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Mr. Sc. Jasmina Bunevska
University « Sv. K. Ohridski»
in Bitola
Faculty of Technical Sciences
Department of Traffic
and Transport
Bitola

Traffic Engineering
*Review**

DEVELOPMENT AND INTRODUCTION OF LOGISTICAL SYSTEM FOR MAINTENANCE OF THE PUBLIC TRANSPORTATION MOTOR VEHICLES: A CASE STUDY

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1 Introduction

Process of change in level of organizational and technical efficiency of public transportation system is in direct relationship of process of change of the technical condition of transport units included in realization of transport tasks. Form aspect of reached level of operational readiness of the system these changes by the end in summary are expressed in manner of transport unit arrival at time which does not correspondent by time schedule. Taking in mind and eventual failures of public transport lines in public transport grid we receive summary of realized transport task which are put in time schedule. With this the level of organizational and technical efficiency of the system is determined.

Public transport enterprise JSP Skopje deals with part of public transport in Skopje city. Its vehicle park is heterogeneous. That means different types of transport units are included in vehicle park in which previously grouping of it was made. Grouping was performed by constructional, technological and exploitation characteristic (KTE) properties. This allows dynamical overview of the change in availability of transport units which is changed during performing transport tasks according time schedule, and also performed mileage.

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2 Acquiring and Determining of Input Data

For necessity of testing and validation of method for determining the level of organizational and technical efficiency of system for public city transportation we made acquiring data for system work. Source of this data is:

- available dispatcher documentation and
- yearly report for enterprise work.

Acquiring of data was performed with help of the information system with is implemented in public transportation enterprise.

Identification, recording and acquiring of data and information was performed trough formatted documents (bearers) with source or related information. For avoiding subjectivity in interpreting the information, data and information bearers are organized by such manner to secure uniqueness without occurrence of subjective descriptions. It was achieved with printing of all necessary and needed answers, so the used data are entered by checking the correct answer. For all data which can not be entered by this way they can be entered on blank space left intentionally for this purpose for exact description of additional information.

For needs of this exploration and acquiring date we made exploration of transport demands in correlation with the system, date which determines age structure of vehicle park and data which determines change of technical condition of vehicles.

For gathering data which are related to transport demands in system a trial period of one year is taken. Representative period

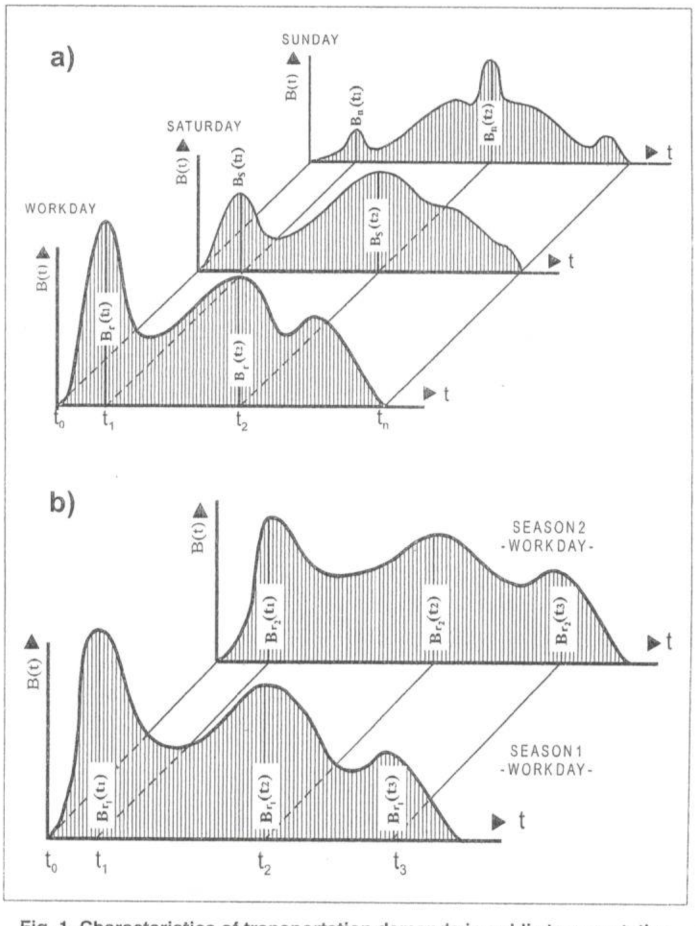


Fig. 1. Characteristics of transportation demands in public transportation system in: a) specific days, b) specific season (JSP Skopje)

in which are defined transport demands is day, during it is necessary to follow the realization of demands for: specific day (working day, Saturday, Sunday), figure 1a, but also for every specific period of year, figure 1b.

A group of data which are related for age structure of vehicle park of the enterprise is made by totally 395 inventory vehicles grouped in 3 specific technical-exploitation groups.

This way of grouping gives us possibility to identify transport units in rough way because transport units which are exploited for public transport enterprise's needs during its life and exploitation period had several engine changes (motor group, driving group etc.), while it is possible to apply engines that are not source for that model or type of transport unit.

Data which determines change of technical condition at transport units are gathered from exploitation personnel. They are characterized by dynamics of failure occurrence and other irregular conditions at transport units during observed period and it is very odd and irregular. In average they have 70 failures or other irregular conditions during work day. Between 41-100 failures are occurred in 82% in working days during year. It is not noticed in one day less than 19 failures, only in one day during year we had occurrence of 220 failures which is because of outstanding technical exam performed by authorized personnel for traffic security.

In relation to homogeneity of failure occurrence at transport units in system for public transportation most frequent change of occurrence we had in period from 06 to 07 h AM, from 12 to 14 h and slightly lower to 15 h and during evening hours from 18 to 19 h. Average number of failure occurrence by hour is 3,35. When we observe only part of working day from 5 to 20 h, average number of failure occurrence is 4,09. If we observe only second part of work days, average number of failure in system is only 0,98. In this period we have total of 25968 failure occurrence and rest of 1943 is for the rest working period of the system. With this conclusion we can justify theory for total cut off for this period for analysis of organizational and technical efficiency of the system in part of working day which begins in 3 h in the morning and lasts to 5 h, and part of the day after 21h to 24 h. Based on previous research it is determined that failure occurrence is by Poison curve delivery with average intensity of 3,79 failures by hour for transport units.

2.1 Structure of Failures by System of Transport Unit

As statistical example for analysis of errors one year period is observed. In chosen period we had 18.965 different failures at transport units which were taken for analysis and shown by sub-systems in following table.

From the table we can see greatest occurrence of failures and engine system, (16,3%), wheels (15,45%), stopping system (12,61%). On this 3 sub-systems we have total of 44,6% of all failures at transport units. On (figure 2) Pareto diagrams of relative frequency of failure occurrence by systems at observed transport units.

Because here we have transport units which are exploited in speed regime of several short by time and way closed cycles, where uninterruptible phases of speeding up and speeding down are changed there it is reasonable engine failure.

During analysis of failure at transport units it is noticeable existence of group *other*. In this group are gathered failures which

Table 1.

Failure structure

Label	*DEVICE/SYSTEM*	*Failure volume*	*Percentual part*	*Total percen…*
A	Engine	3059,05	16,13	16,13
B	Transmission	2008,39	10,59	26,72
C	Cooling system	893,25	4,71	31,43
D	Standing system	1498,23	7,9	39,33
E	Heating system	510,15	2,69	41,99
F	Chassis	1052,55	5,55	47,54
G	Stearing system	286,37	1,51	49,05
H	Tyres	2931,98	15,46	64,51
I	Electric system	1976,15	10,42	74,93
J	Breaking system	2391,48	12,61	87,09
K	Other	2448,38	12,91	100,00

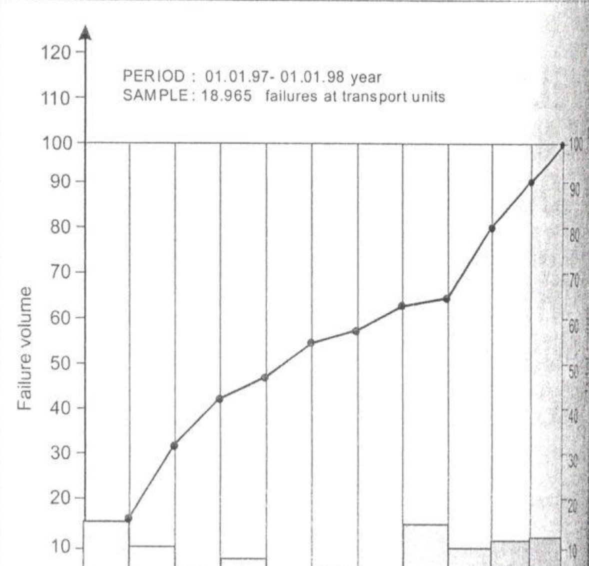


Fig. 2. Pareto diagram of volume and structure of failures at transport… in system

can not for sure to be grouped or describe by present in… tional system.

For fails frequency analysis at transport units and constr… of Pareto diagram we had 18.965 conditions which could… tally defined by origin and by cause of the failure.

3 Model Description

Failures which have occurred and which can not be repa… driver of transport unit itself are reported to dispatcher… which organizes vehicle removal. Failure removal can b… formed by mobile or stationary team organized in system… exploration JSP Skopje had 3 mobile teams which were e… for failure removal on site. There is other possibility for fai… moval in auto-base stations in Avtokomanda or Gjorce Pe…

Based on statistical exploration it can be define that … failure occurred at transport units in system are repaired b… bile teams and 40% in auto-base stations. From total num…

failures which are repaired by stationary teams in auto-base stations 60% are done in Avtokomanda and 40% in Gjorce Petrov. Also frequency of failure occurrence during day is different according change of transport demands in system.

Failure occurring is by Poison delivery and stream ?? After failure occurs at any transport unit in correlation with previously determined proportionally of failure repair, failed transport units are repaired by mobile or stationary teams.

If transport unit should be repaired by mobile team after failure, model checks mobile repair team availability. If there is no mobile repair team available then transport unit waits in queue until any mobile repair team is available.

For easier determining the process of failure removing in auto-base stations it is supposed that there are 3 stationary teams in each auto-base station in Avtokomanda and Gjorce Petrov. Also waiting queue for failed transport units is provided by model in each auto-base station. On base of previous statistical exploration it is determined that failure repair has Exponential delivery with average repair duration (?) of 39 minutes.

In practice after fail transport unit's occurrence, dispatcher service organizes engaging new reserve transport unit. There is every day average of 4 transport units in JSP Skopje which stay in reserve and are engaged in traffic in cases of failed transport unit. When there is no reserve transport unit available and fail transport unit occurs driving time schedule is corrected. Dispatcher increases interval of following the units which fills the gap that happens of failed transport unit.

All previously stated situations from common practice are taken in mind when model was founded.

Totally in this model were used: 19 devices, 3 rows, 4 warehouses and 1 memory location.

4 Model Testing

Model testing was performed 8 times with change of the seed of random number generator.

Only a segment of data was picked up for showing necessary factors of system functionality, because output statistics of GPSS are quite big in volume and not suitable for show.

On base of those results average values of those characteristics are shown in following histograms.

From this histograms (figure 3 and 4) we can see that first mobile team have 65,11% engagement during referential period of simulation and average time of intervention of 41,49 minutes. Rule, that first mobile repair team should be main bearer of repair process is kept in this case. Real time for one repair of the

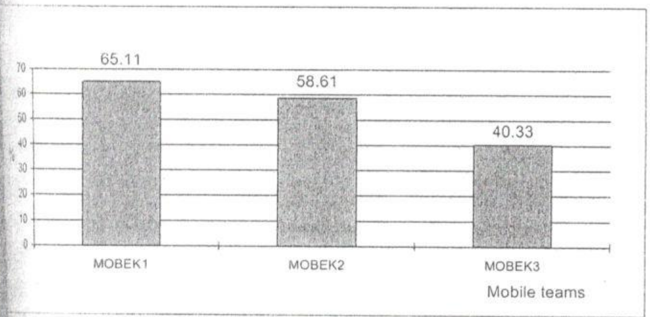


Fig. 3. Histogram of average engagement of mobile repair units in system

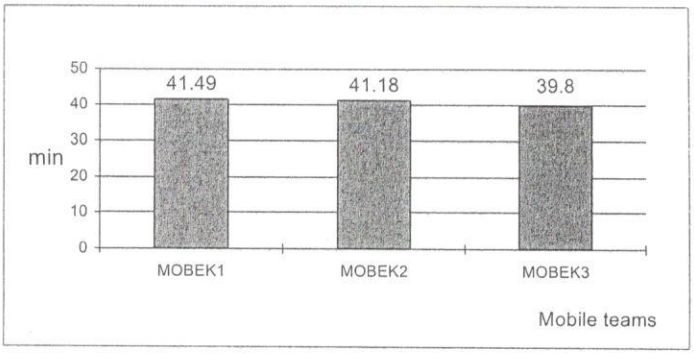


Fig. 4. Histogram of average duration of intervention of mobile repair teams

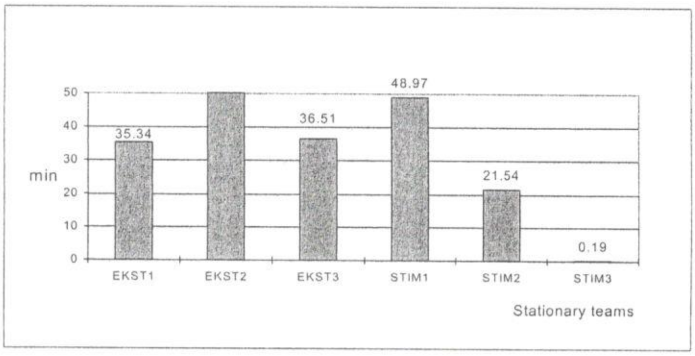


Fig. 5. Average time engaged by stationery repair teams in auto-base stations in Avtokomanda and Gjorce Petrov

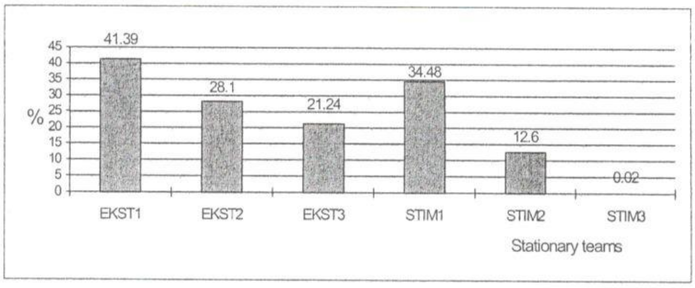


Fig. 6. Average engagement of stationery teams on auto-base stations

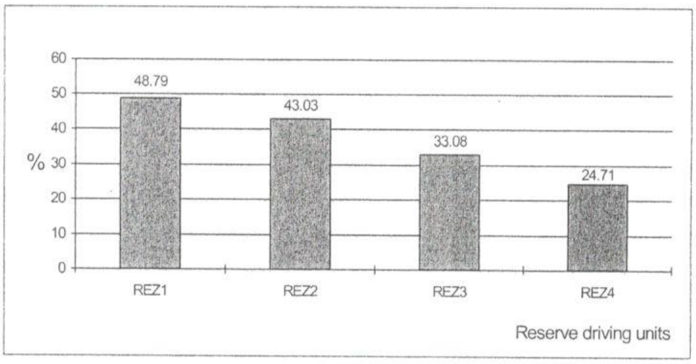


Fig. 7. Average unengagemnet of reserve transport unit

system is previously determined and it is 39 minutes. Deviation is minimal.

Results of simulation shows us that average repair time is biggest at second stationary repair team (EKST2) in auto-base station Avtokomanda and it is 50,28 minutes, while in auto-base station Gjorce Petrov for (STIM1) team it is 48,97 minutes.

Practically exploration performed on real system shows us that there is not possible easy identification of the team which actu-

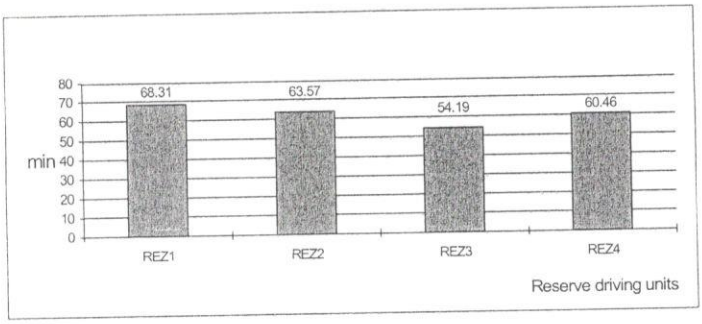


Fig. 8. Average time of unengagemnet of reserve transport unit between two engagements

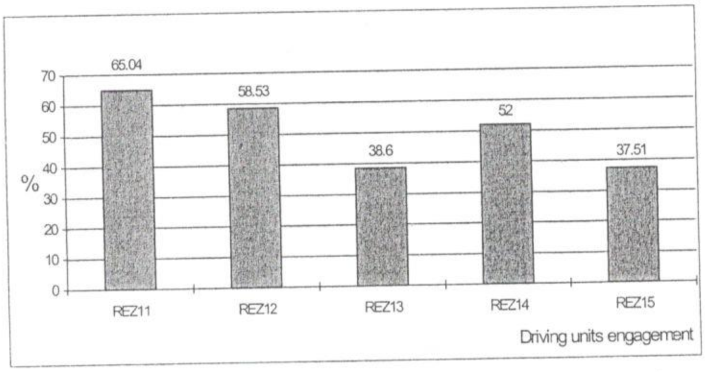


Fig. 9. Average number of engaged reserve transport units in correlation with mobile or stationary repair teams

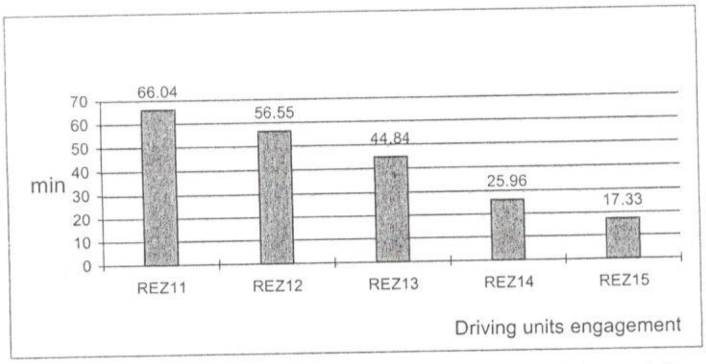


Fig. 10. Average time of engagement of reserve transport unit in correlation with mobile or stationary repair teams

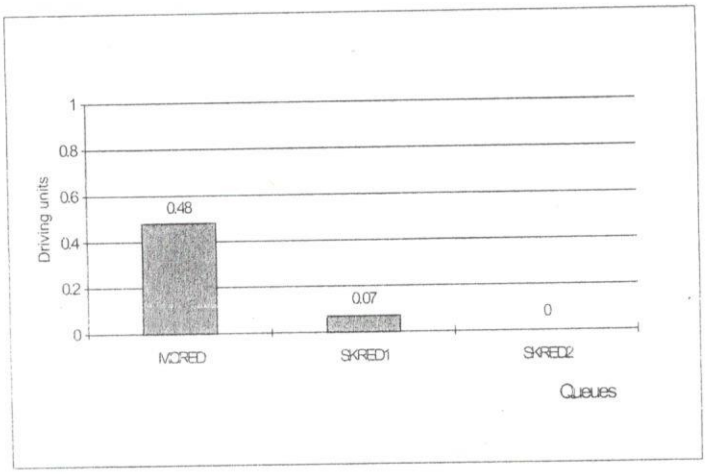


Fig. 11. Average number of transport units in waiting queues

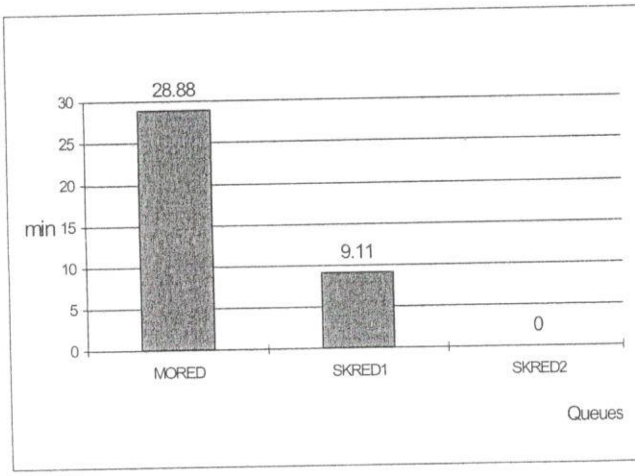


Fig. 12. Average time spent in waiting queue

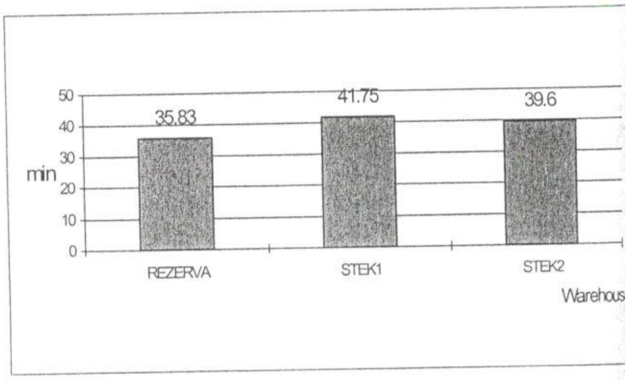


Fig. 13. Average time spent in warehouses

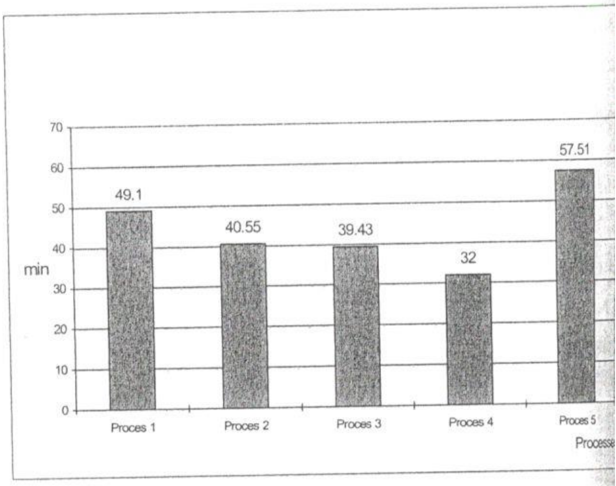


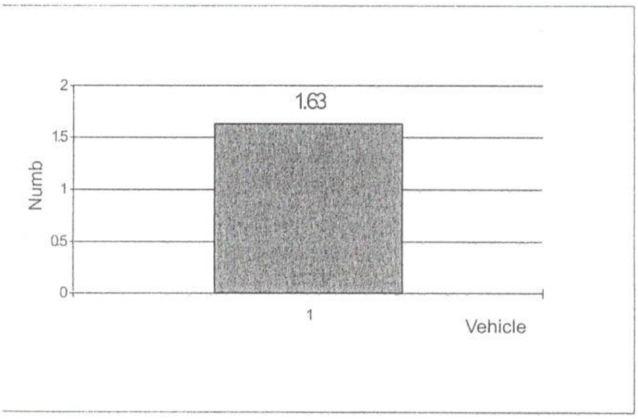
Fig. 14. Average time spent by processes

ally did the repair because that was not stated on document But, average time of repair for all teams could be determin follows: 46,33 minutes in auto-base station Avtokomand 50,44 minutes in Gjorce Petrov auto-base station.

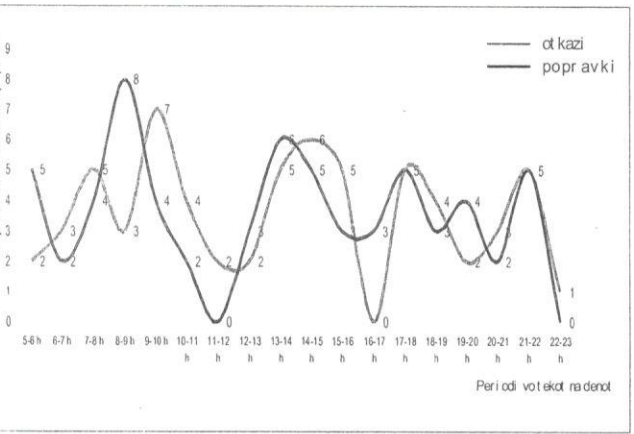
There are reserve transport units in system. Its number is able but most common number is of 4 transport units with Degree of unengagement of each of driving units is show figure 6.

Average time of unengagement of reserve transport uni tween two engagements is shown on figure 7 and 8.

During intervention in system waiting queues are form average for intervention was waiting 0,48 units.



. 15. Average number of not repaired transport units during one day



16. Simulation of intensity of failures and repairs for specific periods during one day

Average waiting time for intervention is 28,88 minutes. (figure 12)

Intensity of change of the failure number and repair number shown by periods of day and acquired by simulation is show on figure 16.

5 Conclusion

Characteristics of this paper is tendency do realize one of possible approach for immediate determining of elements of logistical support at transport systems in its exploitation part.

On this example with identified exploitation conditions at vehicle park of JSP Skopje a model is developed by which we can establish relationship between processes of change to the technical condition of the transport units and realized quality of technical service and maintenance as elements of logistical support.

Such stated model gives us way by calculation to determine and later dynamic simulate condition of the system based upon statistical relationship. On this way prediction of system availability with capable transport units is achieved, and all integrated technical support of maintenance system can be raised to level which enable technical correctness at transport units to be greatest when demands for it are greatest.

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MMARY

)ukoski
ı Simjanovska Sretenova
nina Bunevska

ɘlopment and Introduction of Logistic System /laintenance of the Public Transportation Motor icles: a Case Study

ıintenance of motor vehicles is an area of practical activity, com-ıg technical, technological, economic and organizational measu-Their purpose is to ensure work capacity and the reliability of effi-:y and safety of the road transportation system. The paper presents ıethodology of setting up a complex informative system for the de-ɔment and introduction of logistic systems for maintaining public portation motor vehicles.

words: informative process, data items, structural connection, in-ative subsystems

SAŽETAK

Ivo Dukoski
Vera Simjanovska Sretenova
Jasmina Bunevska

Razvoj i uvođenje logističkih sustava za održavanje motornih vozila u javnom prijevozu: studija slučaja

Održavanje motornih vozila je područje praktičnih aktivnosti, koje se sastoji od tehničkih, tehnoloških, ekonomskih i organizacijskih mjera. Njihova je svrha osigurati radnu sposobnost i pouzdanu djelotvornost kao i sigurnost sustava cestovnog prijevoza. U radu se daje metodologija uspostave kompleksnog informacijskog sustava za razvoj i uvođenje logističkih sustava za održavanje motornih vozila u javnom prijevozu.

Ključne riječi: informacijski proces, podaci, strukturna veza, informacijski podsustavi