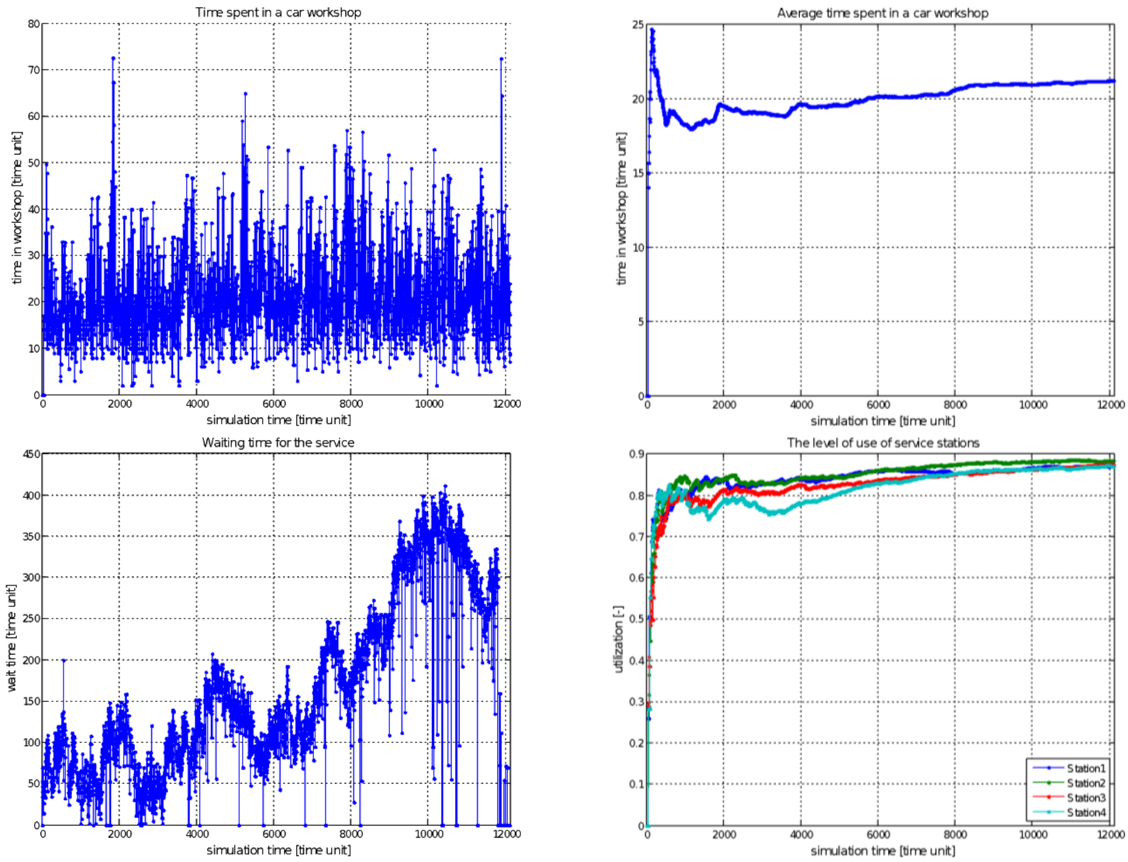

Fig. 8. Comparison of simulation results with an additional stream of fleet vehicles

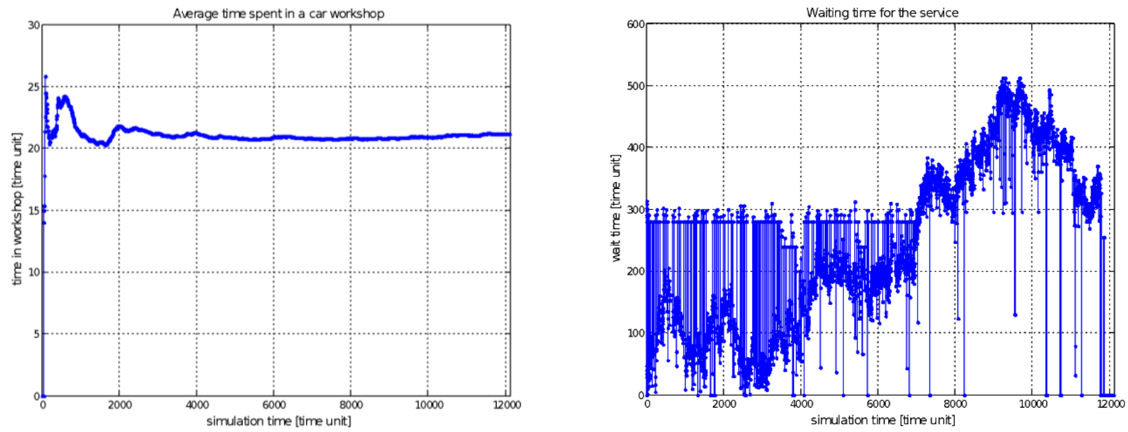

Fig. 9. Average time spent in the workshop and waiting time for the service
(Second strategy for fleet vehicle records)

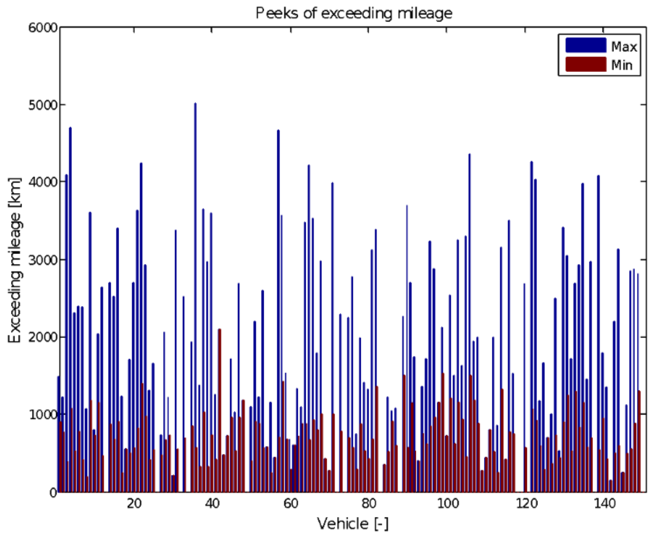

Fig. 10. Strategy 1 - maximum and minimum exceedances of the mileage limit

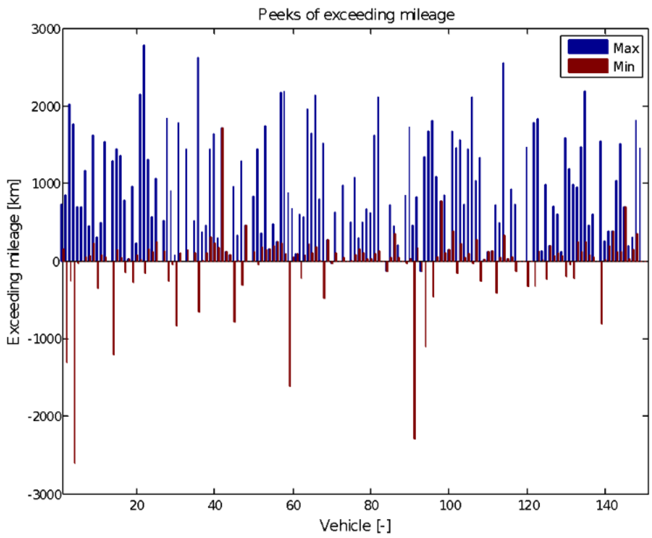

Fig. 11. Strategy 2 - maximum and minimum exceedances of the mileage limit

7. CONCLUSIONS

The simulation model of a workshop that simultaneously serves a stream of individual and fleet customers was used to detect possible blockages and establish safe boundary parameters. However, this model is quite universal. Assuming the required parameters, an inverse analysis is possible to estimate the number of necessary positions in the workshop. Additional statistical analyzes can also be performed after performing the simulation based on files documenting the events and the completed work schedule. Although the model was created based on the analysis of a specific case, it is easy to modify and adjust to other conditions and needs.

The problem of inspecting fleet vehicles does not only concern transport related to the supply chain. The increase in the number of vehicle rental companies and the developing idea of vehicle sharing may increase the demand for this type of service in the future. The reason for the inspection may be not only exceeding the mileage limit and performing maintenance following the manufacturer's recommendations. Moreover, it is equally important to systematically monitor the technical condition of rented cars and react quickly to various types of minor damage or devastation.

Based on the simulation analysis of the operation of the selected workshop, it was possible to determine that the workshop will work properly when individual customers report with an interval of not less than 4/5 hours. On the other hand, the limit number of fleet vehicles serviced by the garage is 150. The most advantageous from the viewpoint of the garage's interests is enrolling fleet customers, after the necessity to perform an inspection, in the first free place in the schedule. In this case, however, it should be considered that some of these inspections would be carried out more than the mileage limit. This can be problematic in newer vehicles, in which the onboard computer limits the power or even stops the vehicle if it is not serviced on time. The results are critically influenced by obtaining reliable and detailed data on fleet vehicle mileage.

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